



LIFT STATION DESIGN AND CONSTRUCTION STANDARDS

2019 - 1ST EDITION

VOLUME 1 OF 2 - STANDARDS



Clark County
Water Reclamation
DISTRICT

LIFT STATION DESIGN AND CONSTRUCTION STANDARDS

2019 - 1ST EDITION

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CLARK COUNTY
WATER RECLAMATION
DISTRICT

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FORWARD

This first edition of the Clark County Water Reclamation District (CCWRD or District) Lift Station Design and Construction Standards (LS-DCS) includes supplemental requirements not included in the Design and Construction Standards for Wastewater Collection Systems Southern Nevada – latest edition (“DCSWCS”). Both documents are intended to be used together, with this document providing the requirements for lift stations within the wastewater collection system. This standard can be employed for the design, rehabilitation or retrofit of any wastewater lift station and force main systems.

The use of the term “Lift Station” as referenced in this document corresponds to pump stations as well as lift stations, making no distinction between either system.

The LS-DCS is a standard for the engineer when planning and designing wastewater facilities and shall be used for both public and private facilities. (For private lift stations, see Section 2.1.7 “Private Sewer Lift Stations.) This standard summarizes and outlines relevant CCWRD policies, applicable codes, and engineering and operational practices and procedures that have been developed to establish a cost-effective, reliable, and safe wastewater collection system. Also to be considered and used in conjunction with this design standard are all applicable current standard drawings, specifications, and industry requirements for the planning and design of associated wastewater infrastructures.

Users of this Design Standard are directed to read the Disclaimer following this Foreword. It should be understood that the design of a wastewater lift station will require drawings and specifications not provided in this document, such as civil, structural, mechanical, electrical, instrumentation and controls, odor control, and architectural requirements. It is the responsibility of the DESIGN ENGINEER to modify or provide design documents adequate to meet the needs of each specific project. This Standard is not a substitute for professional experience, nor is it meant to relieve the DESIGN ENGINEER from his/her responsibility to use good engineering judgment. The DESIGN ENGINEER shall be responsible for providing a design that, within industry standards, can be safely repaired and maintained, will provide good operational service and life, and will not create a public nuisance or hazard.

The Standard may be revised by issuance of a supplement to correct errors and omissions found in these specifications and to reflect advanced thinking and the changing technology of the construction industry. Each supplement shall supersede any previous supplement by inclusion of all pertinent portions. Section 1 of the Design and Construction Standards provides General Information, Definitions, Abbreviations, and other requirements that shall apply throughout this Standard. In cases where the user of this document believes a conflict or discrepancy exists between the DCSWCS and the LS-DCS, the LS-DCS govern over wastewater lift station and force main requirements unless the DCSWCS is interpreted to provide more stringent requirements, in that case the applicable requirement will be left to CCWRD discretion or shall be resolved as per Section 1.4 of the DCSWCS.

In addition to the DCSWCS, additional References that supplement and are hereby made part of this Standard include:

- CCWRD Approved Equipment List (AEL)
- CCWRD Approved Materials List (AML)
- CCWRD Asset Management Standards -- Current Edition (including bill of materials format)
- CCWRD CAD Standards for CIP Projects – Current Edition
- CCWRD CCTV Standards – Current Edition
- CCWRD Clean Water Program Corrosion Protection STANDARDS – Current Edition
- CCWRD Safety and Security Standard – Current Edition
- CCWRD Survey Standards for Developer Projects – Current Edition

Standards:

1. ACI 318 (Current adopted edition)
2. ACI 350, 350.1, 350.2 and 350.3 (Current adopted edition)
3. ACI 530 (Current adopted edition)
4. AISC (Current adopted edition)
5. Aluminum Design Manual (Current adopted edition)
6. ASCE 7 (Current adopted edition)
7. Hydraulic Institute Standards (Current edition)
8. IBC (Current adopted edition)
9. IEEE (Current adopted edition)
10. IMC International Mechanical Code (Current adopted edition)
11. IPC International Plumbing Code (Current adopted edition)
12. NDEP Water Technical Sheets WTS-14
13. NEC (Current adopted edition)
14. OSHA 1910 General Industry
15. OSHA 1926 Construction Industry
16. Great Lakes – Upper Mississippi River Board (GLUMRB) Ten State Standards
17. WPCF Manual of Practice No. 9

These Lift Station Design and Construction Standards, 1st Edition, have been adopted by Resolution of their governing body as follows:

CLARK COUNTY WATER RECLAMATION DISTRICT
Adopted by Board of Trustees

May 7, 2019

CLARK COUNTY WATER RECLAMATION DISTRICT
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DISCLAIMER

The Clark County Water Reclamation District makes no warranty either expressed or implied as to the accuracy or reliability of the information contained in this LS-DCS.

The *LS-DCS* is a document of the Clark County Water Reclamation District (CCWRD). It was prepared and developed as a standard to CCWRD divisions that will be involved with the design and maintenance of sewer lift stations, force mains, and associated sewer appurtenances. It may not be fully adequate to address all aspects of municipal sewer systems. Therefore, it is prudent for DESIGN ENGINEERS to avail their best professional experiences and good judgment in using the information in this Document.

This Document is posted in the CCWRD website for use by design consultants, public agencies, and DESIGN ENGINEERS who may have the need for its use. The users of this *LS-DCS* shall be responsible to provide a design that can be safely constructed, repaired, and maintained, and which will provide good service and life, and which will not create public nuisance or hazard.

CCWRD approval of Lift Station Planning Studies and Project Designs does not relieve the Developer from coordinating with other Agencies or complying with other applicable requirements, such as State and Federal Regulations and Statutes, environmental studies and requirements, and Bureau of Land Management (BLM) policies and permitting requirements.

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INTRODUCTION

This *LS-DCS* sets forth criteria to be used for the design of systems which may consist of lift stations, dry and wet wells, vaults, pumps, force mains, odor control systems, electrical systems, and related appurtenances. It includes criteria for determining capacity and sizing of lift stations, siting of lift stations and yard piping, alignment of force mains, estimating wastewater flow rates, and corrosion control requirements.

Definitions:

Unless expressly redefined in the *LS-DCS*, the Definitions and Abbreviations contained in the “Design and Construction Standards” shall apply to this document. In this Standard, “District Representative” shall have the same Definition as an “Agency Representative” in the *DCSWCS.DX*

Single family residential developments are prohibited from containing private lift stations, private force mains and related appurtenances as per the *DCSWCS*. All lift stations and force mains in single family developments shall be public and shall be located in public parcels granted in Fee Title ownership to the District or in easements granted to the District or in easements granted to the District (See 2.10.4.a)

The DESIGN ENGINEER shall coordinate all lift station designs with CCWRD. The DESIGN ENGINEER shall coordinate with the District Representative to ensure that there is capacity in the sewer system downstream of the tributary areas planned for development, and that flows from new projects will not adversely affect the downstream conveyance systems operated by the CCWRD. As part of the design review process, Project applicants shall coordinate with the District Representative to determine if wastewater flow estimates of individual areas planned for development generate more than 5 percent of the wastewater stream at the point of connection with the CCWRD’s sewer lines and to verify that downstream mains are not identified on the CCWRD’s list of critical sewers.

There may be equipment brand names or specific manufacturers mentioned by name in this *LS-DCS*. This document does not intend to restrict the use of acceptable equal materials and manufacturers. The DESIGN ENGINEER is also directed to review the CCWRD’s “Approved Materials List” for acceptable construction materials to be used on lift stations and collection system projects. In some cases, the CCWRD Project Manager or the District Representative may direct the DESIGN ENGINEER or land developers to specify sole-source equipment, materials, and services, as provided for in State of Nevada purchasing division NRS guidelines. In such cases, the DESIGN ENGINEER shall specify the brand names of the designated manufacturers.

This *LS-DCS* governs all public sewer systems which are maintained by the CCWRD. Each lift station shall be reviewed by CCWRD as an individual project, and design and

construction requirements for each lift station may change slightly to accommodate specific Project criteria, such as pumping capacity (size of station), location within the collection system, site clearances, and criticality.

DEVIATIONS FROM THE LIFT STATION DESIGN AND CONSTRUCTION STANDARDS:

The DESIGN ENGINEER shall direct all project specific deviations from the *LS-DCS*, and/or other referenced specifications, to the attention of the District Representative. The District Representative, in consultation with the Project Engineer and other staff, will evaluate the request for deviation and, based on the evaluation, will decide whether to accept or reject the proposed deviation. The DESIGN ENGINEER shall prepare the request for deviation using the format of ATTACHMENT 4 which is included as a part of this document.

Nomenclature:

BPV = Backflow Preventer Valve

CCWRD or District = Clark County Water Reclamation District

CMU = Cement Masonry Unit

DCSWCS = Design and Construction Standards for Wastewater Collection Systems – Southern Nevada, latest edition.

DIP = Ductile Iron Pipe

LS-DCS = Lift Station Design and Construction Standards

MCC = Motor Control Center

NACE = Nevada Corrosion Control Engineer

NPSHA = Net Positive Suction Head Available

NPSHR = Net Positive Suction Head Required

PR = Pressure Reducer

PVC = Polyvinyl Chloride

TDH = Total Dynamic Head

VFD = Variable Frequency Drive

CHAPTER 1
LIFT STATION SYSTEM PLANNING

GENERAL

This Chapter covers criteria for estimating wastewater flows and basic criteria for planning sewer lift stations. An approved lift station Planning Study shall identify a summary of the estimated sewer flows, lift station design capacity, gravity and force main sizing, hydraulic calculations, pump selections, site layouts, and land use and topographic maps. The DESIGN ENGINEER shall coordinate with the District Representative at the start of all lift station projects to categorize the lift station and determine Special Station Requirements as per Section 2.1.4. Stakeholders and regulatory agencies understand that the design, location, and installation of lift stations systems can substantially impact quality of life, safety, and the environment. Where good design alone cannot satisfy the needs and requirements of the public, planners, regulatory agencies, and the District Representative will endeavor to work with the designer to resolve conflicts which may arise. Where difficulties are encountered, the DESIGN ENGINEER shall meet with the District Representative during the preliminary engineering phase and propose resolution.

1.1 PRELIMINARY PROJECT PLANNING

1.1.1 Lift Station Location

Community plans and new developments shall be designed to eliminate the need for lift stations whenever possible. However, constraints may dictate the need for a lift station, such as topography (washes, hills/mountains), protected lands, environmentally sensitive habitat, and excessive gravity sewer infrastructure costs which will impede regional development and commerce. All public lift station locations shall be reviewed by CCWRD on a case-by-case basis.

1.2 PLANNING STUDY

1.2.1 General Requirements for Studies

For new development and/or redevelopment, a lift station Planning Study for proposed and/or existing sewer facilities shall be prepared, as directed by the District Representative. A minimum of three (3) copies of the Planning Study shall be submitted, each stamped and wet/electronically signed by a Professional Engineer registered in the State of Nevada. Each study shall be bound and formatted in accordance with this LS-DCS.

- a. Developers shall obtain geotechnical investigations to verify site suitability and associated design recommendations for lift station elements, such as block walls, pavements, buildings and/or equipment slabs on grade, wet well and other below grade foundations, excavations and structure backfills, or other

requirements identified by the DESIGN ENGINEER or the District Representative. Geotechnical investigations shall include seismic considerations. Geotechnical Reports are a required element of a Planning Study. Geotechnical Reports shall include as a minimum evaluation parameters in the document, including but not limited to: water soluble sulfate content, chlorite content, soil allowable bearing capacity, lateral soil pressure parameters (internal friction angle, passive, active and at rest soil pressure coefficients), pH, granulometry (gradation), boring soil profiles, proximity to seismic faults, information regarding soil conditions that could affect the design of the facility.

Geotechnical investigations shall be done by a registered engineer at the Developer's cost. The geotechnical investigation shall contain adequate information to identify suitability of design and siting. The investigation shall be submitted to CCWRD as a condition of Project approval

For a new development, the Planning Study shall also include land use maps, and the Planning Study must be approved prior to approval of the Tentative Map.

b. Collection System Capacity Coordination

For new development and/or redevelopment, the Developer shall coordinate with CCWRD as per the DCSWCS to verify downstream sewer capacity. The lift station study shall document the capacity of sewer collection and trunk sewer systems that will be impacted downstream of the new development and/or redevelopment. Authorization and approval to impact any downstream sewer system must be obtained from the reviewing District Representative. If such downstream sewer system has already been identified as critical or sub-critical in a monitoring report, the District Representative may require additional flow monitoring of such downstream sewer systems to determine if adequate capacity is available. The Developer will pay the cost of additional flow monitoring performed by or for the District.

For an existing development, the lift station study shall address the existing capacity within the existing sewer collection system, and identify all existing facilities whose capacity will be exceeded by projected sewage flows. "Exceeding capacity" means non-conformance to the capacity requirements for collection systems set forth in the DCSWCS. Where available capacity will be exceeded, the lift station study shall propose up-sizing of existing sewer facilities to conform to DCSWCS design requirements.

Lift Station Design Capacity (as per Section 1.3.2) from the proposed new development will be added to the modeled or field measured maximum flow in the existing downstream (offsite) sewer to determine if the projected d/D will comply with the depth criteria described in the DCSWCS. If these criteria are not met, a comprehensive sewer study of the offsite area shall be prepared by the DESIGN ENGINEER, and upsizing may be required. The existing system studied shall not be less than the greater of 5 pipe reaches (i.e. manhole to manhole) or 2,500 feet from the point of discharge of the new improvements into the existing system.

c. Drainage Basin

For a new development, the Planning Study shall address the sewage generating potential of the entire drainage basin that the lift station is proposed to serve, along with contributing future areas that would be forced to utilize the same lift station due to the same constraints (topographic, environmental, etc.). The DESIGN ENGINEER shall coordinate with the District Representative on future contributing areas to be included with the Drainage Basin, or show how these future developments could be feasibly served by gravity sewer (without impacting downstream capacity at their points of connection, as per 1.2.1.a).

The Planning Study shall also include current topographic maps of the entire drainage basin and any and all adjacent new developments contributing to the lift station for which a planning study has not yet been submitted and/or approved. The maps shall demonstrate that no adjacent development will be precluded from obtaining sewer service, including potential and existing pumped lands outside of the drainage basin and any lands outside of the unincorporated County with potential to be served, where no current master sewerage plan exists. The lift station study shall also show all desired sewer system alignments, superimposed upon planned street alignments, and potential points of entry of sewage from surrounding lands.

1.2.2 Flow Estimation

a. General

Lift Station Design Capacity shall be determined as per Section 1.3.2 of this Standard. "Peak Wastewater Flow" (also known as Peak Wet Weather Wastewater Flow) shall be calculated in conformance with the requirements of the DCSWCS 2.2.1, and as clarified below in Section 1.2.2.c. DESIGN ENGINEER shall coordinate with the District Representative to obtain or verify the Dry Weather

wastewater generation (in gallons per average day, or Equivalent Residential Units ERU) from various land uses. Calculations based on Population Equivalents (Average Dry Weather flow of 80 gallons per day, per population equivalent) may also be accepted. In certain commercial/industrial land uses, supplementation with flow data from the Plumbing Code may be required and will be reviewed on a case-by-case basis. Flow from a parcel having splash pad(s) or multiple swimming pools may have significant coincidental discharge impacts and should be accounted for.

Dry Weather Sanitary Peaking factors and Wet-Weather flow allowance (at least 25% of Dry Weather Peak) shall be as per the DCSWCS, current edition.

b. Land Use

Present or projected land use, whichever results in higher generated average dry weather flows, shall be used to generate potential sewage flows. Developers are advised to base land use projections on the best available information provided by District and in consultation with District, as an approved Lift Station Project may control or otherwise restrict the allowable future land uses and density in the Drainage Basin.

c. Flow Determination and Calculations

Sewage generation calculations shall be based on the following:

1. Land Use or Zoning
2. Parcel Size (acres)
3. Density (units, square footage, or population per acre)
4. Total Units or Population (parcel size multiplied by density)
5. Average Dry Weather Flow per unit above (Criteria from CCWRD based on land use)
6. Calculated Average Dry Weather Flow
7. Peaking Factor for Dry Weather Flow (from DCSWCS)
 - i. From Table C of DCSWCS, using the general curve
 - ii. Other industry standard peaking factors may be accepted on a case by case basis
8. Calculated Peak Dry Weather Flow

9. Peaking Factor for Wet Weather Flow (from DCSWCS)
10. Calculated Peak Wet Weather Flow

Continue the tabulation until all contributing parcels have been routed in the collection system to the lift station. Tabulate the Total Average Dry Weather Flow (from all parcels), Peaking Factor for Dry Weather Flow (for Total Average Dry flow), and the calculated Peak Dry Weather Flow from all parcels.

The Peak Dry Weather Flow from the service area shall be multiplied by the Peaking Factor for Wet Weather (at least 1.25 as per DCSWCS), creating the resulting "Peak Wet Weather Flow" or "Peak Wastewater Flow".

Peaking Factor for Wet Weather (PFWW) for the collection system

Table C of DCSWCS is highly recommended for use in designing the collection system pipeline sizing and slopes for conformance, but sizing of the sewer system is not required for the Lift Station Planning Study itself.

1.2.3 Map Criteria

Include the following on the map(s) for the lift station study for development projects:

- a. Work order numbers, tentative map numbers, and any discretionary permit numbers [i.e. Conditional Use Permit (CUP), Planned Residential Development (PRD), or Planned Industrial Development (PID)].
- b. Project name
- c. Vicinity map
- d. Location Map
- e. Scale of sufficient size to accommodate the details required by this list.
 1. Minimum Scale 1" = 100'
- f. Reference drawing numbers for existing sewer mains
- g. Limits of the project area and Drainage Basin
- h. Streets with names or distinguishing labels and dimensions

- i. All known existing and proposed utilities with adequate separation, whether in streets, side yards, or canyon slopes
 - 1. Provide Call Before You Dig contact information on maps
- j. Existing and proposed sewer mains labeled as public or private
- k. Depths of all sewer mains which exceed standard depths
 - 1. Refer to DCSWCS Section 2.2.15
- l. All existing and proposed easements
 - 1. Refer to DCSWCS Section 1.5 and Table A
 - 2. Indicate whether these will be permanent, to be abandoned after construction, or will be dedicated
- m. Paved width of all easements and connections to streets and manholes
- n. Typical sewer excavation bench section for limits of easement width and paving
- o. Topography of the entire Drainage Basin and the proposed development
 - 1. May be provided as a separate map for clarity
- p. Copies of grading plans or elevations for existing and proposed grades throughout the project area
- q. Manhole numbers and reach or pipe segment numbers for ease of comparison with the flow data in the Flow Determination calculations.
 - 1. Label all points of connection where project flows discharge to existing facilities and, where applicable, to the terminus of the study area.
 - 2. For off-site sewer mains, show information for a minimum of two reaches upstream and downstream.
- r. Pipes labeled with size, type, flow direction, and slope.
- s. Manholes, within the limits of the project area, shown with rim elevation and invert elevation.
 - 1. Note that sewer depth information is more critical where:

- i. Mains are not at standard depths (DCSWCS Section 2.2.15)
- ii. they are located in easements
- iii. off-site flows join the project area
- iv. grading is proposed over existing facilities
- t. Number of dwelling units per pipe reach
 - 1. Equivalent dwelling units per each reach shall be identified beginning from the most upstream manhole to the downstream end of project boundary
- u. Land use areas labeled as single family residential, multi-family residential, commercial, industrial, schools, parks, open space, multiple habitat preservation area (MHPA), multiple species conservation program area (MSCP), stream beds or 100-year flood area.
- v. Location of all proposed lift stations
 - 1. Label all lift stations as public or private
 - 2. For public lift stations, show access roads and lots as dedicated in fee title to the District or as easements to the District.
 - 3. All pipe systems upstream of private lift stations shall be clearly labeled "PRIVATE"

1.3 LIFT STATION PLANNING CRITERIA

1.3.1 Determination of Public vs. Private Lift Station System Status

All lift stations for single family residential developments must be designed and constructed as "Public", regardless of parcels served, or capacity.

Other land uses such as multi-family residential, commercial, industrial, government, schools, and parks will be evaluated by the DESIGN ENGINEER in coordination with the District Representative to determine the public or private status of the facility.

1.3.2 Lift Station Design Capacity

- a. The Design Capacity for a Public Lift Station shall be determined as per DCSWCS Section 2.4, including the following clarifications. The Design Capacity shall be the greatest of:

1. 1.25 times the full pipe hydraulic capacity of the gravity sewer entering the pump station wet well
2. 1.36 times the “ultimate” Peak Dry Weather Flow
“Ultimate” based on future projected build-out within the Drainage Basin per Section 1.2.1.b and 1.2.2.
3. Peak Wastewater Flow (Peak Wet Weather Flow), as per DCSWCS 2.2.1
 - i. For areas where the Peaking Factor for Wet Weather exceeds 1.36 (see Section 1.2.2.c)
 - ii. Typically 1.25 is used for Wet Weather Peaking, meaning that cases 1) or 2) above will typically govern.

After the DESIGN ENGINEER’S calculation of Design Capacity, the CCWRD shall review the presented flows based on the number of motor start/stops per hour for the extremes of very small and very large average daily flows. For very small flows the CCWRD may adjust the Design Capacity downward. For very large flows the CCWRD may adjust the needed station design requirements based on the difficulty of a large station handling the small initial flows that the station may experience.

- b. Coordinate with the District Representative to confirm emergency wet well storage requirements. The Lift Station Design Capacity may need to be increased to accommodate the lack of emergency storage in some wet wells:
 1. Lift Stations are required to be equipped with at least two (2) hours of emergency storage as per Section 2.2.5.g. If this is not feasible, the Lift Station Design Capacity may be increased to compensate. At the District’s discretion, additional storage space may be required in outlying areas where more than a 2-hour response time is required.
 2. Some Lift Stations with Special Requirements may require six (6) hours of emergency storage as per Section 2.2.6. Where this storage is not provided in design, then a reserve capacity factor greater than 1.0 shall be used and an appropriate factor shall be evaluated for approval on a case-by-case basis by the District Representative overseeing the preparation of the planning study subject to current Federal, State or Local Government requirements, more stringent parameters for lift station emergency storage capacity may be required. (Ref. current adopted Ten State Standards and NDEP requirements).

1.3.3 Reserve Pumps

All public lift stations shall be provided with one permanently installed and operational “reserve” pump. The reserve pump shall be identical to the other pump(s) provided in make, model, and design capacity. Typical pumping arrangements are as follows:

- a. “Duplex”
 1. One pump working alone is capable of pumping the Lift Station Design Capacity
 2. A second, identical pump is installed as a reserve
 3. The pumps are controlled to operate in a “Lead”, “Reserve” configuration
 - i. “Reserve” pump only comes on if the first pump fails to start or first pump is out of service.
 - ii. Control system shall alternate the pumps to be “Lead”, or “Reserve” after each pumping cycle to give similar service time and exercise each pump
- b. “Triplex”
 1. For larger capacity lift stations (case by case), where diurnal flow patterns will create operational benefits of having multiple pumps to ramp up or down to match demand. See Section 2.1.4.
 2. Two pumps working together are capable of pumping the Lift Station Design Capacity
 3. A third, identical pump is installed as a reserve

4. The pumps are controlled to operate in a “Lead”, “Lag 1”, and “Lag 2” configuration
 - i. “Lag 1” pump comes on if the first pump fails to keep up with flow into the wet well, or when flows are approaching Design Capacity
 - ii. “Lag 2” pump comes on only if the first two pumps fail to keep up with flow into the wet well, or if one of the pumps has failed, or during High-High Alarm
 - iii. Control system shall rotate the pumps to be “Lead”, “Lag 1” or “Lag 2” after each pumping cycle to give similar service time and exercise each pump
- c. Larger stations shall be evaluated on a case-by-case basis. Stations with 4 pumps or more will have complex wet well designs and pumping configurations, but will always have at least one (1) identical reserve pump installed. A basic guideline is that a 5 pump station maintains 3 duty pumps (with peak flow capacity) and 2 reserve pumps.

1.4 PLANNING STUDY REQUIREMENTS

1.4.1 Planning Study Sections

The following sections shall be included in the Lift Station Planning Study

- a. Lift Station Location & Justification – as per Section 1.1.1
- b. Drainage Basin delineation, including Offsite Developments – as per Sections 1.2.1 and 1.2.3
- c. Land Use Projections and Maps, including Offsite Developments – as per Sections 1.2.2 and 1.2.3
- d. Existing Sewer Downstream Capacity – as per Section 1.2.1
 1. Include impact from proposed lift station, and include additional study and upsizing of offsite pipelines, if required
- e. Flow Determinations and Calculations – as per Section 1.2.2
- f. Lift Station Design Capacity – as per Section 1.3.2
- g. Force Main Sizing and Hydraulic Calculations – as per DCSWCS and Section 2.2.2

- h. Proposed Lift Station Configuration (Duplex, Triplex, etc) – as per Sections 1.3.3 and 2.1.4
- i. Preliminary Site Plans as per Sections 2.1.8. Include Odor Control Pad as per Section 2.6.4.
- j. Pump Station hydraulic calculations – as per Section 2.2.2
 - 1. Prepare hydraulic calculations for friction losses and minor losses within the lift station facility itself, including but not limited to:
 - 2. Minor or local losses at suction inlet
 - 3. Suction piping (identify Net Positive Suction Head), including losses at valves, fittings and tees
 - 4. Discharge Piping, including local losses at valves, fittings and tees
 - 5. Combine with force main hydraulic calculations to determine a total dynamic head requirements
- k. Determine/Recommend Pump Design Point(s)
- l. Recommend pump selection(s) and curve(s) at Design Point(s)
- m. If required as a Special Station Requirement, evaluate constant speed vs variable pumping as per Section 2.2
- n. Recommend major equipment/instruments, verify use of sole-source equipment
- o. Control Strategy Narrative
- p. Appendices:
 - 1. Preliminary Site Plans, Equipment Layouts
 - 2. Hydraulic Calculations
 - 3. Pump Curves and cut sheets
 - 4. Equipment cut sheets (as applicable)
- q. Supplemental Submittals:

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CHAPTER 2

SEWER LIFT STATION DESIGN CRITERIA AND EQUIPMENT DESIGN STANDARD

2.1 GENERAL REQUIREMENTS FOR DESIGN ENGINEERS2.1.1 Implementation of Design Standard Requirements

This Chapter describes the design and equipment/material requirements for new District sewer lift station facilities. The DESIGN ENGINEER is required to comprehensively implement the criteria in this Chapter in the preparation of detailed design drawings and specifications.

2.1.2 Documentation of Implementation of Design Standard Requirements

An accepted Lift Station Planning Study (accepted by the District) shall act as the basis for the design of the lift station. The DESIGN ENGINEER shall prepare a written attachment to plan submittals, indicating that the submitted design complies with the required criteria of the Lift Station Planning Study. This can be in the form of a cover letter (signed by the responsible DESIGN ENGINEER and under company letterhead) attached to a copy of the Lift Station Planning Study with a "check-off" on each item incorporated into the design of the station. The DESIGN ENGINEER shall also reference and discuss any criteria in this Design Standard to which the DESIGN ENGINEER takes exception. The DESIGN ENGINEER shall note when each particular criterion will be incorporated into the design (i.e., at which stage of design submittal). The "check-off" list shall also have space in the margin to note where a criterion has been incorporated in the plans and specifications. This response shall be updated and resubmitted with each design submittal. All engineering submittals, including engineering reports shall have the Nevada Professional Engineering stamp of the DESIGN ENGINEER (engineer of record).

2.1.3 Written Responses to Design Review Comments

The DESIGN ENGINEER shall receive design review comments from the District as marked plans and specifications and/or tabulated written comments. For all comments, the consultant shall provide written response comments in a tabular form including the following information: comment number, applicable drawing and/or specification reference, review comment summary, District recommended action, and DESIGN ENGINEER responses, including status of changes.

2.1.4 Special Station Requirements

All lift stations shall be reviewed to see if special requirements apply. The design criteria for special station requirements are not required for all stations. The District, the DESIGN ENGINEER, and community representatives, will determine the special station requirements of the project. Special stations are typically those with high lift conditions, high pumping capacity requirements (to be determined case by case), or wide range of variations in pumping capacity required based on land use and specific diurnal flow patterns. It may also involve special environmental concerns or other special design requirements. The District Engineer will direct the DESIGN ENGINEER as to which of these requirements shall be incorporated into the facility design.

See Section 2.1.5 for the kickoff meeting process for obtaining Special Requirements for the lift station project. The following definitions may be used to categorize a station and may determine special requirements in coordination with the District Representative:

- a. “Small Stations: - having a capacity less than approximately 120 gpm (0.173 MGD), and with a force main of 4-inches in diameter. Force mains less than 4-inches in diameter shall only be used if approved by the District.

NOTE: Small stations may be allowed to be provided in submersible configurations, and may have differing instrumentation and/or equipment requirements to accommodate “pre-engineered” systems. No more than 2 pumps are allowed in submersible configurations.

- b. “Duplex Stations” – having a capacity less than approximately 1.0 MGD, or with a force main 8-inches in diameter or smaller

NOTE: Public Duplex stations that are not also categorized as “Small” will typically be required to be installed in a dry pit configuration (submersibles not allowed).

- c. “Triplex Stations” – having a capacity greater than approximately 1.0 MGD, but with a force main 12-inches in diameter or smaller

NOTE: Triplex public stations will not be allowed in a submersible pumping arrangement. Special requirements may apply to these stations on a case-by-case basis, based on the location of the lift station, land uses served, and criticality.

- d. “Large Stations” – having a capacity more than approximately 3.0 MGD, or with a force main larger than 12-inches in diameter

NOTE: Larger stations require an evaluation of constant speed vs variable speed pumping (as per Section 2.2.2.a) and may be required to incorporate variable frequency drive motors and equipment. They may have more than 3 pumps to accommodate the range between near term and build-out flows or near term and future diurnal patterns (coordinate with District Representative). All “Large” stations will be reviewed for Special Requirements, and the DESIGN ENGINEER is advised to meet with CCWRD prior to developing a detailed Scope of Work, or Schedule, for Large Stations.

2.1.5 Project Meetings with the District

At the discretion of the District and prior to the commencement of design, and for each design submittal, the DESIGN ENGINEER shall meet with the District. The submittal meetings shall be for the purpose of summarizing the key design information being submitted and discussing compliance and design review. The DESIGN ENGINEER shall prepare meeting notes summarizing all issues discussed and their resolutions.

The Developer or Design Engineer shall coordinate a kickoff meeting with the District Representative, prior to preparation of a detailed Scope of Work or Schedule, to obtain the Special Requirements of the Lift Station Project. The DESIGN ENGINEER shall facilitate the meeting and coordinate with the District on a procedure as follows:

- a. Prepare a Lift Station Data Sheet provided by the District Representative and location exhibit for the station to be designed or remodeled, and submit to the District Representative.
- b. Based on the Data Sheet, the District Representative will prepare an internal questionnaire of special requirements and distribute to CCWRD staff in Engineering, Construction Management, Operations, Maintenance, Security, Electrical, & Instrumentations and Controls.
- c. The District Representative will request a workshop with the DESIGN ENGINEER, including staff from the appropriate CCWRD departments, to review the special requirements of the lift station.
- d. The workshop (typically 1-2 hours) will involve discussion of details on the Lift Station Data Sheet and the routed internal questionnaire. The DESIGN ENGINEER and District Representative will coordinate to assign or confirm Special Requirements and other design criteria to the lift station project.
- e. The questionnaire will be edited by the DESIGN ENGINEER, reflecting the project consensus decisions, lift station Category, and

Special Requirements, then sent back to the District for final check/edits.

- f. The final document becomes the design criteria for the lift station, including its categorization (see below), special requirements, and any other requirements pertinent to the Lift Station Planning Study.

2.1.6 Requirements for Design Documents

At a minimum, design Drawings shall conform to DCSWCS Section 2.3.5. The design drawings and technical specifications shall include all information necessary for the construction of the lift station per normally accepted requirements of engineering design practice. Design documents shall include, but not be limited to:

- a. Drawings as required per DCSWCS Section 2.3.5
- b. Civil plans (site, grading, yard piping, access, easements and fee Title boundaries)
- c. Existing underground utilities
- d. Bypass pumping Plans
 - 1) Temporary bypass pumping design (if required)
 - 2) Permanent Bypass pumping plan. See Attachment 3 sample & coordinate with District Engineer
- e. Pipeline and station profiles with HGL and wet well operation levels
- f. Design details
- g. Equipment schedules – verify sole source equipment with CCWRD
- h. Check Approved Materials Lists for materials and technology updates
- i. Pump curves including system curves and design parameters
- j. Architectural plans (elevations, schedules, details)
- k. Location of equipment to be installed and clearances
- l. Construction salvage and demolition notes
- m. Structural and mechanical plans and sections
- n. Odor control (as applicable), plan and profile drawings for liquid and air phase must be provided.

- o. Corrosion mitigation (i.e. chemical induced corrosion and cathodic protection)
- p. Heating, ventilation, and air conditioning (HVAC)
- q. Plumbing diagrams
- r. Electrical layouts and one line diagrams.
- s. Electrical power and lighting diagrams
- t. Control and telemetry system layout and schematic
- u. Piping and instrumentation diagrams (P&IDs)
- v. Warning notes
- w. Complete dimensions of all aspects of station construction
- x. site security
- y. detailed landscaping and irrigation systems plans as may be required per Title 30
- z. Fire suppression system (if required)

The DESIGN ENGINEER shall provide drawing notes stating that the CONTRACTOR shall be responsible for job site safety.

Equipment to be provided in the technical specifications shall be supplied from a single manufacturer for each job and selected from the manufacturers' most current model offering, and of the same series. CONTRACTORS are required to request consecutive serial numbering on ordered equipment on District lift station projects, for groups of identical equipment installed on a single project. CONTRACTORS are to provide written documentation of the received response to the required numbering request.

2.1.7 Private Sewer Lift Stations

2.1.7 Private Sewer Lift Stations

Private lift stations (privately-owned and operated) serving more than one parcel shall not be located in the public right-of-way. Private lift stations shall require separate structural, mechanical, and electrical permits from the Clark County Building Department. However, private lift station plans are not reviewed for compliance with this document except as indicated in this section, Section 2.1.7. All lift stations for single family residential developments must be designed and constructed as "Public", regardless of

parcels served, or capacity. The District recognizes that most private lift stations will be provided as “pre-engineered” and/or “pre-manufactured” units, with proprietary electrical, instrumentation, and control systems. Typical land uses where private lift stations may be found are multi-family residential, commercial, industrial, government, schools, and parks

As such, it shall be the responsibility of the DESIGN ENGINEER to ensure that all private lift stations are adequately sized, have sufficient redundant measures (dual force mains, back-up power supply, auto dialer alarm system to a 24-hour response licensed plumber with experience in sewage lift stations or a 24-hour response company that specializes in the maintenance of sewage lift stations with a Nevada Water Pollution Control Grade Operator on staff, etc.), and comply with all applicable local, state, and federal regulations. All private lift stations shall be provided with at least one permanently installed and one operational “reserve” pump. In the design of such facilities, the DESIGN ENGINEER shall utilize sound engineering judgment to provide for an adequate design for any potential failure during the service life of the lift station.

If a developer elects to construct a private sewer system including a sewer lift station, then a letter of agreement must be executed over all parcels served in the development if the lift station will serve two or more parcels. A copy of this agreement is available at the Clark County Water Reclamation District website (www.cleanwaterteam.com, and refer to Customer Care/Development Services).

Also required is a recorded copy of the CC&R’s for the multi-family residential or business owners association, outlining the responsibility and maintenance requirements for the shared private improvements.

- a. Wherever possible, the private onsite force main shall discharge to a private onsite manhole, thence by gravity from the private onsite manhole to a public manhole in the public right-of-way. When this is not apparently possible, the Developer is directed to meet with the District Representative to determine alternatives before proceeding with Design.
- b. The District shall add the following notes on the drawings on the private lift station sheet:

CCWRD NOTE: Hydrogen sulfide level shall not exceed 0.1 parts per million (ppm) in solution and 1.0 ppm in the liquid phase.

CCWRD NOTE: The Clark County Water Reclamation District (CCWRD) signature on these civil improvement plans does not denote any CCWRD approval of the onsite private lift station and force main. CCWRD approval is exclusively for the offsite public sewer improvements.

2.1.8 Lift Station Site Requirements and Parcels

Refer to Standard Plates SP-1 for typical site layouts. These layouts show minimum Parcel dimensions to accommodate lift station structures and equipment, paving areas for maintenance vehicle accessibility, and clearance within the secure site to permit full movement of larger equipment (such as boom trucks or cranes) that may be required to remove or maintain installed pumps. For Duplex Stations, parcels shall provide a minimum 20-foot clearance from the outside of any part of the wet well to the parcel boundaries. For Triplex and Large Stations, see District Representative for applicable minimum clearance. This clearance shall be increased by 1-foot for each foot of wet well depth greater than 10 feet. Parcel widths may also be increased as directed by the Agency to provide sufficient clearance for Special Station Requirements, when applicable.

2.1.9 Operational Reliability of Lift Stations while Submerged

Dry Pit Lift stations with motors over 50 HP shall be designed with TEBC immersible pump motors and submersible sump pumps (see requirements) to assure that the lift station continues to operate while the dry well is temporarily submerged, avoiding unnecessary Sanitary Sewer Overflow's (SSO's) until CCWRD crews can mitigate the unwanted condition.

2.2 HYDRAULIC DESIGN CRITERIA

2.2.1 Purpose

This Section provides the basic criteria for determining the required hydraulic design requirements of the lift station facility. The DESIGN ENGINEER shall also be responsible for determining the required capacity and design of other facility subsystems not addressed here per applicable codes and industry standards.

2.2.2 Pump and System Calculations

a. Constant versus Variable Speed Pumps:

Constant speed pumps shall generally be used for Duplex Stations and most Triplex Stations. All Large Stations shall be evaluated for use of variable speed pumps as per following Section 2.2.2.b. Check with the District Representative for Triplex Stations for Special Station Requirements based on special site conditions and/or flow conditions. District shall approve type of pump drive for each facility.

b. Variable Speed Pumps (Special Station Requirement):

Variable speed pumps shall be evaluated for use at Large Stations, and select Triplex Stations, in coordination with the District Representative. In the Lift Station Planning Study for these stations, the DESIGN ENGINEER shall prepare alternative analysis that calculates the life cycle cost of operational cycling of constant speed versus variable speed pumps to determine if variable speed is the best apparent alternative for the facility. This shall include an evaluation of operation/cycling that will occur during periods of minimum flow rate vs. periods of maximum flow rate. Also, the relative life-cycle cost comparison of constant versus variable speed pumps for lift stations shall include the cost of all structure(s), mechanical and electrical equipment that would be affected by the pump selection.

The District shall thereafter direct the DESIGN ENGINEER to incorporate constant or variable speed pumps in its design, based on the approved Lift Station Planning Study.

c. Uniform Sizing and Number of Service and Reserve Pumps:

All installed pumps shall be of the same size. The minimum number of pumps per station shall be two. In stations with two pumps (Duplex Stations), each pump shall be capable of pumping the design flow with the second pump acting as a full reserve. In stations with more than two pumps (Triplex or Larger), an identical “reserve” of the same size and capacity as the other service pumps shall be installed.

Pumps to be supplied from a single manufacturer for each job and selected from the manufacturers' most current model offering.

d. Calculation of Hydraulic Losses:

A pump is designed to raise energy in a fluid to overcome the static head and total energy lost through the fluid's conveyance. The total loss of energy or head in a pumped pipeline system is commonly estimated using a combination of local losses, commonly referred to as 'minor' losses, (H_{local}) and friction losses, commonly referred to as line losses (H_{line}) in the system. Local losses are energy losses that occur at specific points in the system where a disturbance or redirection of flow occurs. Fittings, valves, expansions and contractions in flow cross section, inline orifices, deflections in pipeline horizontal and vertical directions, joints, and inlets and outlets all represent local losses. At these positions in the pipeline system, the local loss can be estimated by multiplying the local (minor) loss coefficient (K) by the velocity head ($V^2/2g$). The local loss coefficient K for valves and fittings can be found in manufacturer's literature. Please note that this coefficient is dimensionless and is not equivalent loss coefficients such as C_v or C_d . If alternate loss coefficients are found in manufacturer's literature then a proper conversion to an equivalent K coefficient will be required.

Local (Minor) Loss:

$$H_{local} = K * \frac{V^2}{2g}$$

Where:

- H_{local} = local head loss, m or ft
 V = average velocity of flowing fluid, m/s or ft/s
 g = acceleration of gravity, 9.81 m/s² or 32.174 ft/s²
 K = local (minor) loss coefficient, dimensionless

These local losses should be combined with the line losses (H_{line}) to develop an estimate of total energy or head loss of the system.

In the United States water and wastewater industry, there are two common methods to estimate line losses (H_{line}) within a system. The first is an empirical method that characterizes H_{line} using an empirical coefficient known as the Hazen-Williams coefficient (C_{HW}). The preferred method of estimating line losses in a pumped system is the Hazen-Williams formula. The Hazen-Williams coefficient applies to pipeline systems that are flowing full, fully turbulent with a Reynolds Number > 4000, with a fluid having little or no variations of viscosity when compared to water, and is flowing at or near a normal temperature of 60 F. The benefit of the Hazen-Williams formulation to estimate line losses is its ease of use in estimating line losses. .

When the Hazen-Williams formula is used, the DESIGN ENGINEER shall provide system curve requirements based on Section 2.2.2.g.1 and: $C=110, 120, 130$ and 140 for plastic or smooth lined pipe or $C_{HW}=100, 110, 120$ and 130 for rough finished interior e.g. polymer concrete or polymer lined pipe. Calculations should show family of system curves overlapping pump curve(s) and this chart as well as design parameters should be included in the drawings for future District reference.

The alternate method of estimating line losses in a pumped system is the Darcy-Weisbach formulation using the Darcy friction factor (f). This method may be used in lieu of the Hazen-Williams formula upon approval of the District.

e. Allowable Pipe Velocities within the Lift Station

In general, the maximum recommended suction pipe velocity is 5.5 fps. Suction velocities between 3 and 4 fps are preferred, if feasible. Velocity at the suction bell shall not exceed 3.5 fps. Install a larger suction line than the pump inlet diameter if required to reduce velocity and inlet head losses. The Net Positive Suction Head available (NPSHa) should be 1.5 times the required net positive suction head (NPSHr) where NPSHr is the value to prevent incipient cavitation.

Use an eccentric reducer to make the transition from suction piping to pump inlet, installed so that air bubbles can travel into the pump to be discharged. The maximum discharge velocity in the force main shall be 8 fps to avoid excessive local and line head losses. All lift station piping shall be designed for a minimum hydraulic velocity of 3 fps in the discharge force main under minimum flow conditions. In minimum flow conditions, minimum actual discharge velocity to be field verified as greater than 3 fps prior to lift station acceptance by the District for all lift stations with greater than 0.5 mgd design flow.

Suction and discharge pipe design shall conform to ANSI/HI Standards for items not explicitly specified in this section.

f. NPSHa Calculation:

Net positive suction head available (NPSHa, adjusted to local elevation and temperature conditions) shall be calculated for all pumps other than column pumps. NPSHa shall be calculated on the basis of the absolute barometric pressure in feet, plus the static suction head (or minus static suction lift in the case of a suction pump application) in feet of water (pool elevation) in the wet well measured from the center of the pump (at the eye of the impeller), minus the vapor pressure of water (in feet) at local temperature and elevation, minus the calculated suction losses to the upstream pump inlet connection (including friction and minor losses), minus 2 feet for partial pressure dissolved gas (air and H₂S). The ratio of NPSHa/NPSHr shall be no less than 1.35; additionally the margin shall not be less than 5 feet. Pump specifications shall include NPSHa values for all anticipated operating conditions. NPSHa shall always be more than net positive suction head required (NPSHr) by the selected pump(s).

NPSH calculations shall be included in the submittal and the NPSHa as well as the NPSHr shall be shown in the Shop drawings alongside the system curve and pump curve diagrams. The margin ratio NPSHa/NPSHr for the selected pump(s) shall be not less than that specified in ANSI/HI 9.6.1 (or current standard) at all specified operational conditions, and the margin ratio shall be calculated using the following methodology:

Specify pumps to be selected for NPSHr (Net Positive Suction Head Required) characteristics using the suction energy methodology set forth in ANSI/HI 9.6.1. Individual restrictions shall apply as set forth below, depending upon the type of pumping equipment. NPSHr, as used in the following paragraphs, shall mean the NPSHR determined in accordance with ANSI/HI 1.6 or 2.6, as applicable for the proposed

pump. The DESIGN ENGINEER shall require the CONTRACTOR to document the method used to determine NPSH_r for the proposed pump in its pump submittal material. The specifications shall require the CONTRACTOR to use suction energy rules in selecting proposed pumps and to apply the selection criteria as set forth in the individual paragraphs below. Percentages stated below shall apply to pump capacity on the selected pump(s) head/capacity curve at the speed required to achieve the specified operating condition.

The CONTRACTOR shall submit the manufacturer's suction energy calculations justifying the proposed pump selection.

1. A minimum NPSH_A/NPSH_R margin ratio of 1.5 shall apply at any operating condition within 85 percent of best efficiency capacity. The minimum acceptable NPSH_A/NPSH_R margin ratio at any other location on the pump's head/capacity curve shall be 2.0. In order to completely eliminate the potential for cavitation the NPSH_A/NPSH_R margin ratio must be between 2 and 5.
2. Notwithstanding item 1 above, the manufacturer shall use the methodology in ANSI/HI 9.6.1 to determine the proposed pump's suction energy. In determining the proposed pumps suction energy, the inlet nozzle size shall be increased by two nozzle sizes to account for impeller design consideration. In employing the suction energy method, the minimum NPSH_A/NPSH_R ratio shall be not less than that recommended in ANSI/HI 9.6. 1 or item 1 above, whichever is greater. For submersible or wet pit pumps, suction nozzle size shall be the impeller eye diameter for the proposed pump.

g. Pump and System Curves:

Calculations and curves shall be developed for each lift station, as described in the following paragraphs.

1. Calculation of System Curves:

Station system curves shall include static lift and all dynamic losses from the station suction piping to the point of discharge. To best represent the range of operation, dynamic losses and plotted system curves (total dynamic head) shall be calculated for two conditions: low wet-well level vs. high discharge level (calculated using a "C_{HW}" value for rougher surfaces of 100 and 110 or "ε" of 0.0066 ft and 0.0034 ft; and smooth surfaces of 100 and 120 or 0.0066 ft and 0.0017 ft), and high wet-well level vs. low discharge level or atmospheric discharge (calculated

using a " C_{HW} " value for rougher surfaces of 120 and 130 or " ϵ " of 0.0017 ft and 0.0008 ft; and smoother surfaces of 130 and 140 or 0.0008 ft and 0.0004). "C" values as per Section 2.2.2.4.

Figure 1.

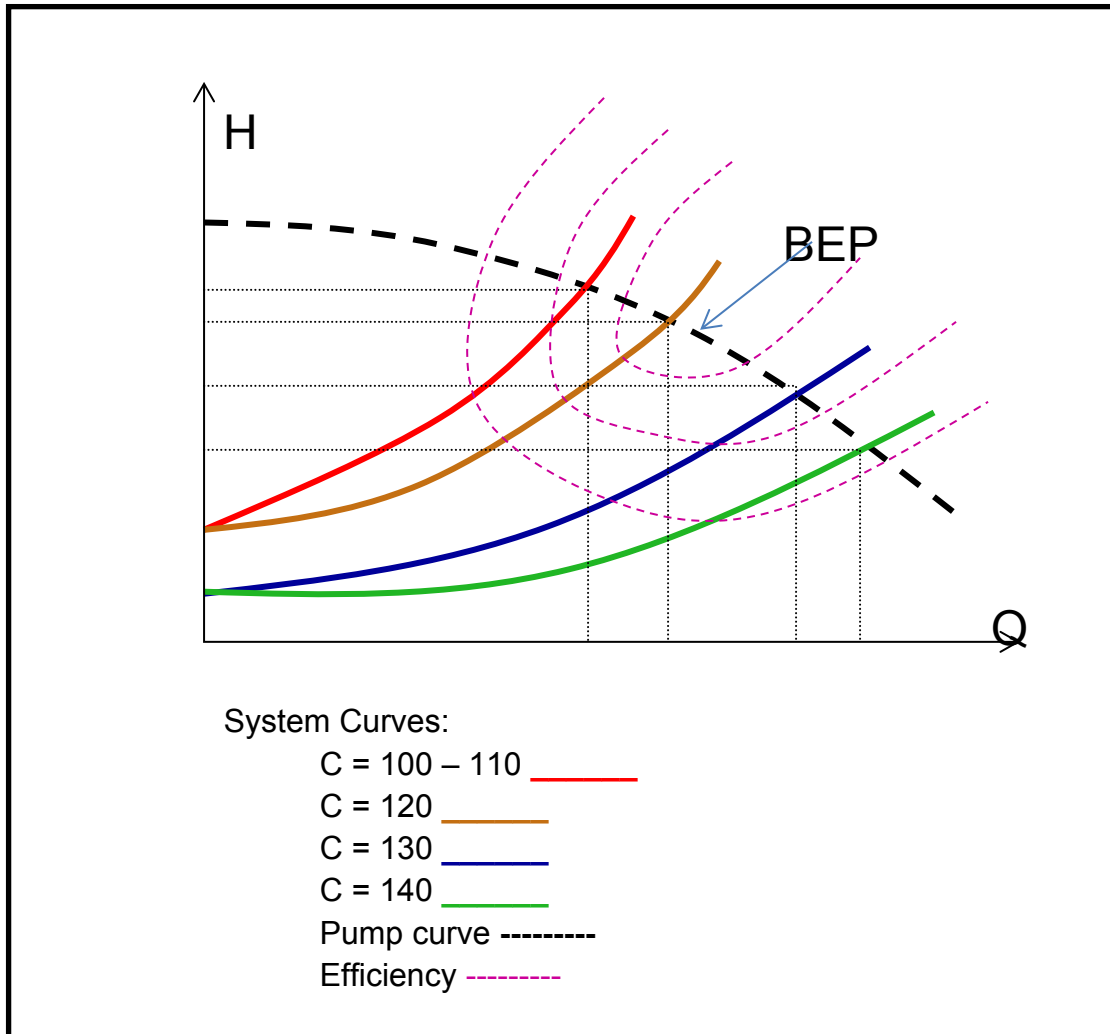


Figure 1. Typical Schematic Representative of System Curves and Pump Performance Curve Depiction

2. Selection of Candidate Manufacturer's Pump Curves:

For each of the above calculated system curves, select a pump curve from a manufacturer's catalogue that meets the required design operating point(s). Each pump curve shall be accomplished by the same model pump, with only the diameter of the impeller varying (note: refer to comments below on purpose of pump curve plots).

3. "Flat" Pump Curves:

Avoid pumps with “flat” pump curves where a small change in total dynamic head (TDH) will result in a large change in pump flow. Pump performance curves used in the design shall have a downward slope along their entire projection; pump performance curves that are flat or slope upward at high heads are not allowed.

4. Plotted System and Pump Curve Information on Design Drawings:

For each of the system curve conditions, provide a plot of the calculated system curve and the associated selected pump curve.

5. Multiple Pump Operation Curves:

Where multiple pump operation is designed (i.e. multiple pumps will operate in series or parallel), provide combined pump curves for multiple pump operation required to meet pumping capacity requirements. Should variable speed pumps be selected, pump curve plots over the full range of variable speed pumping, and for multiple variable speed pumps in operation shall be provided.

6. Other Information and Pump Curves:

The plots of the associated system and candidate manufacturers' pump curves required as design submittals under Section 2.2.2.g shall include the following information: Head versus NPSHR versus Q, Hp versus Q, and efficiency versus Q for the candidate pumps at the required operating speed(s). These curves also shall have the manufacturers' allowable operating regions (ANSI/HI 9.6.3) plotted on them to demonstrate that all specified continuous duty operating points are within the candidate manufacturers' recommended pump operating regions. The selected motor shall be appropriately sized throughout the maximum speed curves. The DESIGN ENGINEER shall require the CONTRACTOR to submit the information described above and to demonstrate that his proposed pumps meet the same requirements and those described below.

7. Pump Selection:

The selected pump must provide for stable operation at all operating points falling between the boundary conditions established by Section 2.2.2.g.1. These boundary conditions

must be within the limits of the pump manufacturers' allowable operating region (ANSI/HI 9.6.3).

The selected pumps shall operate without incipient cavitation or with vibrations in the X, Y, and Z direction are 25% below the allowable pump vibration limits established by the Hydraulic Institute per HI 9.6.4. Vibration shall be within these limits over the entire design range of flow and head conditions (operating points) including those produced by multiple pump operation and/or variable speed.

Pump NPSHr shall be checked vs. the NPSHa to assure the pump design requirements of subsection 2.2.2.6 are met.

Unless otherwise noted or specified, pump Head/Q curves shall slope in one continuous curve within the specified operating conditions. No points of reverse slope inflection will be permitted within the specified zone of continuous duty operation. Pumps with Head/Q curves as described in paragraph 9.6.3.3.12 of ANSI/HI 9.6.3 are specifically prohibited in the specified range of operating conditions and where startup/shutdown conditions entail operation against a slow opening/closing valve.

Pumps shall be designed in accordance with applicable portions of ANSI/HI 1.1-1.6, 2.1-2.6, and 9.1-9.6. The pumps shall be specifically designed to pump raw wastewater and shall operate without clogging or fouling caused by material in the pumped fluid at any operating condition within the range of service specified.

8. *Design Pump Rating and Requirements:*

The specified pump shall be rated to deliver the station design capacity at the worst combination of static head and pipeline C_{HW} or ϵ value (refer to Section 2.2.2.g.1) and local/minor losses, and also selected to operate in the manufacturers' Preferred Operating Region (ANSI/HI 9.6.3) at the Head/Q curve intersection with the system curve established by the best combination of static lift and pipeline C_{HW} or ϵ value, i.e. operation in a "runoff" condition (rightmost pump curve limit) is not allowed. The rated condition and all other continuous duty operating conditions specified for full speed operation in the detailed specification section shall fall within the manufacturers' Preferred Operating Region as defined in ANSI/HI 9.6.3. The Preferred Operating Region shall be not less than that specified in paragraph 2.1.12 of API 610. Proposed pumps shall be

selected to allow not less than a five percent increase in head, as specified in paragraph 2.1.4 of API 610. Variable speed operation to achieve this objective shall not be considered. Pump selections proposing maximum diameter impellers for the proposed pump model and casing size shall not be accepted.

9. *Impeller Information for Plotted System and Pump Curves:*

The purpose of providing separate plotting of the above associated system and pump curves on the design drawings is to show that for the above various C_{HW} or ϵ values, the candidate manufacturers' pump can be made to operate at the required design points. This will be accomplished by only varying (replacing) the impeller diameter. This is to assure that the lift station pumps can be configured and designed to operate through the " C_{HW} " or " ϵ " value changes that typically occur during the extended service of the facility (i.e., grease coating, biolayer coating and corrosion occurring inside the pipe reducing the C_{HW} or increasing the " ϵ " factor value over the service life.

10. *Specification of Design Pumps:*

Based on the above calculations, the candidate manufacturers' design pump to be listed in the project specifications and supplied during construction shall be specified so the installed impeller shall be the correct size to operate with the **$C_{HW}120$ or $\epsilon 0.0017$** curve. In no case, shall the maximum diameter impeller available for a particular model pump be selected (Refer to subsections 2.2.2.g.7 and 2.2.2.g.9). The design pump performance curve shall intersect the design system curve at a flow within 25-percent of the Best Efficiency Capacity.

2.2.3 Mass Elastic Systems and Critical Speed Calculations

Each pumping unit, consisting of pump, intermediate shafting, couplings, motor, supports and all attached appurtenances shall have no dangerous critical or resonant frequencies or multiples of resonant frequencies within 20 percent above and 15 percent below the speed (range) required by the pump to meet the indicated operating conditions. A dangerous critical speed shall be defined as one which produces a torsional stress exceeding 3500 psi. The DESIGN ENGINEER shall require the pump manufacturer, through the CONTRACTOR, to be responsible for the analysis of critical speeds and the complete mass elastic system, which shall be analyzed and certified by a registered professional engineer regularly engaged in this

type of work. Analysis shall be at least equal to the industry standard technique developed by Dunkerly and Holzer.

2.2.4 Surge Pressure Calculations

a. Surge Analysis Methodology:

Lift stations shall be independently evaluated by the DESIGN ENGINEER for the potential for hydraulic transients. Small Stations will not require a transient analysis if they meet any of the following criteria:

1. Force mains smaller than 6-inch diameter and less than 1500 feet long
2. Pumping flows < 100 gpm
3. Systems with less than 30 feet of static differential pressure between suction and discharge and velocities less than 3 fps

Systems where column separation is a concern shall be analyzed for surge conditions and mitigation. Column separation can occur but is not limited to systems with:

- Pipes with high points (Knees)
- Force mains that requires automatic air venting or air vacuum valves
- Force mains with steep gradients (greater than 300 feet long followed by a long shallow gradient)

Computer programs for transient analysis shall be approved by the District on a case-by-case basis. Current programs for transient analysis utilizing the 'Method of Characteristics' numerical algorithm or other programs approved by the District, shall be used for evaluation of all hydraulic transient phenomena and proposed control measures. Each program is unique in terms of its capabilities and must be assessed in each situation to make sure the program can handle the complexities of the analysis involved.

b. Submittal of Calculations:

Prior to initiating detailed design of a lift station, the hydraulic transient calculations prepared by the DESIGN ENGINEER shall be submitted to the District. Transient analyses shall be performed by qualified staffs who have prepared at least five (5) transient analyses for similar pumping facilities. DESIGN ENGINEERS or their sub-consultants

shall submit their project experience with their analysis. The analysis shall include a narrative description of any potential for hydraulic transients and the steps recommended by the DESIGN ENGINEER for further action or mitigation of the hydraulic transients. Based on the contents of this submittal, the District may direct the DESIGN ENGINEER to design the necessary means for mitigation of hydraulic transients.

c. Transient Control Measures:

Where recommended as per transient analysis, transient control measures shall be addressed in the design of lift stations. Devices for transient control shall be considered in design, and installed as required to reduce pressure surges with pump starts and stops. Transient control measures to be considered singly or in combination for wastewater systems are limited to the following and listed in the order of preference:

1. Force Main Alignment: Revisions to force main horizontal and vertical alignments to eliminate potential column separation zones
2. Vacuum Relief Valves and Pressure Release Valves (Combination Type)
 - i. Locate vacuum relief valves at critical locations along the force main to prevent column separation and damaging vacuum conditions following pump shutoff
 - ii. These valves shall be suited for wastewater applications and be approved by the governing agency.
 - iii. Pressure relief valves shall be used on lift station manifold piping or along the pipeline at control devices that may introduce hydraulic transient conditions.
3. Slow-Closing, Hydraulically-Operated Pump Discharge Valves to control head rise during closure in the pressurized discharge pipelines. This requires special consideration for flow reversal through the pump unit.
4. Vacuum Relief Valves or Check Valves (Vented to Wet Well) for entry of air into the line to prevent column separation following pump shutoff
5. Shaft-Mounted Flywheels to increase moment of inertia for systems subject to column separation.

- i. Special District approval is required
 - ii. Shaft flywheels are not preferred and utilized only where design absolutely requires use of a flywheel arrangement
6. Surge tanks
- i. Must be approved by the District
 - ii. The design submittal shall contain detailed calculations and surge analysis computer modeling demonstrating the designs' effectiveness at reducing transient surges.

Air relief valves, air vacuum valves or combination air relief and air vacuum valves shall be installed per the DCSWCS requirements (unless otherwise specified by the District Representative), and discharge air shall be filtered through a District approved Odor Control System. No direct release of odors to atmosphere shall be allowed.

2.2.5 Wet Well Calculations

a. Flow Data Table:

Provide a table of Manning's Equation flow calculation data on the design drawings for the gravity sewer line discharging into the wet well up to 500 feet upstream. Flow Data Table columns shall include:

1. Pipe section name/identifier (manhole to manhole)
2. Average Flow (Q_a)
3. Peak Dry Weather Flow (Q_p)
4. Peak Wet Weather Flow (Q_{max})
5. Manning's "n" value used, 0.013 for wastewater
6. Calculated "d/D", with "d" being depth of flow and "D" being diameter of pipe

For free discharging inlet force mains, provide Q_a , Q_p , and Q_{max}

b. Wet Well Inlet:

The wet well gravity or force main sewer inlet invert shall be at least 6-inches above the normal high water operating level to minimize turbulence and odor generation, and in gravity inlets to maintain the top air space in the inlet pipe(s). The wet well inlet shall be designed

in accordance with ANSI/HI 9.8 Pump Intake Design Standard for Solid-Bearing Liquids.

c. Wet Well Operating Volume:

Wet well operating volume is defined as the volume between “Low Level” (All Pumps Off), and “High Level” (All Pumps On, excepting reserve). The wet well operating volume and pump(s) sequencing start/stop call levels shall be configured to reduce wastewater residence time while not exceeding the pump manufacturer’s recommended maximum starts per hour.

1. Wastewater residence time shall not exceed 30-minutes at average flow rate; unless otherwise approved by the District.
2. For periods of very low flow, the volume to be pumped by the first pump call shall be as small as possible to allow regular pumping down of the wet well volume to prevent septic action from taking place.

For Duplex Stations, the controlling (worst case) flow rate for Wet Well Operating Volume is half of the Lift Station Design Capacity, or $Q/2$. In Duplex configurations, the Operating Volume, $V(\min)$, can be calculated directly by the following equation:

$$V = T \cdot Q / 4$$

Where:

V: minimum Operating Volume, in gallons

T: minimum time in minutes between pump starts

Q: Lift Station Design Capacity, in gallons per minute (1 pump running), peak design flowrate including safety factors.

Triplex and Large Stations may have complex wet well Operating Volume calculations depending on the number of pumps and their capacity, manufacturer of pumps and their motor horsepower, and the capacity of downstream collection systems. The following sections provide performance criteria for calculation of such systems. The DESIGN ENGINEER shall coordinate with the District Representative on the wet well volume calculation methods for these stations. Criteria 1) and 2) of this 2.2.5.c must be met at all lift stations.

Where variable speed pumps are installed (i.e. to provide the required variation in pumping rate for minimum flow through peak wet weather flow conditions), the pump(s) start/stop call levels in the wet well shall be

configured to satisfy the above requirements over the entire range of design pumping rates and pump sequencing.

d. Minimum Flow into the Wet Well

Calculation: In the sizing of a lift station wet well for Triplex and Large Stations, determination of minimum flow is important to control cycling of constant speed pumps. Wet well should be large enough to provide enough running time to prevent overheating of the motor (consult manufacturer's maximum starts per hour requirements), but not too large in order to prevent septic conditions in the wet well. Table 2-1 shall be used to determine minimum flow (note: typically 20 to 30% of the average daily flow as shown) (Source: WPCF Manual of Practice No. 9). Design shall also be compliant with the Ten State Standards, the wet-well size must maintain a maximum 30-minute fluid stagnation time.

Table 2-1 RATIO OF MINIMUM TO AVERAGE FLOW

Average Flow, mgd	Min. Flow Factor
Less than 1	0.2
2	0.24
3	0.26
4	0.27
5	0.28
7	0.30
10	0.32
>10	Consult District

e. First Pump Call Level in the Wet Well Operating Volume:

For Duplex Stations, the first pump call volume is equal to the total Wet Well Operating Volume calculated in Section 2.2.5.c. Duplex Stations have only one Operating Volume, which is also the "First Call" volume.

For Triplex or Large Stations, the minimum wet well operating volume for first pump call based on start and stop levels shall be equal to the following:

$$V_1 = (Q - Q_{\min}) \times T$$

Where:

V_1 : First Pump Call Operating Volume, in gallons

T: minimum time in minutes between pump starts

Q: Lift Station Design Capacity, in gallons per minute

Q_{\min} : Minimum Inflow as per Section 2.2.5.d

f. Wet Well Operating and Alarm Levels:

The wet well low and high operating water levels and alarm levels shall be indicated on the design drawings, with associated elevations. Typical level names are as follows:

“High-High”	Alarm Level, All Pumps On (including reserve)
“High”	All Pumps On, excepting reserve
“Lag 1, 2, 3”	Levels at which each sequenced pump is called
“Lead”	First Pump Call Level
“Low”	All Pumps Off (auto)
“Low-Low”	Alarm Level, All Pumps Off (auto)

The pump automatic shut-off level shall be located above the pump volute level to ensure sufficient net positive suction head per Section 2.2.2.f. Minimum submergence of the pump suction bells (this defines the “Low” flow level) shall be not less than that determined in accordance with Section 9.8.7 of the Hydraulic Institute Pump Intake Design Standard. The automatic low level shut-off feature shall be capable of being manually disabled during cleaning cycles of self-cleaning trench type wet wells.

The minimum wet well level submergence of the top of the suction line for centrifugal pumps shall be:

$$S = D + 0.574 * \frac{Q}{D^{1.5}}$$

Where:

S = Minimum suction crown submergence in inches

D = Suction pipe diameter in inches

Q = Pump flow rate in US gallons per minute

g. Emergency Storage Volume:

Separate from the wet well operating volume, the DESIGN ENGINEER shall provide an emergency storage volume sufficient to accommodate storage of two (2) hours sewage influent volume at

peak wet weather flow. Emergency storage volume shall be provided above the High-High Alarm Level (above the Wet Well Operating Volume), and up to the lowest sewage spill/overflow elevation. The Emergency Storage Volume can be accomplished by the following measures singly or in combination, and listed in order of preference:

1. additional storage in the wet well above the operating volume
2. separate overflow tank and storage in other onsite structures and sewer lines within the lift station property line (see Section 2.2.5.h)
3. Emergency pumping capability shall be accomplished by connection of the station to at least two independent utility substations, or by provision of portable or in-place internal combustion engine equipment which will generate electrical or mechanical energy, or by the provision of portable pumping equipment. Such emergency standby systems shall have sufficient capacity to start up and maintain the total rated running capacity of the station. Regardless of the type of emergency standby system provided, a portable pump connection to the force main with rapid connection capabilities and appropriate valving shall be provided outside the dry well and wet well

This Emergency Volume will allow operating personnel at least two (2) hours to respond to a station failure alarm and/or to shut off all pumps to perform emergency repairs to correct a failure condition.

h. Influent Line Storage:

The offsite influent sewer (beyond the lift station property line) shall not be designed to accommodate storage, nor shall it be calculated in the Emergency Storage Volume. Other onsite, below grade vaults, structures, and sewer lines connected to the wet well may be included in the Emergency Storage Volume.

i. Spill Location Indication:

Influent sewer and lift station spill locations and elevation(s) shall be indicated on the design drawings (lowest upstream elevation or wet well cover elevation where backup spill will occur). A collection lines tributary area map for the lift station showing the influent sewer and lift station spill locations is also required to be part of the Lift Station O&M Manual submittal as specified in the Operation and Maintenance manual section (3.4.4).

Though the Spill Location may be located offsite due to topography, offsite collection systems shall not be incorporated into Emergency Storage Volume calculations.

2.2.6 Six-Hour Emergency Storage (Special Station Requirement)

In select areas where maximum protection from spillage must be provided, such as areas where a station sewage spill would flow into a water supply reservoir or other sensitive areas as determined by the District Representative, a six-hour emergency overflow storage (at peak wet weather flow rate) shall be provided. Section 2.2.5 shall apply in its entirety, using six (6) hours storage in lieu of two (2) hours. To achieve this larger emergency storage volume, supplemental onsite storage may be required in coordination with the District Representative, such as:

a. Closed Tanks:

Where Six-Hour emergency storage cannot be provided in the wet well, emergency storage can be an underground structure or a separate tank that is normally empty but can drain by gravity back into the wet well. This storage is also available to be utilized for flow equalization during large storm events should peak wet weather flows exceed the lift station design capacity.

b. Ponds:

In isolated areas, or where determined as such by the District, such as stations with low wet well detention times, high flows, or similar, an open-air basin or a pond may be accepted as an emergency storage in lieu of an underground concrete structure. However, the basin shall be lined with an impermeable flexible barrier, and may be required to be protected by a layer of asphalt or concrete. Provision shall be made for draining the emergency storage basin back into the wet well.

2.3 PUMPS

Standard Design: Vertical, non-clog, raw sewage pumps shall be specified and provided in constructed or packaged wet well/dry well type sewer lift stations, and shall have the features indicated, including those provided for in the following sections.

Vertical non-clog sewage pumps are to be vertical close coupled pumps utilizing open impellers or multiple hardened chopper elements meeting minimum current District specifications. Pumps shall be driven by either TEFC drip proof or TEBC immersible motors meeting the requirement of section 2.3.2 of this document. Pumps shall utilize a "P" type motor mounting flange, or common equivalent, such that a standard drip proof TEFC type motor can be substituted in emergency situations. Manufacturers meeting this pump specification are Cornell, KSB, and Smith and Loveless, no other known equals.

Except where Special station requirements are indicated and approved by the District, sewage lift stations shall be of the wet well/dry well type. Dry wells, including their superstructure, shall be completely separated from the wet well. Use NFPA 820 requirements to maintain NEC class I, Division II classification for wet wells and "no classification" for dry wells.

A submersible type lift station may be used for Small Stations and for Duplex Stations on a case-by-case basis to be approved by the District.

Triplex and Large Stations with over 50 HP motors must be provided with immersible pump motors in dry well configurations.

2.3.1 Vertical Non-Clog Pumps

a. Multiple Units and Seals:

At least two pumps shall be provided. See Sections 1.3.2 and 2.1.4.

Pumps provided for District lift stations shall be equipped with tandem mechanical or double acting mechanical seals, requiring no seal water flush. Pump assemblies utilizing intermediate oil filled bearing and seal housings are acceptable if the assembly maintains the required immersion rating. Pump seal chamber designs capable of introducing moisture into the pump motor shall not be acceptable. All impellers shall be epoxy fusion coated.

b. Pump Openings and Grinder Pumps:

Pumps shall be capable of passing spheres of at least 3 inches in diameter and pump suction and discharge piping shall be at least 4 inches in diameter, unless otherwise approved by District.

Grinder pumps and grinding equipment shall not be employed in District lift stations, unless otherwise approved by District. Other mitigation means shall be presented by the DESIGN ENGINEER, and reviewed and approved by the District where raw sewage characteristics indicate such measures are required.

c. Priming:

The pump shall be placed so that under normal operating conditions, it will operate under a positive suction head.

d. Intake Piping and Discharge Piping:

Each pump shall have an individual intake. No common intake headers will be permitted unless approved by the District Representative. The wet well shall be designed to avoid turbulence near the intake. The intake piping shall be as straight and short as possible. Stainless steel baffles, when necessary, shall be provided in front of inlet piping.

The discharge piping shall include the ability to drain the discharge force main from a point located downstream of the check valve and to drain to the lift station wet well. A low point 2" discharge header drain connection is required for servicing and maintenance.

e. Pump Bases:

Pump concrete support bases shall be monolithically constructed with the dry well floor concrete pour and include an equipment ground. Edges of the pump concrete bases shall be chamfered ($\frac{3}{4}$ " inch minimum).

Pre-engineered steel pump bases may be acceptable to the District, provided that Structural Calculations sealed by a Professional Engineer are submitted to the District with the design package. Structural calculations for pump bases shall account for all dynamic and static loads, pumping thrust, surge pressure or transients, and seismic conditions.

f. Stainless Steel Anchor Bolts for Pump Bases:

Anchor bolts shall be cast in place only, and constructed with stainless steel class 316. Wedge type or chemical type anchor bolts are not allowed for rotating equipment, and shall be specifically prohibited. All pump mounting hardware shall be 316 stainless steel, with dissimilar metal connections employing isolation bushings.

g. Dry Well Dewatering:

One separate submersible type sump pump equipped with dual check valves shall be provided and located in a sump in the dry well to remove leakage or drainage. The discharge shall be located as high as possible above the normal high water level in the wet well. Submersible sump pump shall be on its own electrical circuit.

1. For Triplex and Large Stations, two separate submersible type sump pumps shall be provided. Use a separate electrical circuit for each pump where dual sump pumps are provided.
2. Spare to be provided: A spare dry well dewatering sump pump shall be provided to the District upon project completion.
3. Each sump pump shall be capable of pumping a head equal to the depth of the lift station. A copy of the pump curves and operation and maintenance manuals shall be provided. Water ejectors connected to a potable water supply will not be approved. All floor and walkway surfaces should have an adequate slope to a point of drainage to the dry well sump. Pump seal water shall be piped to the sump. Concrete floors shall also receive a broom finish on the floor for non-slip, all floors subject to moisture shall be coated with a high traffic non-skid sulfuric acid resistant epoxy coating that shall extend vertically 12 inches on all walls connected to the floor.

2.3.2 Lift Station Pump Motors

a. Immersible Feature:

All lift station pump motors over 50 HP shall be rated as immersible (not submersible/immersible) for a minimum period of 14 days at 25 foot depth per immersion event.

b. Motor Horsepower Selection:

The motor shall be sized with sufficient rated name plate horsepower to meet the requirements of Section 2.2.2 for Pump and motor selections.

c. Pump Motor Features:

General: Specify drip proof TEFC motors up to 50 HP. Totally enclosed blower or oil jacket cooled (pumped medium cooling jackets not permitted) immersible motors shall be used over 50 HP. The motor shall not be directly attached to the pump in a way that a common seal between the pump wet end and the electric motor exists which could introduce moisture/fluid into the electric motor; a

leaking/failed pump seal discharge must drain harmlessly away from the electric motor, controls, etc. Pump motors shall utilize a “P” type motor mounting flange, or common equivalent, such that a standard drip proof TEFC type motor can be substituted in emergency situations. Known acceptable manufacturers of pump assemblies meeting this general specification are Cornell, KSB, and Smith & Loveless, no other known equals.

Pump motor protective sensors: Coordinate with the District Representative to obtain the District’s Standard pump motor specifications. Motors over 20 horsepower shall be equipped with embedded winding temperature thermistor(s); motors over 100 horsepower shall additionally employ external fitted Triaxial (X-Y-Z) vibration sensors with a 4-20 ma output to PLC for alarms. All motor sensors shall be factory-wired to either cable or motor connection box and configuring equipment installed to provide PLC alarm signals. Avoid greatly oversizing motors since both efficiency and power factors drop in motors running below their full load rating. Variable speed motors should additionally be inverter duty. Provide a motor stand as required to allow access to the motor coupling for maintenance. For immersible motors with blower provide float to disable the blower if motor becomes halfway submerged with PLC condition status.

2.3.3 Equipment Clearances

a. Minimum Equipment Clearances:

The District shall approve all minimum equipment clearances, but in general they shall be as follows:

1. NEC minimum panel clearances
2. OSHA requirements for accesses and ladders
3. Equipment Removal Clearances as per Section 2.7.2
4. 42 inches horizontal between adjacent items of equipment (pumps, motors, piping, equipment, valves, appurtenances, and station walls
5. 18 inches vertical from floor to edge of flanges, valves, and other appurtenances
6. 90 inches vertical (floor to overhead obstruction)

Clearance shall be actual, to most outstanding dimension (i.e., edge of flange), not nominal. Equipment shall be located to

provide the above clearances on all sides. Grease fittings shall be located/extended so that lubrication of machinery can be performed without removing access covers. Any oil/gear lube drain plugs must be easily accessible and extensions/drain cocks provided where the oil cannot drain directly into a catch container. Clearance of at least 18-inches shall be provided to all flange and disassembling joint bolts for wrench turns. Valve actuators/op-nuts shall be easily accessible without special tools or extensions. Minimum available clearances of equipment shall be labeled in the design drawings for District review and for contractors use in construction.

2.3.4 Spare Parts To Be Furnished

Furnish the following spare parts and spares at all lift station facilities. All equipment to be tagged per O&M Manual and tagging list shall be provided within the Asset Management bill of materials.

- a. One (1) EACH complete set of mechanical seals, bearings, gasket set, wear rings, fasteners, and spare impeller for EACH size/type pump installed to be provided.
 1. The one complete spare seal kit to be provided will be made available at the time of the station's acceptance. Also, a certified mechanical detail drawing of the seal installation from the station manufacturer shall be provided.
- b. All special tools needed to work on the pumps/motors per manufacturer's recommendation.
- c. Spare parts and any special tools needed to work on the emergency power plant to include any needed air and fuel filters.

2.3.5 Large Lift Stations (Special Station Requirement)

- a. Classification:

With special designation/approval by the District, the following may be required for Large Stations (as per Section 2.1.4)

- b. Mechanical Seals for Variable Speed Pumps (Special Station Requirement):

Seals on variable speed pumps shall be designed to operate properly over the range of pump speeds. The District does not allow split mechanical seals.

- c. Air-Gap Seal Water Pressurization System (Special Station Requirement):

Pumps requiring seal water shall not be acceptable for lift stations.

2.3.6 Lift Station Equipment Retrofit Projects (Special Station Requirement)

- a. Retrofitting Equipment in Existing Lift Stations:

The following types of equipment are not allowed for the design of new facilities due to higher maintenance requirements, and other operational concerns. Where existing facilities with this type of equipment are retrofitted, the following equipment features shall be incorporated:

1. Dry Pit Submersible (Special Station Requirement):

Pump Installation (Special Station Requirement): This type of pump is typically not allowed due to maintenance procedure requirements and onsite repair limitations. Specify vertical close coupled pumps with either TEFC or TEBC immersible motors instead, as specified in Section 2.3.2

2. Wet Well Submersible Pump Installation (Special Station Requirement):

This type of pump shall be permitted only in Small Stations at the discretion of CCWRD.

2.4 PIPING AND APPURTENANCES

2.4.1 Isolation Valves

- a. Dry Well Isolation Valves:

All valves shall be designed to specifically handle raw wastewater and shall be of a bonneted double face knife type, eccentric plug or full flow plug valves, with District discretion as to type. Identified valves shall be equipped with motorized operators at the discretion of the District, and capable of local and remote open/close control. All electrical valve actuators shall be "Rotork or REXA" type or equal to match existing equipment. Electric actuators shall be equipped with local/off/remote (LOR) switches and opened/closed limit switches that all provide feedback signals to the PLC based on valve position. Additionally, the actuators will be fed command signals from the PLC for remote control. Actuators using cam actuated micro-switches for limit indications are unacceptable.

b. Valve Operators:

Valves shall be provided with a manual operator by the manufacturer in case of power outage

c. Valve Accessibility:

All valves in the dry well shall be accessible from the floor, 6 ft above floor maximum.

d. Elevated Valve Access:

Elevated valves mounted more than 6 feet above the floor shall be safely accessible from the stairwell, special platforms, landings, or catwalks installed as required for access. A ladder with safety climb equipment and harness shall be provided on all platforms and catwalks. Chain operators are encouraged where practical for hand operation, and may be provided if approved by the District.

Means to hoist valving for maintenance or replacement removal shall be provided. The design documents shall require that the contractor installed the valve during construction with the permanent hoisting equipment intended for that purpose.

e. Suction Valve Extensions:

Suction valves shall be fitted with extensions to the grade level (or the floor above if below grade station) at the District's discretion. Where required, suction valves shall be fitted with hand wheels in the dry well, and hand wheels (or recessed and covered valve keys as required) at the level above. The extension shall be equipped with two (2) U-joint type fittings at the valve to allow ease of rotation in the event of minor out of alignment of the extension installation.

f. Buried Valves:

For buried applications, provide fusion-bonded epoxy coated valves with water tight bonnets and buried service gear operators. Provide a valve extension to the ground level for operating the valve for each buried valve more than 5 feet below grade. Provide 2 each, extendable buried valve operating tools for all different type buried valves to be kept onsite. Locate buried valves within the station's fenced-in area, unless approved by the District. Isolation valves that are required to be located outside the station on the inlet and force main shall be located as shallow as possible. Stems shall not rise above finished grade.

g. Wet Well Isolation Valve:

Locate a fully wedged sluice gate conforming to AWWA C-560 on the wet well inlet sewer, with manual actuator (hand-wheel or District approved device) provided above grade. Apply fusion epoxy coat on all ferrous items, or provide sluice gate as 316 Stainless Steel.

h. Emergency Bypass Arrangements:

All lift stations shall be provided with emergency bypass blind flange connections for both force mains as per Standard Plate SP-14. Provide adequate site clearances for temporary emergency installation of mobile pump unit(s) and temporary piping without impeding vehicular access to the site. All bolts shall be type 316 stainless-steel. Locate and size the components as follows:

1. Suction Riser: Shall be connected as close as practical to the floor of the wet well, and sized 1 standard diameter larger than the lift station discharge force main(s). The Riser shall continue to ground or floor surface, terminating in a 90-degree elbow (to turn piping parallel to ground or floor), with installed isolation valve (per 2.4.1.a) and blind flange cap. The minimum allowable diameter size for the connection is 6 inches.
2. Discharge Quick Connects or Risers: Provide one 6-inch diameter (minimum diameter) quick connect location for each force main.
 - i. For Small Stations that may be equipped with a force main valve vault, provide 6-inch (minimum) quick connections in the vault piping assembly, one for each force main, with an isolation valve and blind flange. Orient the blind flange at 45 degrees up from horizontal for ease of connecting large diameter flexible hoses from mobile pumping units in the service box vault. Provide additional clearance inside the vault (horizontal and vertical) for connection of hoses. If possible, in below grade vault systems, the system shall be designed and installed in a manner that will not require confined space entry, allowing all connections and valve operations to be effected from the surface.
 - ii. For all other installations, risers shall be connected by "wye" fitting on each force main, downstream of the flex couplings and force main isolation valve. Riser shall be same diameter and material as force main. The Riser shall

continue to ground surface, terminating in a 90-degree elbow, with installed isolation valve (per 2.4.1.a) and blind flange cap. The minimum allowable diameter size for the connection is 6 inches.

3. **Special Station Requirement:** Large Stations may require special design of the quick connections to Risers at ground surface. Mobile pumping equipment owned by CCWRD has specific connection sizes and pumping capacities, therefore Large Stations may have capacities large enough to require connection of multiple mobile pumping units in an emergency. In these cases, the risers shall be equipped with multiple valved connections above grade to accommodate multiple pumping unit installations during an emergency. Sufficient site clearance shall be required for multiple emergency units to be installed together at the quick connect location.

- i. **Underground Valves in Vaults (Special Station Requirement):**

Where difficult soil and/or site conditions exist such that buried valves may not be easily accessible for emergency repairs, locate valves in a vault for easy access to valve bonnet pickings, gear operators and/or pressure greasing fittings. This would include force main isolation valves and emergency pump connection valves.

Valve closure times shall also be evaluated to prevent excessive transient phenomena (water hammer) from occurring, a surge pressure critical time analysis shall be provided. Valve manufacturer shall be contacted to provide valve closure data and diagrams to limit the excessive transient pressure to within the allowable design pressure limits.

2.4.2 Check Valves

- a. **General Features**

External Spring Lever Check Valves: Specify external spring lever weighted arm check valves. Install the check valve in a horizontal position to prevent pipe clogging from sedimentation. Vertical installations are undesirable and will be reviewed on a case-by-case basis. The valve shall have an access plate for cleaning debris from the check assembly. Install a sufficiently strong spring on the valve to close the valve before return water will cause a "slamming valve" (design to close when the flow of liquid in the force main halts prior to the back surge wave). The valve flapper shaft and all fasteners in contact with the pumped liquid shall be Type 316 stainless steel.

b. Specific Valve Feature:

Specify a low head-loss type check valve, approved for sewer applications. This type of valve will typically require less than a 25-degree swing for full port opening and have a "no slam" closing characteristic due to the minimal check movement. A full port opening through the valve is typically provided using a wide valve body. GA Industries figure 250 cushioned swing check valve or District approved equal.

c. Air/Cushion Close Valve (Special Station Requirement):

As recommended by transient analysis only: Where large discharge heads or flows may cause water hammer, install air/oil cushion type timed closing valves. These valves should be designed to close when the flow of liquid in the force main halts prior to the back surge wave, with a slow close during the final 10 percent of valve closing.

d. Proximity Switch:

Install a proximity type limit switch on the check valve. Limit switch shall indicate valve open/closed condition, and provide dry contact indication to the PLC for alarm condition. Switch housing shall be NEMA 6P.

2.4.3 Piping and Fittings

a. General:

1. Refer to AML and DCSWCS for material requirements
2. Short sweep elbows not allowed
3. Use of dissimilar metals shall be avoided as much as practical. Where dissimilar metals must be connected, provide nylon insulating bushings.

b. Ductile Iron Pipe:

The CCWRD in standard applications will not allow carbon steel pipe materials in raw wastewater applications. Sewage suction and discharge piping and fittings installed in the wet well and the dry well shall be epoxy lined and coated ductile iron (DI).

c. Threaded-On Ductile Iron Flanges: The CCWRD in standard applications will not allow carbon steel pipe materials in raw wastewater applications.

Threaded-on ductile iron flanges shall be made up with epoxy on the threads for sealing for corrosion protection.

d. Make-Up Length Piping:

Provide flanged by plain end pipe fittings and restrained tie rod coupling section for make-up length fittings.

e. Pipe Disassembly Lengths:

Discharge piping shall be fitted and connected so that there are no lengths of pipe that cannot be disassembled and removed from the station utilizing the station overhead crane rail hoist.

f. Approved Pipe Joints:

All pipe joints must be restrained. The following types of joints are acceptable: flanged (above grade applications only), and dresser-type coupling restrained by tie rods. Threaded on type DI pipe flanges are allowable. For this type the DESIGN ENGINEER shall specify assembly per AWWA standards.

g. Non-Approved Coupling Fittings:

The following fittings are not allowable and shall not be used in design: rubber bellows-type couplings, and flange coupling adaptors (i.e. pipe restraint with set screws).

h. Victaulic Couplings (Special Station Requirement):

These fittings are not generally allowed. However, for retrofit projects and where piping space is critical, grooved pipe couplings may be utilized with proper bracing against lateral and rotational movement.

i. Restrained Couplings for Ease of Piping Alignment:

On suction and discharge piping larger than 4 inches, connected to each pump and on the discharge manifold horizontal and vertical runs, install two flexible sleeve couplings with tie rod thrust restraint to absorb piping misalignment and prevent stress in the pump and piping and for ease of piping removal.

j. Piping Supports and Bracing:

Piping supports shall be provided under the suction and discharge lines. Piping supports shall be designed to support the piping runs both vertically and horizontally. Bracing shall be provided to resist the maximum expected pressure transient forces. Typically, the end of the manifold will be braced to the adjacent wall for this purpose.

k. Seismic Design:

All Piping supports shall be designed to meet local Seismic code requirements currently adopted. The importance factor for lift station design shall not be less than $I=1.25$. Concrete anchors shall be performed with seismic certified anchor systems designed for cracked concrete conditions; embedded J-Bolts are not allowed.

l. Base Elbows:

Base elbow fittings shall be installed on pedestals at vertical bends. The vertical piping run shall be braced horizontally and vertically to the wall, so that base elbows are not required to resist any horizontal or vertical thrust loads.

m. Manifold Configuration:

For manifolds, utilize wye fittings rather than tee type fittings. Connect discharge piping from individual pumps horizontally into the side of the manifold. (Note: to minimize deposition of solids at check valves).

n. Manifold to Force Main(s) Piping Configuration:

Design dual force mains that can be operated independently. Within the dry well pump room or the lift station site, as determined necessary by the District Representative, the manifold shall wye into two separate force mains.

1. Each force main shall be provided with an isolation valve downstream of the wye. Configuration shall allow operation of pumps through either force main, while the other force main is isolated for maintenance/repair.
2. Provide each force main with a dedicated pressure transducer or digital pressure gauge capable of providing feedback to the PLC with indications on SCADA HMI.
3. Configure PLC and SCADA HMI so that pressure differences between the force mains can indicate which force main is active during operation.

o. Buried pipe joints with corrodible metallic components shall be completely coated with petrolatum tape and wrapped per AWWA C217 and the manufacturer's recommendations.

2.4.4 Force Main Drain Lines

a. Force Main Drain Lines to Wet Well:

Within the dry well pump room or the lift station site, as determined necessary by the District Representative, provide a drain line with isolation valve from each discharge force main, and discharge to the wet well. Configuration shall allow draining back the entire force main while the other is operating in the event of a force main break. Where hydraulics permit, the dedicated force main drain lines shall be sized to allow the drainage of the unused force main to artificially increase influent flow into the wet well to enable running of multiple pumps and consequently increase flow in the operating force main to reach scour velocities of 6-fps. Drains shall be installed with a dedicated throttling valve and a separate isolation valve (between throttling valve and wet-well), all valves shall comply with wastewater applications. Drainage pipes shall be no smaller than 4-in. unless approved by District, and discharge in wet well shall be above high-high water level.

b. Force Main Drain Lines (Special Station Requirement):

For Large Stations or stations with critical flooding concerns (i.e., existing electrical equipment located in below-grade pump room not permitted for new lift stations or retrofits), the drainage from the force main(s) and any sump pump installation in the dry well shall be discharged to the sewer manhole immediately upstream of the wet well provided the wet well contains an inlet gate. The gate shall be closed to prevent further flooding and to allow repair work on any pump room leakage.

2.4.5 Small Appurtenance Pipe Fittings

a. Small Appurtenance Piping:

Two-inch diameter or less piping appurtenances connected to station piping (i.e. air release valve connections, seal water drain lines, or seal piping drain lines) shall be Type 316 stainless steel. Galvanized steel shall not be permitted. Install corrosion isolation nylon bushings when mounting dissimilar metal pipe fittings such as bronze air release gauge cocks on manifold piping.

2.4.6 Stainless Steel Bolting

a. Dry Well Fasteners:

All dry well pump and pipe fasteners shall be Type 316 stainless steel.

b. Wet Well and Buried Fittings Fasteners:

All wet well fasteners and anchor bolts, and all fasteners for buried fittings shall be Type 316 stainless steel.

2.4.7 Air Release Valves and Fittings

a. Installation Locations:

Locate air release valves on the discharge piping of the following:

1. Flooded Suction Pumps:

At the top of each lift station sewage pump volute discharge, provide ½ inch or larger, as suitable, stainless steel Tee fitting with two schedules 80 PVC ball valves. From the vertical valve plumb with schedule 80 PVC pipe, using unions for regular removal, a purge line system to the sump pump basin,

b. Air Release Valves:

Install two sewage application combination type air release and vacuum valves on discharge manifolds located at the piping penetration from the dry well. Configure valves so that each can stay in operation while the other is maintained. Valves are typically 4-inch size, or larger as determined by DESIGN ENGINEER due to flow requirements or transient analysis. Provide an independent connection with isolation valve for each valve to the discharge manifold. Brace the valves to the station wall. This installation shall be accessible by a catwalk platform for maintenance.

1. For above grade installations, provide Vent-O-Mat model 100RGX1031 or better; others must be approved for substitution.

2. Air release valve discharge piping shall be piped to the station wet well.

3. For below grade locations, provide valves in an adjacent manhole, and specify Vent-O-Mat model 100RGX1031 or better; others must be approved for substitution.

4. Odor control units for air valve discharge shall be provided where required by District Representative or where odor can cause inconvenience to the public.
- c. **Stainless Steel Pipe Fittings:**

As specified above, for each air valve assembly or gauge cock, the pipe nipple connection to the manifold and all other piping in the assembly shall be Type 316 stainless steel. Provide a corporation stop type isolation valve and pipe union on the assembly to allow maintenance and removal of each air release valve.
- d. **Air Valve Drain Piping:**

Air release valve discharge piping shall be piped clear of adjacent piping and equipment to minimize corrosive effect over time.
- e. **Submersible Pumps (Special Station Requirement):**

For retrofit projects or new projects where these types of pumps are allowed, locate the following equipment in a discharge valve vault: sewage-type air relief valve H-TEC model 986 (with no known equal), discharge check valve, and isolation valve. A For check valves, provide 2-inch drilled hole with piped gooseneck and manual valve to be installed on the discharge piping vertical wall penetration in the wet well for manual air release if approved by District.

2.4.8 Schedule of Pipe Materials

- a. **Schedule on Mechanical Drawings:**

Include data schedule on the mechanical drawings with the following information for each pipe valve and appurtenance to be provided: item number, size, type, material or kind, quantity, remarks, and specification reference. Additional data may be required by the CCWRD Asset Management Standards.

2.4.9 Lining and Coating

Refer to Chapter 3 and Clean Water Program Corrosion Control Requirements.

2.5 ELECTRICAL, CONTROLS, AND INSTRUMENTATION

2.5.1 General

Electrical controls and instrumentation have been standardized by the District. The DESIGN ENGINEER shall obtain a copy of these standards from the District, and shall incorporate them in the design after making modifications to meet project specific requirements.

2.5.2 Electrical Service for Lift Stations:

The electrical service facilities shall be provided for the lift station in accordance with Nevada Energy electrical utility specifications standard plans and requirements. The DESIGN ENGINEER is responsible for coordination with Nevada Energy for design and construction of offsite electrical services. The electrical service going from the power company's service drops to the lift station shall be installed in conduit conforming to CCWRD standard specifications; direct burial will not be acceptable.

a. Transfer of Utility Service:

The transfer of the title of utilities from the Developer into the District's name shall be done after final acceptance, as per Chapter 4 (4.1.5).

2.5.3 Electrical Equipment:

a. General Location Requirements:

Coordinate with District Representative on locations of electrical equipment, depending on the configuration and Special Requirements of the lift station. All electrical equipment shall be located in dedicated electrical rooms (Large Stations), outdoors under an awning type structure, or within separate cabinet enclosures secured by padlock. Only mandatory conduits and local safety lock-out-stop controls essential for operation and maintenance of equipment within dry wells shall be allowed in dry wells. Local safety lock-out-stop/E-stop controls for all equipment shall remove all voltage sources of connected equipment when activated and shall have a lock-out feature. All electrically powered lift station equipment shall require a mechanical disconnect within line of sight.

b. Outdoor enclosures, including "soft" starter and variable frequency drive cabinets (where applicable) shall be shielded from sunlight on the southern and western exposures by siding or the fence enclosure.

c. Outdoor enclosures for variable frequency drives (VFD) shall include a panel air conditioning unit that is capable of maintaining the panel

internal space temperature below 90 degrees Fahrenheit in all weather conditions.

- d. Electrical systems and components (e.g., motors, lights, cables, conduits, switchboxes, control circuits, etc.) in raw sewage wet wells, and in all enclosed or partially enclosed spaces where hazardous concentrations of flammable gases or vapors may be present, shall comply with the National Electrical Code requirements for Class 1 Group C and D, Division 1 locations. The installation shall comply with NFPA 820. In addition, equipment located in the wet well shall be suitable for use under corrosive conditions.
- e. No junction boxes are permitted to be located in wet wells
- f. Equipment within the wet well shall be designed to be removable for service or replacement without requiring physical entry in the wet well. See Standard Plate SP-06 for typical wet well arrangements.
- g. Wet Well Level Control:

Provide two systems. The primary system shall be a bubbler system and the secondary system shall be a radar level system.
 - 1. Radar Level System shall be vega level sensor with stainless steel construction and rated as submersible. The sensor shall be mounted in such a manner that it can be removed for servicing as debris and grease can build-up underneath the sensor and effect the head pressure. The transmitter outputs shall be selected per electrical design requirements (4-20 mA).
 - 2. The higher of the two signals (bubbler versus ultrasonic level) shall be selected by the control system for the pump start/stop and control purposes.
 - 3. The installation detail shall be as shown on the associated standard electrical/control drawings in the Design Standard attachments.
- h. Each flexible cable shall be provided with watertight seal and separate strain relief with the terminations and/or splices being done above ground outside the wet well.
- i. Main Circuit Breaker located above ground shall be provided for all lift stations.
- j. Dry wells are required to be monitored for hazardous gasses, ventilation and alarm functions provided, and are to be designed to be classified as hazardous environments for electrical installations.

- k. All electrical equipment and connecting hardware on lift stations in unclassified areas shall be NEMA rated per the following:
 - 1. Outdoors: NEMA 3R
 - 2. Corrosive Areas: NEMA 4X
 - 3. Note: DESIGN ENGINEER shall coordinate with District Representative to identify/classify areas as having harsh or corrosive environmental conditions, such as odor control units or irrigation overspray.
 - 4. Dedicated and protected electrical rooms: NEMA 1
 - 5. Dry wells: NEMA 6P
 - 6. Electric rooms subject to flooding/submergence: NEMA 6P
- l. During design, a short circuit analysis shall be performed in accordance with 2.5.5.c, using actual values obtained from the power company with the equipment ratings determined from this analysis. A full lift station short circuit device protection study, execution and Arc Flash Boundary analysis and labeling shall be performed by an independent certified electrical systems testing agency prior to lift station testing/final acceptance during construction. The associated documents generated during the study will be turned over to the District with the O&M Manuals.
- m. All electrical conduits shall be positively sealed at both ends to protect against migration of corrosive gasses or liquid which can damage electrical/electronic equipment.
- n. Motor Control Center (MCC) Service Entrance Equipment
 - 1. Refer to CCWRD Standard Electrical Specifications and Approved Materials Lists for standard equipment and requirements
 - 2. Motor control center service entrance equipment shall be factory prepared sections
 - 3. All motor control center circuit breakers and motor starters shall be NEMA approved equipment.
 - 4. Motor speed control equipment shall not be adapted for installation in the MCC enclosure. VFD, soft starters, solid state reduced voltage starters (SSRV), and similar pump speed

control equipment shall be provided and installed in the manufacturer's proprietary enclosure.

o. Wiring and Bus Bars

1. Stranded copper wire shall be used for all power and control wire sizes; solid copper wire is not acceptable. #10 AWG and smaller shall be solid, #8 AWG and larger shall be stranded. No aluminum wire or connectors shall be allowed for any station wiring.
2. The MCC and other control panels shall have bus bars and connectors constructed of tin-plated solid copper. All wiring within MCC shall be pre-wired in the factory to reduce field wiring by CONTRACTOR. NEMA Class II B wiring shall be specified.

p. Seismic Braces:

Seismic braces shall be installed on all electric service cabinets and other free standing equipment per code requirements for seismic area. Provide a detail drawing of the seismic braces in the design drawings along with calculations. All electrical equipment shall be anchored to satisfy the seismic code per latest adopted building code.

q. Power Panel

1. The power panel for lighting and auxiliary equipment shall have balanced loads within 15% for each phase.
2. The panel shall have its own transformer and not rely on a transformer in the control panel for service voltage.

r. Electrical Conduit

1. Underground conduit shall be schedule 40 PVC with reinforced concrete encasement. Underground conduit and elbows shall be constructed with water-tight glued joints. Stub-ups shall be PVC coated galvanized steel, Robroy or equivalent. All couplings and fittings for stub-up shall be coated and threaded. Use long radius conduit fittings to allow pulling cable.
2. Above ground conduit and stub-ups shall be rigid galvanized steel, PVC coated 40 mils thick exterior and 2 mil thick phenolic on the interior.
3. The CONTRACTOR shall provide a pull cord in completed conduit installation for future use.

s. Conduit Routing Schedule:

Conduits shall be whole size only. Provide a table in the design drawings that shows the conduit routing schedule as shown in Table 2-2:

Table 2-2. CONDUIT ROUTING SCHEDULE

CONDUIT ROUTING SCHEDULE				
Conduit	Diameter	# of Conduits	Size	From/to Via

t. Electrical Outlets

1. Provide 120 volt electrical outlets in the station for operation of miscellaneous station equipment and/or repair power tools. No control system cabinet or pumping/process equipment shall share a circuit installed for general use. All convenience outlets shall be dedicated circuits. All outlets below grade and at exterior locations shall be GFI (ground fault interrupter) protected by GFCI (ground fault circuit interrupter) circuit breakers at panels.
2. All outlets shall have wet location covers to protect against splashing even when receptacles are in use.

u. Pump Control and Alarm Circuit "Ladder Logic" Diagrams

1. The DESIGN ENGINEER is referred to ATTACHMENT 3 in this LS-DCS, and shall make the necessary modifications to include project-specific requirements (i.e., number, size of pumps, above/below grade facilities, etc.).
2. Specify that the "as-built" electrical drawings shall show the actual "as-built" wire number labels to conform to District standards. (All wires and control devices in the Control Panel shall be labeled by the CONTRACTOR).

v. Pump Control Description:

A pump control sequence description shall be provided in the design specifications, and also shall be included in the Summary of Operation Section of the Operations & Maintenance Manual. The

description shall be in accordance with the standard in ATTACHMENT 3.

w. Calibration Schedule:

Provide a control device calibration range schedule on the design plans for reference during installation and adjustment of the control devices.

x. Provide power monitoring at all sites with an ethernet connection to the PLC cabinet.

2.5.4 Power Switchgear and Distribution

a. Lockout Safety

Provide circuit breakers with a "lockout/tag out" safety switch handle to provide a switch disconnect of power for use during maintenance operations on machinery. Circuit breakers shall be clearly labeled with equipment designation.

b. Circuit Breakers:

Use of motor circuit protectors for magnetic starters shall be limited to motors rated below 150 HP. The use of motor circuit protectors (MCPs - fully magnetic circuit breakers) on larger motors such as 150 HP and above can cause MCP trip during start-up and the setting cannot be adjusted beyond the 13 times full load amperes (i.e. FLA) per NEC. Use thermal magnetic circuit breakers for motors larger than 150 HP. Additionally, when solid state starters are used, the circuit breakers should be thermal magnetic type.

c. Switchgear/Switchboard Rating Coordination

The circuit breakers shall be designed so that the main circuit breakers will not trip when a supplied breaker is overloaded.

DESIGN ENGINEER shall perform a short circuit fault performance study to determine levels of fault current throughout the facility. Calculation procedure and methods shall be in accordance with IEEE Red Book, Recommended Practice for Electrical Power Distribution for Industrial Plants. The selected electrical equipment interrupting and withstand ratings shall be based upon results of this study. The available fault current shall be obtained from the power company. The Arc Flash and Coordination Study and model is required for each station using ETAP software. The model shall be submitted to the District.

d. Line Power Monitoring:

The following line power failure conditions shall be monitored by protective devices.

1. Power Quality A PQM shall be connected using Ethernet Communications to the PLC cabinet. Meter (PQM) shall be provided and configured to display phase voltage and current on the lift station SCADA screen. The PQM shall have all power quality monitoring functions properly configured and provide dedicated dry contacts closure to the PLC for alarms input for unbalanced current/voltage, high/low voltage, and phase loss, and shall be configured to calculate and output current and historical cost of usage data to the SCADA historical servers.
2. Coordinate with the District Representative to determine additional information and alarms to be transmitted by line power monitor to the PLC and SCADA system. Line monitor system shall not trigger the ATS or otherwise interrupt power unless specifically required by the District.

e. Ground Fault Protection

1. The project specifications shall include a requirement for the CONTRACTOR to provide a qualified NETA Accredited independent sub-CONTRACTOR who will test and provide written certification of complete ground fault testing and verification.
2. Ground fault protection (GFP) shall be provided on main circuit breakers, when the service is 800A or larger.

f. Grounding System:

Install a 10-foot copper bonded grounding rod in a groundwell. Grounding to cold water piping is not acceptable. Ground connections to the buried grounding system shall be made at all electrical enclosures and equipment. Ensure adequate corrosion protection of the ground rod system and bare copper grounding wire. All grounded connections shall be exothermic (welded) connections. No bolted connections shall be buried.

2.5.5 Motor Starter Design

- a. Across the line starters shall be used up to 25 HP. Starters shall incorporate solid state adjustable overloads and reversing contacts for condition based reverse cycle cleaning. All local wiring and PLC

- I/O to utilize condition monitoring controllers for reverse cycle clearing shall be provided.
- b. For over 20 HP, either VFD's or solid state soft starters shall be used based on the study of constant speed versus variable speed drives performed by the DESIGN ENGINEER.
 - c. Soft starters shall be fully featured and include across the line bypass for starting. Acceptable soft starters are Allen-Bradley SMC flex, equal, or better as determined by the District Representative.
 - d. VFD/soft starters require across the line bypass at the discretion of the District Representative.
 - e. Solid state motor starters shall have adjustable current limit of 50 to 150 percent of full load current and acceleration time adjustments. Solid state starters shall have over temperature protection.
 - f. Variable speed controllers used for lift station pumps and the related electrical system must be sized and field programmable to be capable of accelerating the pump to full speed within 10 seconds and holding this set point for up to 60 seconds before ramping to the control signal set point. This provides for adequate clearing of accumulated wastewater debris and less frequent pump plugging typical in raw sewage pumps
 - g. All motor starters shall be equipped to provide under-voltage release and overload protection on all three phases. Additionally, all motor starters shall provide the following:
 1. Motor starter coil and contacts shall be easily replaceable without removing the motor starter from its mounted position or the removal of phase conductors.
 2. Provide fuses on the primary and secondary sides of the control power transformers. Install separate power control transformer for each motor starter.
 3. For small appurtenant equipment and other applications, motor starters shall be vertical actuation type
 4. Motor starters shall meet NEMA standards, minimum size is number 1.
 5. Overload relays shall be of block-type, utilizing eutectic melting alloy type spindles, and shall have visual trip indication with trip-free operation.

6. Pressing of the overload reset lever shall not actuate the control contact until such time as the overload spindle has reset. The reset lever shall be accessible through the control panel door. Resetting of the overload reset lever will cause a snap-action control contact to reset, thus reestablishing a control circuit.
 7. Overload relays shall be manual and automatic reset. Trip setting shall be determined by heater element only and not be adjustable settings. Overload elements shall be melting alloy type.
- h. Emergency Motor Controls
1. Motors over 25 H.P.: Motor winding imbedded "motor high temperature" pump interlock.
 2. Provide pedestal mounted emergency stop/lock-out-stop push button at pump unit.
 3. **Special Station Requirement – Rehabilitation/Retrofit of below grade MCCs:** For protection of below grade MCC/control panel locations not rated for submergence, in event of flooding, "Dry well flood" float switch shall cause an alarm to the PLC and SCADA, and at the direction of the District Representative, may also cause main breaker and/or emergency generator breaker shunt disconnect.
- i. Motor Starter Circuit Hand Operation
1. Design this circuit so that in "Hand" (Local Control) position, the circuit interlocks including the motor over-temperature and motor starter overload contacts shall be "hard relay wired" outside the PLC to allow operation of this circuit in hand should failure of the PLC occur.
 2. Design control circuit so that "Local Control – Off – Remote Control" (L-O-R) switch selection to "Off" or "Local Control" operation or lockout of circuit breaker sends status to PLC/SCADA but does not result in alarm.
- j. Pump Status Indicator Lights:
- For each pump include the following LED indicator lights on the pump control panel: pump call (white); pump running (green); pump off (red); pump failure (amber).
- k. Pump Run Time:

Pump run time for each sewage pump shall be displayed on the lift station secondary SCADA screen, and configured to be resettable upon pump overhaul or replacement.

1. **Special Station Requirement:** Coordinate with District Representative to determine if physical elapsed time meters should be provided to provide backup to software-based meter

l. Telemetry Alarms:

Refer to District Standard Specifications and Drawings in the Attachments to the LS-DCS.

m. Station Status and Alarm Condition Panel:

Special Station Requirement: New CCWRD lift stations do not typically include annunciator panels. Coordinate with District Representative on the need/type of local control panel display or annunciator to indicate normal lift station status conditions, and also all alarm conditions. The alarm conditions to be indicated shall correspond to the telemetry alarm points.

1. Panel Indicator Light Bulbs:

If an annunciator is required, all indicating lights and alarm annunciator lights shall be connected to a "push-to-test" button to test for proper functioning of the bulbs. Lamps shall be L.E.D. type.

n. Alarm and Control Relay Resets

Provide per current District Standard Specifications

- o. Provide and install condition based plugging detection and reverse cycle controller for each pump. Current acceptable proprietary controller inventoried and certified for District use is Deragger II (or current version). manufactured by Clearwater Controls, with no known equal.

2.5.6 Telemetry and SCADA Programming

Provide telemetry per current District Standard Specifications and Drawings. After the requirements found in Attachment 3 and elsewhere in these standards are followed, the District is responsible for programming the SCADA (Supervisory Control and Data Acquisition) computer system once a project is actually in design. SCADA is used for gathering and analyzing real time data and remote control of the lift station. No advance copies will be provided due to cybersecurity concerns. The District will also

coordinate the migration to the next generation automatic control system, such as HMI (Human Machine Interface), as it becomes available.

2.5.7 Standby Power System

a. Standby Power:

1. Backup power sources shall provide status signals to the lift station PLC for remote status and alarming. The ATS is to be networked to the PLC for additional information beyond the hardwired signals. Signals wired from the backup power source and monitored by the PLC shall include as a minimum: Utility power unavailable, generator running, generator fault, low fuel, ATS transfer plus any other conditions that could limit the availability of the backup power source or indicate utility power failure.
2. Power service panels for District Lift Stations shall be connected to a stand by generator, automatically started upon loss of utility power, and incorporated via an automatic transfer switch and generator control cubicle with an external manual operation handle and fully programmable power transfer/retransfer scheming and generator exercising features.
 - i. Generator and transfer switch specification approval is to be per District requirements.
 - ii. The generator shall be sized to operate the station at full design capacity without risk of overload while running continuously in the region's most extreme weather conditions.

Special Station Requirement: For new Small Stations, or at stations being rehabilitated or retrofitted, check with the District Representative on whether a permanent generator should be installed. In some cases, subject to District approval, only the mobile generator electrical connection plug will be required.

- iii. Fuel type shall be Natural gas where utility is locally available; otherwise Diesel Fuel.
- iv. All lift stations shall have a mobile generator electrical connection plug installed on the approved transfer switch per District specification, to connect a mobile stand by generator, in the event of generator failure. See Section 2.5.7.e.

- b. Automatic Transfer Switch
 - 1. The station shall have an interlock protected standby power transfer switch to automatically start the generator in the event of loss of any phase of power, reverse power or low voltage brownout.
 - 2. The transfer switch shall include time delay controls for the following functions: prevent start/stop short cycling of the emergency generator due to momentary dips in line voltage; transfer the load to the generator when it is at rated voltage and frequency, return to line power with adjustable time delay when line power is restored, and initiate an engine shutdown
 - i. Note: Provide "programmed neutral" time delay (i.e., adjustable 0-10 second to allow equipment to coast off before transfer) or in-phase monitor (i.e., large units to match generator-to-line phasing).
 - 3. The transfer switch shall have an interlock for isolation to prevent auto operation during maintenance.
 - 4. Provide "Load Sequencer" control with two NC and two NO auxiliary contacts for the control system that can operate prior to transfer in either direction (i.e., to avoid control/alarm relay problem as required at transfer). All transfer switches shall have load shed or synchronization controls to avoid current surges due to out of phase conditions at transfers.
 - 5. The transfer switch shall have the capability of being programmed to perform unsupervised generator exercising.
- c. Manual Transfer Switch (Special Station Requirement)
 - 1. The manual transfer system shall require the use of an enable latch or key to sequentially open the line power service and then transfer to the emergency power service connection.
 - 2. The DESIGN ENGINEER shall ensure that the transfer switch is rated at the same amperage interrupting capacity (AIC) withstand rating as the line power service.
 - 3. The following warning sign shall be posted on the transfer switch panel: "DO NOT TRANSFER POWER WHEN UNDER LOAD"
- d. Stand By Generator Installation Location

1. For outside installation, the stand by generator shall be installed under an overhead roof for protection from the elements. This overhead roof shall be equipped with a 115 volt electrical service and lighting.
 2. Generators installed outside the building shall be installed inside a noise attenuating/security enclosure with access panels secured by padlocks. This enclosure and the generator control panel as installed at the site shall be completely secure from entry by rodents or other small animals. The noise attenuation be sized for 75 dba at 23 feet.
- e. Standby Plug-In Connection:
- At all stations, install a manual transfer switch and an emergency plug-in power connection to the station for use with a portable generator. The plug-in connector shall be a Hubbel, Part No. HDL4100MI9W, or for services larger than 100 amps, a “Camlock” system.
- f. Maintenance Service Contract:
- A one year service contract shall be provided by the Stand by Generator Vendor (CONTRACTOR) as part of their requirements as listed in the design specifications. This service contract shall include all routine service checks recommended by the manufacturer during the first year of operation including the following: changing fluids; adjusting drive belts; adjusting/checking all equipment; monthly exercise of unit under load. The CONTRACTOR shall coordinate this work with the District.

2.5.8 Other Station Requirements

- a. Site lighting and Emergency Lighting:
 1. Outdoor station lighting shall be LED type fixtures, mounted to direct the light in a downward direction. The fixtures will be shielded from structures on adjacent properties. Typically, lighting shall be installed at the midpoint elevation on the interior side of the block walls with the lighting directed down.
 2. In dry wells and in sites with buildings, install and provide lighted LED exit signs at the station access doors.
- b. Corrosion Control System (Special Station Requirement)
 1. When required due to corrosive soils or special considerations: install corrosion control equipment as required to protect the

station buried piping and force main which can include the following: cathodic test stations; sacrificial anodes; impressed current; rectifiers; insulation flange kits; and pipe flange bonding wiring (for continuous bonding). Nylon insulation bushings are to be installed between dissimilar metals in piping (i.e. brass fittings connected to manifolds), between pumps and inlet and discharge piping (to insulate from inductance current caused by motors as required in Impressed Current Corrosion Control Systems).

2. Install an electrolytic insulating blanket on corrosion protected pipelines installed near corrosion protected natural gas lines. Ensure a minimum of 25 feet of separation between the lines and install the blanket to extend 25 feet either side of the pipeline at the crossing.
3. Corrosion control system and protective coatings on the force main piping shall be designed to ensure protection for the useful life of the station (typically 50 years). Buried and submerged force main and gravity pipeline materials shall be constructed of materials resistant to corrosion. Buried poly-wrapped ductile iron piping is not allowed on lift station sites.

2.6 VENTILATION

2.6.1 General Requirements

- a. Dry Well Required Air Changes:

DESIGN ENGINEER shall provide an adequate ventilation system as required by NFPA 820. No less than twelve continuous air changes per hour plus additional requirements for motor and switchgear cooling as required shall be provided for the dry well by a powered supply and exhaust system. Lift Station ventilation shall be continuous and positive ventilation flow shall be monitored with a proof type "sail switch", or similar, and provide dry contact indication to the PLC for loss of ventilation alarm. Intermittent ventilation, if allowed by the District, shall maintain a minimum of 30 air changes per hour. For small package type duplex lift stations, the ventilation system shall be capable of being programmed to run intermittently via the PLC programming for preset time periods, and run continuously while the hatch entry is opened. The air change requirements shall be based on 100 percent fresh air.

- b. Air Supply/Exhaust Locations:

Air shall be supplied into the dry well pump room at ceiling level and removed (suction ports) at floor levels. Air shall also be supplied at ceiling level and removed at floor level from the upper level motor control center room when H₂S infiltration is possible in this environment. For buried duplex package type lift stations, the ventilation air supply and exhaust points shall be located 36 to 48 inches above grade and conveyed in properly sized duct work of material suitable for the installation conditions. The above grade supply and exhaust duct piping shall be of rigid metal and terminated with 180 degree turndowns, capped with ¼ inch stainless wire mesh to protect against rain, debris, and rodent entry. Position ventilation inlet/exhaust points as per 2.6.2 so that no short circuiting or recirculation of exhausted dry well air/gasses into the station could occur

c. Ductwork Materials:

Ductwork for all applications except wet well exhaust shall be constructed of aluminum with PVC coating/lining. Wet well exhaust ductwork shall be constructed of fiberglass reinforced polyester (FRP). All diffusers, registers, and dampers shall have nylon bearings, stainless steel shafts, and be PVC-coated aluminum or FRP matching the connecting ductwork material.

d. Maintenance Access Covers and lubrication points:

Provide access covers for ease of maintenance of motors and fan pulleys

e. Location of Fan Installations:

Locate supply and exhaust fans as appropriate for the lift station dry well construction type, always either:

1. At least 5 ft above the floor of the dry well (typical in manufactured duplex units), or
2. Above grade at the dry well roof exterior for larger in-ground type construction.

Fans are required to be readily accessible with short portable ladders.

f. Ventilation Filters (Special Station Requirement):

Install a pre-filter and a high-efficiency final filter on inlet vent ducting for noise attenuation and to minimize dust in the station. Filters shall be located for convenient maintenance access, and be provided with

an access cover. Label the filter locations to alert the operator to the need for periodic maintenance of the filters.

g. Rodent Proofing Openings:

Ventilation openings shall be provided with stainless steel screens, secured with stainless steel fasteners, to prevent the entrance of birds, rodents, and other small animals.

2.6.2 Avoiding Ventilation Cross Circuiting

a. Ventilation Short-Circuiting Considerations:

Locate the ventilation air inlet upstream of all exhaust air outlets relative to the prevailing wind direction. The minimum separation between any air inlet and discharge outlet shall be 10 feet, and inlets/outlets should be located at opposite ends of the dry well when possible. Ensure that ventilation inlets are not located where emergency generator exhaust or wet well venting can be drawn into the station ventilation. Both these potentially hazardous discharges should be vented at the roof level to provide dispersion.

2.6.3 Noise Attenuation

a. Maximum Allowable Noise Levels at Property Line:

Maximum allowable outside sound level at the property line shall be 45 dbA. Install acoustic doors, inlet and outlet baffles/silencers; locate fans away from the inlets and outlets or other measures on the station as required.

b. Maximum Allowable Noise Levels Inside Station:

Provide acoustic liners in the ducting and take any other measures as required to minimize ventilation noise inside the station such that the noise does not interfere with voice communication, or constitute a hearing hazard.

2.6.4 Wet Well Ventilation, Future Odor Control Provisions

CCWRD has standardized the installation of passive infrastructure at new lift stations to accommodate the potential future installation of odor control systems by CCWRD. For rehabilitation or retrofit of existing lift stations, coordinate with the District Representative for any Special Station Requirements specific to active odor control or power ventilation requirements for wet wells.

Provide the following infrastructure at wet wells to accommodate future installation (by CCWRD) of wet well ventilation and odor control systems:

a. Odor Control Pad

All stations require an Odor Control Pad with associated stub connections noted in the subsequent sub-sections. Refer to Standard Plate SP-27 for construction details.

1. Size:

- i. Small and Duplex Stations: 20 ft x 20 ft
- ii. Triplex and Large Stations: 40 ft x 40 ft

2. Fence:

- i. If site is not otherwise secured by a fence or wall, provide 10 foot high chain link fence with privacy slats around the Odor Control Pad.
- ii. Provide fence with 20 foot wide gate for ingress/egress
- iii. Provide signage on fence gate stating "PROPERTY OF CCWRD". Coordinate sign size, font, and color with District Representative.

b. Gas Phase Ventilation Suction and Discharge Pipe

Gas Phase Ventilation Suction Pipe is NOT required for Small Stations (coordinate with District Representative to categorize facility), but is required at all other stations. Refer to Standard Plate SP-10 for construction details.

- 1. Scrubbed Volume (cubic feet): Defined as the contained volume, in cubic feet, above the "Low Level" (All Pumps Off) of all buried facilities on the lift station site that is directly connected to the wet well and collection system, including the wet well, grit/rock catcher, and connecting piping. The Scrubbed Volume terminates at the lift station property line.
- 2. Ducting shall be circular FRP and, where installed above grade, shall be coated with an ultraviolet resistant coating such as polyurethane.
- 3. Connect suction vent pipe to wet well at a location/orientation closest to the Odor Control Pad. Connect to wet well (and grit/rock catcher) at least 5 feet above crown of sewer inlet pipe.
 - i. In addition to suction vent pipe, provide riser ventilation duct of equal diameter on the opposite side of the wet well to act as the future air inlet. See Standard Plate SP-10 for

- installation details. Provide inlet vent riser with 180 degree turn-down above grade (bottom of turn down at least 36 inches above finished grade) and install passive odor control and rodent proof screen.
- ii. Where a lift station also has a grit/rock catcher per Section 2.8.3, connect the grit/rock catcher to the wet well with an additional (separate) vent pipe of same diameter as the main wet well vent pipe (sized per Table 2-3 below), and include the grit/rock catcher volume in the Scrubbed Volume.
4. Terminate vent pipe from wet well at corner of Odor Control Pad closest to wet well as shown on the SP-21. Provide with airtight secured cap a minimum of 3 feet above Odor Control Pad finish grade.
 5. Size wet well vent inlet and outlet (and connection to grit/rock catcher, if applicable) at least 8-inches in diameter, or as per Table 3.6-1 below:

Table 2-3. GAS PHASE MINIMUM VENTILATION PIPE SIZING

GAS PHASE VENTILATION PIPE SIZING	
Scrubbed Volume (cubic feet)	Duct Diameter (inches)
< 1,250	8
1,251 – 1,950	10
1,951 – 2,800	12
2,801 – 3,800	14
3,801 – 5,000	16
5,001 – 6,300	18
6,301 – 7,800	20
7,801 – 11,250	24
11,251 – 17,500	30
17,501 – 25,000	36
> 25,000	Submit hydraulic calculations

6. Note: The above table includes the following future criteria assumptions, to be used by the DESIGN ENGINEER for facilities with Scrubbed Volumes more than 25,000 cubic feet, or for when Odor Control Pads are more than 200 feet from the wet well connection:

- i. Continuous scrubbing at 10 air changes per hour
 - ii. Pipe velocity less than 10 feet per second (for future noise considerations)
 - iii. Friction losses of less than 1 inch water column per 100 feet of pipe. Vent pipe is assumed to be less than 200 feet long.
7. In Special Stations and when required by the District Representative, the DESIGN ENGINEER will be required to perform air flow analysis calculations. The Spitzglass equation for airflow or an equivalent District approves method may be used. The design criteria shall follow:
- i. Air flow velocity in pipes shall remain below 3,000 feet per minute for below grade applications and 1,500 feet per minute in above grade applications where neighbors can be disturbed by noise.
 - ii. Head loss shall remain below 1 inch per 100 feet of pipe length
 - iii. The table below provides maximum airflow guidelines per the previous requirements of 3,000 feet per minute and 1 inch per 100 feet.

iv.

Table 2-4. MAXIMUM AIRFLOWS

MAXIMUM AIRFLOWS			
SWR Pipe Diameter In	Airflow cfm	Velocity ft/min	Head Loss in/100ft
6	350	1,783	1.0
8	750	2,149	1.0
10	1,300	2,384	1.0
12	2,090	2,661	1.0
15	3,600	2,934	1.0
18	5,300	2,999	0.9
21	6,500	2,702	0.6
24	9,400	2,992	0.7
27	11,900	2,993	0.7
30	14,700	2,995	0.6
33	17,800	2,997	0.6
36	21,200	2,999	0.6
42	28,800	2,993	0.5
48	37,700	3,000	0.5
60	58,000	2,954	0.4
72	84,000	2,971	0.4

- c. Liquid Phase Conduit (Blank):
1. See Standard Plate SP-27 for installation of blank Liquid Phase Conduit for future installation of odor control chemical feed by CCWRD.
 2. Provide 2-inch diameter PVC conduit with drag line, from Odor Control Pad to discharge manhole upstream of wet well.
 - i. Install 2-inch conduit at least 4 feet horizontally from Gas Phase Ventilation Pipe. 4 feet separation applies to trench separation and also to Odor Control Pad stubs.
 - ii. Stub up conduit through Odor Control Pad at least 6-inches above finish grade and provide air-tight cap.
 - iii. Bury conduit minimum 3 feet deep to top of conduit. Install with smooth bends and sweeps. Angled fittings not allowed. Slope conduit at minimum 2% slope towards

discharge manhole and stub into discharge manhole 6-inches and provide air tight cap.

- iv. Conduit to be left blank with drag line in place for future use by CCWRD.

d. Future Power Supply to Odor Control Pad:

Provide one (1) blank 4-inch power conduit with drag line from the Odor Control Pad to the site power supply duct bank(s). Stub blank 4-inch power conduit up through Odor Control Pad at least 6-inches, and provide with air tight cap. Locate power stub in Pad as per standard detail, and at opposite end of Potable Water Supply line.

e. Potable Water Supply Pipeline to Odor Control Pad:

1. Provide 2-inch diameter water line from site water supply line. Install with corp stop so that pipeline can be tested, drained, and then left in place inactive for future use.
2. Stub up through Odor Control Pad at opposite end of Pad from electrical connection. Extend water line at least 3 feet above finish grade of slab and cap with a secure fitting for future use. Provide pipe support and insulation for waterline above Pad grade.
3. Pressure test waterline as per CCWRD specifications and then drain after acceptance.

f. Passive Odor Control:

Provide for passive venting through a properly sized odor control canister containing activated charcoal. Charcoal canisters shall conform to the DCSWCS, and be of a design which will permit replacement of the media when required.

2.6.5 Air Conditioning/Cooling Systems

a. Electrical Rooms:

All dedicated lift station electrical rooms shall be ventilated at a minimum of 6 air changes per hour and equipped with package heat pump units which can control the full load room temperature to 72 deg. F year round. Filters shall be as specified and as required by the equipment manufacturer.

b. Panel Cooling: (Special Station Requirement):

Where required for VFD units or other specialized electronic equipment, provide dedicated panel air filtration and/or air conditioning equipment for special treatment of the panel air temperature below 90 degrees Fahrenheit. Filters shall be as specified by the manufacturer and the pre-filter shall be the washable-type. Provide sunshades and enclosures as specified in Section 2.5.3. All PLC and network cabinets require air conditioning to prevent temperature rise above 90 degrees F. This is a requirement even if located inside an air conditioned electrical room.

2.7 DRY WELL

2.7.1 General Requirements

a. Above-Grade Building/Fenced Area Construction:

Lift stations shall generally be constructed with an above grade building housing the electrical panels, motor control center, control panels and pump motors. Where a separate electrical building is not provided, electrical/controls equipment shall be located in a fenced and shaded area conforming to Section 2.5.3, all other District electrical specifications, and outdoor wet locations in accordance with National Electrical Code, NFPA 70.

b. Stairway Access:

All lift stations shall generally have stairways constructed for access to all levels of the dry well. Stairways may be constructed of cast- in-place concrete or anodized aluminum structural members. Stairs shall be equipped with safety rails, kick plates, non-skid nosing plates or safety treads, and safety chains (at access openings as required). Where aluminum safety rails are installed on cast- in-place concrete stairs, provide rubber corrosion insulating strips at contact points with concrete.

c. Underground Station Access Stairs:

Where stations are constructed without an above-grade building, stairways for access into underground stations shall be installed instead of ladders, depending on the size of the lift station. Provide railings and/or multiple detachable chains around stairway access openings for employee and public safety. Install nonskid stair safety tread. Opening the dry well door shall automatically light the stairway. Stairways shall also be constructed between floors. Exceptions for pre-manufactured lift stations shall be considered. All lift stations with personnel access to depths greater than 20 feet shall be provided

with an automatic man lift in addition to the provided stair or ladder access.

d. Underground Station Equipment Hatches:

For safety reasons, the dry well for underground lift stations shall have two separate access hatches in addition to the stair access hatch. One access is for personnel entering by safety tripod and the other for removal of equipment. Access floor doors shall be AASHTO HL93 truck load rated, dual leaf type fitted with stainless steel hinges and stainless steel vertical spring in a closed tube, spring balanced doors requiring a maximum force of 40 lbs. Provide a recessed padlock compartment in the doors. Opening of stair access hatch shall automatically turn on the lights. Exceptions for pre-manufactured lift stations shall be considered.

A ladder-up or equivalent hand-hold ladder entry device shall be provided at every manway into the lift station.

Personnel access hatches and equipment access hatches shall be located such that ladder up devices do not interfere with the movement and removal of equipment. Manways should not be "in line" with equipment access.

Provide all accesses and hatches with removable fall protection netting.

e. Personnel Access to Equipment-Elevated Platforms:

All equipment requiring routine maintenance or operation (i.e., isolation valves, air valves, pump shaft U-joints, eye bolts for chain hoist attachment, etc) that cannot be designed to be accessible from the floor level, shall have access provided by catwalk platform with 42 inch high Schedule 80 guardrails. Provide a ladder or stair access to the platform. The ladder shall be provided with installed safety climb rail and harness equipment, and a Ladder Up Post, hand rail or safety post that extends 3 feet above the ladder for safe access, Miller Industries or equal or as required by OSHA.

f. Rolling Stairway for Equipment Access (Special Station Requirement):

An alternative to the platform access described in the preceding subsection is installation of a rolling stairway in the pump room and/or intermediate levels. This stairway is to provide safe access to the equipment described in the previous subsection that requires routine access during operation and maintenance.

g. Fire Extinguishers:

Install fire extinguishers rated for Class A, B, and C fires in the motor room, motor control center room, pump room and standby generator room/area.

h. Fire Rated Doors:

Install NFPA-approved fire resistant door between the standby generator room (if provided in same building) and the rest of the dry well.

i. Dry Well Lights:

LED type lighting shall be used. All lighting must be easily and safely accessible for relamping or fixture replacement, with no special equipment or access measure needed, beyond stepladders, for its service or replacement.

j. Safety Lighting:

Provide battery back up LED emergency lighting in egress paths and in stairways.

k. Safety Warning Signs:

Safety warning signs shall be posted near all hazardous equipment in plain, unobstructed view and shall include warnings for automatic starting of pumps and other equipment. Warning signs shall include the following: Warning Automatic Starting Of Equipment, Warning High Voltage (at Main Service Center and Motor Control Center), and Warning Hazardous Chemicals (at odor control systems).

l. Concrete Surface Sealing:

All interior concrete floor surfaces of the dry well shall be protected with a sealer/hardener finish coating with a non-skid additive

m. Non-Skid Coating:

Provide non-skid type floor finish coating around equipment where maintenance will be performed.

All dry well floors shall be coated with high traffic sulfuric acid resistant epoxy coating that shall extend 12 inches vertically on all wall surfaces. The above applies to, but is not limited to, floors in dry-wells, valve vaults, odor control facilities, and any floor, pedestal or surface exposed to raw wastewater or chemical attack.

n. Equipment Maintenance Clearance:

All equipment shall have 42-inches clearance from other equipment for maintenance and repair work space requirements.

o. Safety Guards:

OSHA Safety guards shall be placed around all moving machinery parts including pump drive shaft assemblies, large counterweighted check valve arms, etc.

p. Valve Wrenches:

Gate keys required for turning station valves shall be provided along with a wall bracket mounted inside the station for storage of the gate keys.

2.7.2 Equipment Removal

a. Hoist Clearance:

Ensure adequate horizontal and vertical clearance between overhead crane hoists and other installed equipment to allow lifting and moving motors and pump equipment to the station doors or out thru vertical access hatchways. Crane rails shall extend beyond double entry doors to allow removal of equipment from the dry well building. Rubber enclosure flaps shall be installed where the crane rail exits through the door cutout.

b. Pump Equipment Hoisting and Positioning:

A system of hoists, cranes, eyebolts, rigging hardware, and manual chain hoists shall be provided to safely install, remove, and position all lift station pumping equipment associated mechanical piping at the lift station. All rigging devices, ladders, chains, and hardware required to accomplish these tasks shall be provided. Eyebolts shall be mechanically connected to the reinforcing bar with a structural insert.

Hoisting support systems shall be designed and specified per the Crane Manufacturers Association of America (CMAA) standards. [CMAA 70](#) – Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling Cranes and [CMAA 74](#) – Specifications for Top Running & Under Running Single Girder Electric Traveling Cranes Utilizing Under Running Trolley Hoist.

Contract documents shall indicate that the contractor shall be required to install pumping and all other equipment serviced by a rigging system, after this hoisting system is in place and shall employ

the permanent hoisting system to install the equipment in order to demonstrate the hoisting system vertical/horizontal alignment, clearance and accessibility are adequate.

c. Traveling Overhead Crane Rail Hoists:

For electrical spark hazard safety, traveling rail trolley hoists shall utilize extending power cords (i.e. instead of open bus type electrical power source) to supply power to the unit trolley as it moves along the crane rail. Crane capacity rating plate shall be installed as to face the entrance to the facility.

d. Equipment Hatches:

Equipment hatches and rail hoists shall readily allow removal or installation of equipment in the station. Access floor doors shall be AASHTO HL93 truckload rated, single leaf type fitted with end chains, stainless steel hinges, stainless steel vertical spring in a closed tube, and be spring balanced doors requiring a maximum force of 40 lbs, Bilco Inc., or equal.

2.7.3 Hazardous Gas/Low O2 Detection Sensors

a. Multi Gas Sensors and Alarms:

Multi-gas type sensors and alarms shall be provided in accordance with CCWRD Standard Specifications.

b. Access to Sensors:

Provide ladder with safety climb rail for access from motor or MCC room to sensors mounted above 5-feet height on the wall.

c. Hazardous Gas Warning Sign:

Locate following warning sign in each area of the lift station:

Warning: Possible Hazardous Gas Conditions. Continuously Operate Portable Hazardous Gas Detection Equipment Inside Facility.

d. Indication:

Detection system shall indicate hazardous conditions even without PLC connections.

2.7.4 Finishes and Standardized Paint Schemes and Lettering

a. Piping Color Scheme and Markers:

Identify piping associated with equipment and other utility lines and identification devices for all hazardous chemicals storage and conveyance facilities and shall include the use of pipe markers that indicate the type of utility line and the flow direction. Table 2-4 shows the color identification scheme for piping.

Table 2-5. EXPOSED PIPING IDENTIFICATION SCHEDULE

Fluid Abbreviation	Function & Identification	Identification Color	Remarks Suggested Tnemec Color or Equal
CA	Compressed Air	yellow	Safety Yellow
CS	Sodium Hydroxide (NaOH)	orange	Safety Orange
EE	Engine Exhaust	Yellow	Safety Yellow
FA	Foul Air	yellow	Safety Yellow
IA	Instrument Air	yellow	Safety Yellow
PRW	Process Water, Industrial Water, Seal Water	Purple	purple
PW	Potable Water	blue	blue
RS	Raw Sewage	green	green
SHC	Sodium Hypochlorite (NaOCl)	orange	Safety orange
Valves		See Remarks Column	Same color corresponding to fluid being carried
VD	Ventilation Ductwork	yellow	Safety Yellow
NG	Natural Gas	Yellow	Safety Yellow
APWA Uniform Color Code was used as the basis for selecting colors	The orange color for the caustic chemicals deviates from APWA.		

b. Paint Scheme for Other Equipment:

The paint scheme for other equipment shall comply with CCWRD Standard Specifications. The types of equipment may include engines, generators, air compressors, and their accessories, and hazardous chemicals storage for odor control systems. The paint scheme for equipment not included above shall be as directed by the District Representative. The following table represents other equipment and is in general compliance with CCWRD Standard Specifications.

Table 2-6. COLOR IDENTIFICATION SCHEDULE FOR EQUIPMENT AND ASSOCIATED PIPING

Equipment Type	Color
Pumps (service pumps) Piping	OSHA Safety Blue OSHA Safety Red
Air Compressor Compressed Air Pipe	Light Green with Dark Green Bands White
Drive Shaft Guard Cage	OSHA Safety Red
General Hazardous Equipment, Valves	OSHA Safety Red
Overhead Crane Rail/Lifting Hook	OSHA Safety Yellow With Black Striping
General Warning – Equipment	OSHA Safety Yellow
Outside Parking Post	OSHA Safety Yellow With Reflectors
Electrical Conduit	Galvanized Rigid Steel
Generator	Manufacturer's Yellow

2.7.5 Sump Pumps

a. Piping to Sump Pump:

Drain the dry well into a sump in the pump room. The sump shall be easily visible from the floor above. Do not drain upper lift station levels directly into the wet well (odor problems may ensue, and a flooded wet well will flood the station). When possible, place sump pump below a hatch to allow for easy access to the sump pumps for replacement.

b. Sump Pump Features:

Sump pumps shall be designed with the following features: Minimum solids passing capability of 3 inches; motor over temperature and seal chamber moisture detection alarms; recessed vortex impeller or non-clog type impeller. Two pumps (one duty and one reserve) shall be provided; and the pump control panel shall be located at the MCC level. Specify pumps with heavy duty rating (bearings and seals) suitable for pumping solids and grit that can operate without overheating in a partially submerged condition. The pump shall include the following features: lower shaft bearings, stainless steel shaft, double silicon carbide mechanical seals, and oil-filled motor. The pump power leads shall plug into an electrical outlet for ease of replacement. Locate this outlet in an accessible area above the height of the raw sewage pump motors. Triplex and Large Stations shall

have two (2) pumps, and the sump pump alarms tied into the District's SCADA system.

c. Sump Pump Discharge Piping Features:

Piping installation shall be designed with the following features: sump opening shall be covered with FRP grating and 316L stainless steel frame opening; PVC discharge piping and fittings, a union at the connection to the PVC discharge piping (to allow pump removal for maintenance); cleanout tee fittings at elbows; swing check valves mounted in a horizontal position (to prevent jamming from sedimentation); and ball type PVC isolation valves on sump pump discharge piping. Route sump pump discharge into the wet well 2 feet above the maximum high water level, or to the first sewer manhole upstream of any wet well which contains an inlet isolation gate.

2.8 WET WELL

2.8.1 Inlet Design

a. Inlet Pipe:

Design the wet well inlet sewer such that its invert is at least 6-inches above the high water operating level. (Note: ensures unusual inlet sewer conditions do not exist that could cause odor problems to occur at upstream sewer lateral roof vents of buildings due to back up of odors from the station wet well). Provide a wall slope below for the flow to flow down, rather than discharging vertically to the water surface. Locate the inlet so that flow is evenly distributed to all the pump suctions. The inlet discharge shall be designed to minimize turbulence and odor generation, and shall be designed in accordance with ANSI/HI 9.8 Pump Intake Design Standard for solid-bearing liquids.

b. Inlet Sewer:

The inlet sewer shall be designed to minimize turbulence and odor generation. Design the line to avoid hydraulic jumps or other conditions that can result in sealing of the air flow space above the water flow line, which can create upstream odor conditions. Flow shall be sub-critical and normal depth for at least the final 10 feet before entering the wet well.

c. Discharge Flow Meter (Duplex, and Special Station and where required by District):

Duplex, Triplex and Large Stations shall have a magnetic flow meter on the discharge force main. Strait pipe clearance (with no valves or other type of flow impedance) shall be provided based on manufacturer's recommendations; however, not less than 5 times the pipe diameter upstream from the flow meter and 3 times downstream.

d. Spill Location:

The influent sewer and lift station spill locations shall be indicated on the design drawings (i.e., lowest upstream elevation or wet well cover elevation where backup spill will occur). Include M.S.L. (mean sea level) elevation information for spill location. Drawings shall indicate "PROB. SPILL POINT EL. XXXX.XX" in a bold box with an arrow pointing to the location in plan view.

2.8.2 Hydraulic Design

a. Suction Elbow:

The distance between the wet well floor and the turned down bell mouth suction inlet of diameter "D" shall be a maximum of D/2 and a minimum of D/4, but not less than 3.5 inches. Minimum submergence of the pump suction bell (the upper end defines the low flow level) shall be determined in accordance with ANSI/HI Section 9.8.7.

b. Self-Cleaning Wet Wells (Special Station Requirement):

Self Cleaning trench type wet wells shall be evaluated for use on Triplex and Large Stations as identified by the District Representative. Wet wells shall be designed in accordance with the Hydraulic Institute Section 9.8 Pump Intake Design Standard for trench type wet wells for solids-bearing liquids. Velocity at the pump intake bell shall not exceed 3.5 fps. Separate overflow storage may be provided if sufficient storage volume cannot be provided in the wet well above the trench. Normal wet well operating level shall not exceed invert of inlet pipe. Design shall employ an electrically actuated inlet sluice gate for wet well level control during cleaning (when the wet well level is drawn down to the pump intake level). Note: This installation shall include non-submerged inlet, constant speed pumping, and overflow storage if required. See Standard Plate SP-11 for self cleaning wet well arrangement.

2.8.3 Grit/Rock chambers and Trash Racks

a. Special Station Requirement: Grit Chamber Required

Large Stations may require grit/rock catcher separation structures. Other designs shall be individually evaluated by the District for similar requirements to assure station operational reliability is preserved. The structure shall be fully lined or coated per wet well standards, incorporate a passive gated bypass overflow channel and inlet/outlet gates. All slide gates shall be electro-hydraulically actuated, with limit switches provided on actuated gates, and dual high level floats installed providing alarm signal to the PLC.

b. Special Station Requirement: Trash Racks

Installation of a 60 degree bar rack, automated step screen, or similar, shall be evaluated individually for each station based on station size and location. Where such devices are utilized, passive overflow/gate control shall be provided to protect lift station equipment and station reliability.

Passive overflow for both structures above (a and b), shall be designed to convey at a minimum the largest of design peak wet weather flow or lift station design capacity, with a freeboard determined by District representative on a case by case basis; as a general rule, the freeboard shall be no less than 3 feet. Overflow shall be easily accessible for cleaning and maintenance.

Where required by District Representative and where access openings for both structures above (a and b), exceed a 4x4 feet square area, install permanent or removable guardrailing systems per OSHA requirements, Schedule 80 minimum guardrail pipe elements are recommended.

2.8.4 Storage Volume Requirements

a. Volume Requirement

Size Operating Volume and Emergency Storage as per Section 2.2.5

b. Passive Overflow (Special Station Requirement):

For low lift stations, design a passive bypass flow line from the wet well to the discharge trunk sewer (TS) if a high wet well water level can rise above the discharge TS elevation without backup/flooding in the inlet line. Passive overflow shall be designed to convey at a minimum the largest of design peak wet weather flow or lift station design capacity. If the overflow is intended to work in a submerged upstream condition it should be evaluated as an inlet or outlet controlled culvert, in any case minor losses (including entrance and exit losses) shall be evaluated. Unless otherwise authorized by the District Representative, freeboard shall not exceed 3 feet. Easy

access for overflow cleaning shall be provided. Minimum overflow diameter shall be 8 inches, smaller diameters down to 4 inches may be allowed for two (2) or more pipes installations (for redundancy in case of clogging). Elliptical polymer concrete pipe can also be used.

2.8.5 Corrosion Protection

Corrosion Protection of Lift Stations shall conform to Chapter 3 of this Design Standard, and the District's current Clean Water Program Corrosion Control Standard lines. All fasteners in the wet well for piping and anchor bolts to be stainless steel 316.

2.8.6 Electrical Equipment Installation

a. Level Control: As per Section 2.5.3.g

b. Explosion Proof Installation:

Conform to Section 2.5.3. No junction boxes or covers shall be installed in the wet well. All electrical conduit and wiring into the wet well shall be NEMA 6P. All conduit penetrations into the wet well shall have NEMA 4X seal off fittings (exception: seal may be installed after splice connection in case of pump cable).

2.8.7 Wet Well Ventilation and Odor Control

a. Ventilation, Odor Control:

Refer to Section 2.6.4 for specific requirements regarding wet well ventilation and odor control. Provide penetrations for inlet and outlet of gas phase odor ventilation piping, including connection to grit/rock catcher structure where applicable.

2.8.8 Hatches, Emergency Access

a. Wet Well Access:

DESIGN ENGINEER shall coordinate with District to determine number, location and size of wet well access covers depending on station size and maintenance truck access by Vactor trucks and other equipment. Typical manhole accessibility is as follows:

1. Duplex Stations: Provide one (1) standard 36-inch diameter manhole cover conforming to DCSWCS Standard Drawing SD-2 on the wet well roof. Locate directly above pump suction area for Vactor truck access.
2. Triplex and Larger Stations: Provide two (2) standard 36-inch diameter manhole covers conforming to DCSWCS Standard

Drawing SD-2 on the wet well roof at opposite ends of the wet well for Vactor truck and personnel access to the pump suction area directly below.

- i. For trench type wet wells and those having a slide gate, trash rack, or other devices requiring maintenance, provide a third access for personnel access directly above the sewer inlet.
- ii. For large wet wells, provide additional accesses in coordination with the District Representative for access to other wet well equipment requiring maintenance that cannot be accessed from the other access points (personnel access is performed by lowering by tripod, and therefore accesses must be directly above such equipment). Locate wet well equipment to minimize the number of accesses.
- iii. Where required by District Representative and where wet well access openings exceed a 4x4 feet square area, install permanent or removable guardrailing systems per OSHA requirements, Schedule 80 minimum guardrail pipe elements are recommended.
- iv. For large wet wells, consideration shall be given to the installation of corrosion resistant (SST 316 or FRP) ladders above the operational levels of wet wells to alleviate the potential for drowning.

2.9 FORCE MAINS

2.9.1 General Requirements

In general, the requirements for force mains, especially that portion located outside the lift station site, shall be that as specified in the District's Section 2.5 "Design Criteria for Force Mains", in DCSWCS.

The force main positive uphill slope shall be maintained as required in the DCSWCS, however, on a case by case basis and as approved by the District, negative force main slopes shall be allowed to permit force mains to go under major storm drain boxes, major storm drain washes and channels, and other similar obstacles or geographic features.

a. Force Main Isolation Valves:

Install isolation valves on each force main both inside the dry well (located near the wall penetration) and upstream of the emergency

pump connections described in Section 2.4.1.h. Force main interconnection and valving is required to be arranged such that flows can be discharged via either, both, or split.

b. Flex Couplings at LIFT STATION Wall:

Install dual flexible couplings (dresser couplings) or ball and socket type fittings) shall be provided outside the station on the force main to allow for differential settlement.

c. Corrosion Protection:

All buried ferrous pipe, fittings, and valves shall be coated as specified in Chapter 3. Also, prior to backfill all carbon steel (including DIP) force main fittings shall be coated with a petrolatum or wax tape system, Trenton Inc., or equal per AWWA C217 and the manufacturer's recommendations. All fasteners on buried fittings shall be 316 stainless-steel.

d. Thrust Blocks:

Thrust blocks are allowed on a case by case basis, and only as a secondary backup system or at locations where future excavation of thrust block foundation will not be possible due to topography or other external factors. Provide thrust blocks at all bends on the force main. In constructing the required dual force mains, ensure that at bends, each force main thrust block is installed against undisturbed soil. Vertical thrust restraining clamps on siphon high points shall be specified as required to restrain the pipe. No vertical thrust blocks are allowed.

e. Restrained Buried Pipe Joints:

Specify restrained mechanical joints as required in special areas (steep sloped areas, fill areas without sufficient resistance to thrust) to ensure security of joints. Indicate locations of restrained joints on the drawings. Fittings that provide joint thrust restraint and/or joint rotation shall be provided as required by pipe guidelines: Uni-Bell, DIPRA, etc. and restraint manufacturers, e.g.: PEBA IRON, Megalug or Flexextend respectively.

f. Use of 45-Degree Elbow fittings:

To reduce the potential for stoppages where a 90-degree change of direction in the force main is required, show and specify two 45-degree elbows or a horizontal curve instead of a 90-degree elbow.

g. Force Main Separation and Pipe Joint Stagger:

Dual force mains shall be provided for each pump station, each having 100-percent of the design hydraulic capacity required. Construct the dual force mains in separate trenches with a minimum 5 feet separation between their outer surfaces. District approval shall be required for areas where obstructions or other restrictions exist and this separation cannot be maintained. Plans should contain a notation for staggering the pipe joints to lessen potential undermining if a leak occurs in either force main.

- h. For cleaning and inspection, provide bidirectional access fittings at each end and along entire length of force mains at 400 foot intervals. Access openings required to be minimum 4 inch or scaled to larger sized force mains for typical jet rodding and camera inspection equipment. Coordinate with District during pre-design.

2.9.2 Isolation Valves and Emergency Pumping Connection

- a. Solid Wedge Type Valves:

For buried applications and when approved by the District, provide "solid wedge" type gate valves for sewage applications with the following features: type 316 stainless steel stem, gate, and seat inserts, stainless steel fasteners in wetted areas, and fusion bond epoxy on all ferrous parts. Valves shall be designed for buried service with water tight bonnet and buried service gear operator.

- b. Isolation Valve Location:

Install isolation valves inside the station fenced-in area. Where difficult soil conditions exist or where valves may not be easily accessible, install the valves in a vault for easy access as per 2.4.1. Also locate valves as per 2.9.1 above.

- c. Force Main Drain Lines:

Install drain valves and piping on each discharge line manifold in the pump room or on the lift station site for draining each force main individually back into the wet well (for use during maintenance to repair leaks in one force main while operating the second force main). Consult with District Representative and District lift station supervisor to determine drain line sizing based on factors such as velocity management and passing of solids 3 inches and greater.

- d. Emergency Pumping Connections: As per Section 2.4.1.h
- e. Valving Diagram:

Specify a wall mounted plastic laminated diagram in the station that shows the location(s) of the dual force mains and the force main valving on the site.

2.9.3 Odor Control

a. Dedicated Gravity Discharge (Special Station Requirement):

In some cases, a dedicated force main gravity discharge line to a trunk sewer may be required to prevent odors on existing gravity mains and laterals. Consult the District Representative for specific odor control requirements.

2.10 STATION BUILDING AND SITE REQUIREMENTS

2.10.1 Structural Concrete

a. Reinforced Concrete:

Specify a shrinkage control concrete mix suitable for wastewater storage structures. The concrete shall include a retarding-densifier admixture for increased flexural strength and shrinkage control (as outlined in ASTM C 157). Structural concrete shall typically have a minimum 28-day compressive strength of 4,500 psi and water-cement ratio no greater than 0.45, unless more stringent requirements per ACI 318 for buildings or ACI 350 for wastewater retaining structures are required due to high water soluble sulfate or other deleterious exposure. Cement used in the mix shall comply with Type V cement requirements (severe sulfite content), no exception. Specify concrete mix with low specific conductivity (sulfate and chloride concentrations) to minimize the potential for reinforcing bar corrosion.

b. Structure Waterproofing and Moisture Barriers:

Specify waterproofing on the outside buried walls of the station structure. The following methods of water proofing are acceptable: coal tar epoxy coating, bituminous sheeting, polyethylene membrane, polypropylene bentonite or crystalline cementitious chemical treatment. Where required by the District, a plastic vapor barrier shall be installed under the lift station and special care shall be taken during construction to avoid puncturing the barrier. All below grade dry wells and wet wells shall be exterior surface coated and joint sealed to prevent groundwater penetration.

c. Wall Penetrations:

Seals at piping and conduit wall penetrations into the station shall be designed with non-shrink grout (with water stops) if below grade, or mechanical synthetic rubber seals if above grade, and be water pressure tight. Elevation of water table and depth of water in wet well shall be taken into consideration. Materials used for seals shall be appropriate for wastewater applications, synthetic rubber seals such as Nitrile (Buna-N) and EPDM are allowed, unless it is expected that deleterious substances in wastewater may be present that may deteriorate these materials.

d. Concrete Form Taper Ties:

Concrete form taper ties shall be provided with integral water stops and, after removal of forms, shall be recessed a minimum of 1 inch from concrete surface and grouted water tight with epoxy grout.

e. Waterstops:

Specify waterstops at all cold concrete construction joints. Waterstops shall be provided as per CCWRD Standard Specifications. Water stop material must be designed for wastewater service. Carbon steel waterstops are considered ineffective and not allowed.

2.10.2 Building Construction

a. Typical Construction:

Facility architecture shall be compatible with local neighborhood and conform to Clark County Planning & Zoning design requirements where applicable. DESIGN ENGINEER is responsible for directing any required County processes, entitlements, and Design Reviews, Special Use Permits, or Planning & Zoning actions with Clark County. DESIGN ENGINEER shall note that while prefabricated buildings and singly-wythe CMU building construction are both typical and normally allowed, exterior finishes, paint colors and roof construction are often controlled by Clark County Planning & Zoning or by community involvement to match local homes or commercial structures.

b. DESIGN ENGINEER is responsible for coordinating with local building officials as well as with the Fire Department to determine building location, accessibility and safety system requirements (including fire suppression system).

2.10.3 Building Features

a. Intrusion Security:

Provide an alarm against unauthorized entry to the lift station (refer to standard Telemetry Specifications). An external monitoring camera may be required at the discretion of the District.

b. Outside Door Fittings and Locks:

All outside doors and frames shall be corrosion and vandal resistant, with stainless steel security fittings and locks. Specify locks with interchangeable Type 316 stainless steel cylinders that can be keyed to the District standard currently in place for lift stations. The CONTRACTOR shall be directed to contact the District for requirements to install standard locks and cylinders. Specify that all keys be stamped "Do Not Duplicate", and specify provision of five (5) complete sets of all required station keys. At Districts discretion, the installation of badge reader boxes and ductwork for future card reader installation may be required to be included in the design; contact District for requirements.

c. Bulletin Board and Reference Shelf:

If required by the District, Specify that the CONTRACTOR shall install in the pump room a 3 feet x 4 feet bulletin board for posting operating information, and an adjacent shelf to hold Operations and Maintenance Reference data.

d. Building Lighting:

Outside building lighting shall, at a minimum, be provided at each station door. Each light shall have a motion sensor along with photocell for control. Lighting shall be LED type with shield.

e. Site Lighting:

Provide outside LED type site lighting with photocell/bypass with time clock and manual on/off control. Minimum security lighting as directed by the District Representative shall be separately controlled from site operation/service lighting. No incandescent, metal halide or standard fluorescent. Standard fixtures with LED Lamps are acceptable.

2.10.4 Site, Access, and Paving

a. Fee Title Property/Easements:

The District shall be granted Fee Title ownership of all sites with the only exception being that if the lift station's capacity is 0.5 mgd (million gallons per day) or less, then an easement shall be granted to the District.

b. Site Paving:

Vehicular access roads to lift stations shall be paved and a minimum of 24 feet wide at a 15 percent maximum slope. Pave station areas as directed by the District. All site paving shall be designed for a minimum AASHTO HL93 truck loading. All non paved areas required to be drainage controlled and graded smooth with no surface aggregate exceeding 3/8". Surface required to be treated with a 5 year rated vegetation controller and covered to 3" depth with a decorated rock, color to be specified per installation to match surroundings.

c. Site Fencing and Walls:

The lift station site shall be enclosed by a CMU wall, minimum eight foot high with barbed wire on top. DESIGN ENGINEER shall coordinate with District Representative for alternatives to barbed wire. Depending on site conditions, changes in wall dimensions or additional security requirements may be required to meet District safety and security standards.

d. Gates:

All sites shall be provided with a lockable gate. No private gates are permitted across access roads.

e. Positioning Maintenance Vehicles:

Access at the station shall allow positioning a crane truck of the size required for removal of station equipment. Access shall also be provided for the positioning of a vactor truck to clean the wet well, where possible, the site shall also include sufficient parking and turnaround space for two 1-ton maintenance trucks. Truck access shall be provided at the locations of the emergency discharge connections and all cleanouts. AASHTO HL93 truck loading covers over buried wetwells shall be provided on all wetwells greater than 4 foot in diameter. (See also 3.2.6 Wet Well Calculations.)

f. Vehicle Turnaround Radius:

For the largest maintenance trucks, provide a minimum turning diameter of 100 feet for accessing the site. A pull-through driveway with dual gate access may also be employed where a turnaround on the site is infeasible. See typical site layouts as per Standard Plate SP - 1 for options.

g. Parking over Wet Well Pipe Connections:

Locating truck access over the inlet and discharge piping penetrations into the station shall be avoided to eliminate pipe shear loadings at these locations.

h. Flood Plain Elevation:

Lift station pad elevations shall be designed to be a minimum of 2 feet above the 100-year flood elevation. Flood plain information shall be indicated on the design drawings.

2.10.5 Water Meter and Backflow Protection

a. Water Meter Costs and Backflow Protection Device:

A drawing note and project specifications shall require the CONTRACTOR to obtain the water meter permit and the reduced pressure (RP) backflow prevention device, and pay all installation costs for the meter and the installation. This cost shall be listed in the construction bid as a line item cost.

b. Water Meter Ownership:

Also, specify that the water meter shall be in the name of the CONTRACTOR and that all meter service charges shall be paid by the CONTRACTOR until the service is transferred to the District at the time the Facility is accepted by the District.

c. Hose Bib and Backflow Protection:

Design a fire hose bib outside adjacent to the wet well where required by the District. The connection to the hose bib shall be separately protected with a reduced pressure backflow preventer valve. Locate parking posts around the hose bib and backflow protection device to protect against traffic. All landscape irrigation systems shall require a dedicated reduced pressure backflow preventer valve.

d. Emergency Eyewash (Special Station Requirement):

For Triplex or Large Stations where hazardous chemicals may be used/stored onsite, the eyewash/shower station shall meet OSHA requirements of 29 CFR 1910.151(c) and ANSI/ISEA Z358.1. Special water temperature considerations exist for exterior installed eyewash stations: Install anti-scalding devices (temperature control valve or thermostatic tempering valve), constant flow meters, and other devices that will help maintain a constant temperature and flow rate. For cold or outdoor locations, emergency showers with heated plumbing are available. In hot climates, outdoor emergency showers should also have a tempering valve so that workers are not exposed

to water that is too hot. Water should be "tepid" being between 60-90°F.

e. Restroom (Special Station Requirement):

For Large Stations, a restroom may be required in the building by the District Representative. If the station includes a restroom facility, a second reduced pressure backflow device shall be provided at the hose bib located next to the wet well. This second RP device shall protect the upstream connection to the restroom from potential contamination from the hose bib. Locate parking posts as required around the hose bib and RP to protect from traffic.

2.10.6 Landscaping

a. Xeriscaping (Special Station Requirement):

Conform to Planning & Zoning requirements and the requirements of Clark County Title 30. Landscaped areas in the lift station shall have District approved low maintenance, drought resistant, low irrigation "xeriscaping" type landscaping. Above grade piping shall be painted PVC. All remaining bare ground within the lift station shall be covered with landscaped crushed rock.

b. Backflow Preventer Valve (BPV) and Irrigation Piping:

The irrigation system piping connection shall be protected by a separate reduced pressure type BPV assembly, with brass bodied stainless ball isolation valves located before and after the BPV. The connection of irrigation piping to the water service line shall not employ any compression type fittings. Connections shall be by PVC solvent weld, threaded, brazed/soldered, or similar method, as appropriate for the piping systems.

2.10.7 Site Lighting

Location of site lighting to be at the top of the perimeter walls to provide site safety, required illumination per code, and minimize light spill over into adjacent properties.

When pole lights are needed to provide additional illumination, light poles should be mounted on a two feet diameter by two feet high concrete pedestal.

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CHAPTER 3 CORROSION CONTROL

3.1 GENERAL

The purpose of this chapter is to provide general recommendations for corrosion control. These standards are intended to be used by the DESIGN ENGINEER in conjunction with the complete and current edition of the Clean Water Program Corrosion Control Standards, Volume I, Chapter 9, accepted industry standards, and CCWRD Standard Specifications. The Corrosion Control Standards provide general recommendations for material selection, protective coatings/linings, and specific recommendations for sewer applications and represent the minimum requirements for presented conditions. Where field conditions differ from those presented, the DESIGN ENGINEER shall evaluate those conditions and make corrosion control design recommendations. All corrosion control drawings, designs and calculations shall be prepared and signed by a licensed Nevada Corrosion Control Engineer or a certified, NACE International Cathodic Protection Specialist. Design Engineer will coordinate corrosion control with electrical drawings.

The District, upon reviewing plan documents, may direct the use of active impressed cathodic protection, where conditions deem it necessary to preserve useful life of assets. Steel dry wells and many pre-manufactured lift stations are highly likely to require impressed current cathodic protection. In addition to coating requirements, all buried carbon steel (including DIP) piping, fittings, and appurtenances constructed of material subject to corrosion shall be poly wrapped as a passive corrosion protection measure.

3.2 SEWER LIFT STATIONS AND FORCE MAINS

3.2.1 Sewer Lift station Piping & Fittings Coatings

All coatings for sewer lift station piping and fittings shall be applied in accordance with the manufacturer's recommendations. Proper preparation of surfaces to be coated typically requires SSPC-SP-10 sandblast to "white metal", proper prime coat, recommended coating thickness per coat, required drying times between coats, and required air temperatures and humidity limits. Provide at least two coats to achieve required final dry coating thickness. Coatings shall be applied pinhole free. Refer to the current edition of the Corrosion Control Guidelines, CCWRD Approved Materials List and CCWRD approved Standard Coating Specifications for the allowable coatings for lift station applications.

3.2.2 Force Main Linings and Coatings

Allowable corrosion protective coatings and linings are provided in the Corrosion Control Standard and the CCWRD Approved Materials List.

3.2.3 Valve Coatings

All valves located in the dry well, wet well, or in buried service shall be coated with fusion-bonded epoxy coating (3M "Scotchkote" #134 or equivalent) inside and out with a 12 mil. minimum thickness. Where fusion-bonded epoxy cannot be applied, high-density liquid epoxy (3M, Inc. #312 or equivalent) shall be allowed.

3.2.4 Pump and Impeller Coating

Coat the impeller, pump bowl and casing, inside and out, and the suction can interiors with 3M Inc. #134 "Scotchkote" fusion-bonded epoxy or approved equivalent. Final dry coating thickness shall be a minimum of 8 mils.

3.2.5 Wet Well Walls

Four options are available at Districts discretion on a case by case basis:

- a. *Concrete Polymer Wet Well: The wet well in its entirety (all surfaces and floor) shall be fabricated of polymer concrete, manufacturers are provided in the CCWRD Approved Materials List.*
- b. *Concrete Polymer Wet Well Insert: An existing wet well may be provided with a polymer concrete insert, wet well interior dimension shall match that of wet well storage capacity hydraulic design calculations. The annular space of the insert and the concrete wet well wall shall be grouted, the insert shall be placed so to rest against plastic grout at the base of the existing wet well which will allow uniform load distribution on wet well base. For manufacturers reference the CCWRD Approved Materials List.*
- c. *Cement Concrete Wet Well with Coating: The interior ceiling, floor, inclined surfaces and walls of wet wells shall be coated as determined by the District Representative, and as provided in the CCWRD Approved Materials List, District Coating Standards. Wet well shall be coated with maximum 125 mils of polyurethane over an epoxy primer base in accordance with SSPC, Section 500-2.4. Refer to CCWRD Standard Specifications. Pipe penetrations shall be sealed with a bonding agent and keyways per Standard Plate SP-16. Specify that the installer shall be certified/licensed for this work by the manufacturer. Specify that the spark testing inspection for this work shall be performed (i.e., highest test equipment spark voltage). The coating shall be free of pinholes as confirmed by the spark testing. Surface preparation and adhesion test requirements are provided by the District.*
- d. *Cement Concrete Wet Well with Liner: The interior ceiling and walls of wet wells shall have cast-in-place T-Lock PVC liner, or approved*

equal as determined by the District Representative, and as provided in the CCWRD Approved Materials List. Wet well floors shall be coated with 125 mils of polyurethane over an epoxy primer base in accordance with SSPC, Section 500-2.4. Refer to CCWRD Standard Specifications. Pipe penetrations shall be sealed with a bonding agent and T-lock as per Standard Plate SP-16 Specify that the installer shall be certified/licensed for this work by the manufacturer. Specify that the spark testing inspection for this work shall be performed (i.e., highest test equipment spark voltage). The coating and PVC lining shall be free of pinholes as confirmed by the spark testing. Surface preparation and adhesion test requirements are provided by the District. Reference the CCWRD Approved Materials List, District Coating Standards.

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CHAPTER 4
CONSTRUCTION MANAGEMENT AND OPERATIONAL TESTING

4.1 CONSTRUCTION MANAGEMENT AND OPERATIONAL TESTING SPECIFICATIONS

4.1.1 General

The DESIGN ENGINEER and CONTRACTOR shall refer to the CCWRD Standard Specifications to supplement and refine the requirements of this Chapter. The DESIGN ENGINEER shall provide appropriate information in the Design Plans and Specifications to describe the following requirements:

4.1.2 Coordination of New Construction With Existing Station Operation

a. Salvage Note on Drawings:

The CONTRACTOR shall remove equipment to be salvaged and deliver to location specified by the District. The District shall list the items to be salvaged by the CONTRACTOR.

b. Temporary Bypass Pumping (Special Station Requirement):

The CONTRACTOR shall install and operate a temporary bypass pumping system as required to maintain pumping operations at existing facilities during construction of the new station. This District approved telemetry system shall include an automated telemetry system to dial out to the CONTRACTOR for repair response and also to the District in the event of failure conditions. The Bypass Pumping Plan shall include temporary odor control and emergency spill prevention plan where required by the District. The CONTRACTOR's Bypass Pumping Plan shall be design and stamped by a Nevada Professional Engineer, then submitted for review and approval by the District.

c. Sequence of Construction (Special Station Requirement):

Where bypass pumping of the existing station and/or for tie-in connection of new facilities is required, the DESIGN ENGINEER shall provide a general recommended sequence of construction on the plans and in the General Provisions to describe the required construction sequence including bypass pumping.

1. Prior to construction, CONTRACTOR shall perform flow monitoring on all lines to be bypassed in accordance with the following requirements. The measured flow rate, minimum,

average, and peak shall be included in the bypass pumping plan.

- i. Contractor shall be required to monitor flows for a minimum of 7 consecutive days encompassing 2 weekends. The flow data shall be collected and recorded at 15-minute intervals.
 - ii. Contractor shall complete 7-day area/velocity flow monitoring on all pipes proposed for diversion. Diverted flows shall be discharged to the closest trunk line (downstream of the diversion), unless otherwise authorized by District Representative.
 - iii. Project Peak Flows shall be calculated without any upstream diversions in place, using the highest flow determined from the following criteria:
 - (1) 1.70 times the Peak 15-Minute Flow or
 - (2) 2.60 times the Average 15-Minute Flow
 - (3) The above are minimum parameters, the DESIGN ENGINEER shall provide more stringent guidelines if higher flows are likely to occur during construction.
 - iv. Project Peak Flows shall be used to determine the number and size of primary pumps, reserve pumps, suction pipes, discharge pipes, redundant discharge pipes, and any other flow related element of the bypass pumping system.
 - v. Pipe velocity through force mains shall be at least 3 fps but not exceed 12 fps.
 - vi. Thrust restraints for bypass piping shall be provided as required by thrust calculations.
2. Specified capacities are minimum requirements. CONTRACTOR shall be responsible for SSOs and shall take all necessary precautions to prevent their occurrence.

4.1.3 Facility Testing

a. General Requirements:

The following describes the general responsibilities of the Design Consultant and the CONTRACTOR:

1. DESIGN ENGINEER Responsibilities:

The DESIGN ENGINEER shall prepare specification sections describing facility testing requirements as discussed below. This Specification will describe the phases of testing and requirements of the CONTRACTOR in accomplishing this testing, and maintaining required test records and documentation. This description shall include a detailed listing in tabular form of all the specific test procedures to be performed by the CONTRACTOR for each phase of the test sequence. The Section shall include a schedule of operational tests that will demonstrate the proper operation of all equipment at the station. The proper operation of all lift station mechanical equipment, electrical controls, emergency power operations and control warning displays shall be demonstrated by the CONTRACTOR. Simulated failure conditions shall be initiated as required to demonstrate proper warning displays.

2. CONTRACTOR Responsibilities:

The CONTRACTOR shall implement the requirements of specification Sections, including demonstration and testing of all equipment as described in the operational test procedures, preparation and completion of required equipment test report forms, test procedures verification checklists, and other documentation to be provided by the CONTRACTOR.

3. Master Test Plan:

Based on the specification requirements, the CONTRACTOR shall prepare a Master Test Plan for approval by the District prior to the start of testing. This plan shall be a bound, step by step compilation of the specific tests to be performed in the facility test sequence, and the sample forms to be submitted documenting the results of the tests and test information. During the step-by-step testing, these forms will require signing off by specified District Representative and the CONTRACTOR's test representative prior to continuation of the test sequence. All tests shall be successfully completed and signed-off by the District.

4. CONTRACTOR Test Coordinator:

The CONTRACTOR shall identify qualified Test Coordinator(s) responsible for accomplishing the required testing.

5. Scheduling of Facility Test Sequence:

The CONTRACTOR shall schedule and coordinate all phases of the facility test sequence and demonstrations with District Representatives. All tests shall be witnessed by the specified District Representative(s) unless otherwise indicated by the District.

6. Testing Costs:

The DESIGN ENGINEER shall provide a general note in the design documents specifying that the CONTRACTOR is responsible for all testing and utility costs including power, fuel, potable water, testing/training specialists, and other testing costs, such as generator fuel, communication costs, etc. associated with the facility test sequence until such time that the station is accepted by the County.

b. Summary of Master Test Plan:

A Master Test Plan shall be submitted for review and approval including the following sequential testing phases:

1. Factory Testing:

This shall include testing and reports on the following major equipment and other equipment as required: pumps (certified pump test curves), motors, switchgear, emergency generators, motors, and variable frequency drive units. Factory testing shall be performed on a fully functioning system that is representative of the conditions of the final installation.

2. Functional Checkouts and Installation Certification:

After all construction is completed, the CONTRACTOR shall submit a completed Manufacturer's Installation Certification form for each major equipment item certifying by the manufacturer's authorized representative that the equipment has been properly installed, aligned, and functionally checked out and is ready for pre-operational and start-up testing. Certification forms shall be submitted for all pumps, motors, extended drive shafts, variable speed drives, emergency generators, electrical switchgear, HVAC equipment, and odor control fans. Documentation demonstrating proper installation of any natural gas or diesel fuel system also shall be submitted. Forms demonstrating successful testing of the switchgear, motor control center, conductor installation, grounding system

resistance, control system loops, circuit breakers and motor starters also shall be submitted. All instruments shall be calibrated for actual site conditions and certifications submitted.

3. Pre-Operational and Start-Up Testing:

Prior to performing Operational Station startup testing, the CONTRACTOR shall have successfully demonstrated to the District that all manual and automatic controls, alarm set points, interlocks, and control sequences (level control, pump speed control, etc.) are functional and ready for Operational Testing. Operational Testing shall include testing and reports on the following and other equipment as required: switchgear and MCC, VFD unit (including testing for harmonic distortion), control system operation, pumping units (including vibration testing on installed pump/motor/drive shaft unit to ensure no unusual libration/harmonics within Hydraulic Institute limits), piping pressure and leakage testing, gate valves, ventilation system, equipment noise testing, generator run test (four hours under full load utilizing a portable load resistance bank), equipment hoists (OSHA Certification), and hazardous gas detection system. Failure conditions shall be simulated as required to demonstrate proper control operations, warning displays and SCADA system communications. This testing may utilize potable water recycled to the wet well for pumping demonstration.

4. HVAC Testing:

The station ventilation systems shall be tested and acceptable certified performance test results shall be submitted prior to acceptance of the station.

5. Operational Test Procedure:

After the CONTRACTOR has successfully completed the Pre-Operational Testing for preliminary mechanical and electrical/control equipment operation, and submitted the equipment certifications described above, the Operational testing shall be scheduled. This shall demonstrate lift station operation on automatic control without equipment or control failure and with sewage tie-in. The lift station mechanical equipment, electrical/control systems, and emergency power equipment shall operate without failure during the operational test. This testing period shall consist of an 8-hour first test followed by a 14-day operational test.

- i. The CONTRACTOR shall actively staff and observe the entire 8-hour test and make final adjustments in the actual operational environment.
- ii. The purpose of the 14-day (operational) performance test is to measure reliability and provide enough time to detect manufacturing defects or pre-mature failures.
 - (1) If any component fails and it takes longer than 4-hours to rectify, then the test re-commences to Day 1.
 - (2) Experiencing more than five (5) total equipment failures or malfunctions, even if they are all quickly remedied (in less than 4 hours) will constitute a failed test, requiring re-commencement to Day 1.
 - (3) Rectification of malfunctions shall be to the satisfaction of the District Representative, and accepted as permanent fixes to the malfunction. Otherwise failed equipment replacement may be required.

6. Performance Measurement Testing

During the final inspection phase, it is important to determine if the station is actually meeting the station capacity for which it was designed so that the final station firm capacity and system force main piping velocity may be known. The installed flow meter shall be used as the key indicator of actual station capacity and force main velocity, versus design calculations. Deviations of more than 5% shall be evaluated by the OWNER as to suitability for lift station acceptance.

Additional performance measurements evaluation should also be a factor in the District acceptance sign off. Several baseline measurements shall be taken and submitted in a simple excel spreadsheet or form indicating the performance measurements existing during commissioning. Where applicable, for each different type and model of pump and motor, these measurements shall include:

- Flow output for individual and maximum pumps running with redundant unit offline
- PSI output for individual and maximum pumps running with redundant unit offline
- Running amperage draw for each pump
- Instantaneous starting in-rush amperage for maximum number of pumps starting simultaneously
- Vibration readings for each pump to be measured in X-Y-Z axis and recorded as acceleration in inches per second
- Communications system's success percentage hourly and daily (Logged percentage shall not be done by the contractor, but may be done by third-party testing or via the SCADA system)

Over time this commissioning data will also be used by the District as a point of comparison for monitoring system performance decay during the operational life of the lift station system.

7. Commissioning:

After all the operational testing and required Master Test Plan documentation is completed and approved by the District, the CONTRACTOR shall make final adjustments to all equipment to ensure proper operation. The District will then accept operational responsibility of the facility. Following completion of all punch list items per District inspection, facility acceptance by

the District and filing of Notice of Completion by the CONTRACTOR can be initiated (refer below).

4.1.4 Operations and Maintenance Manual

Provide a comprehensive DRAFT and FINAL Lift Station Operation and Maintenance manual (L/S O&M) for all constructed lift stations. Four hard copies, in 3 ring binders, of the first DRAFT manual (plus one electronic pdf file), to be used in the onsite training sessions, will be delivered to the District Lift stations O&M department prior to onsite training for review, markup, and comment. The DRAFT Manual(s) shall be submitted at least 90 days prior to the desired start of Pre-Operational Testing. The CONTRACTOR shall identify the submittal of the DRAFT Manual in their baseline project schedule. After start-up, the comments received from the District shall be incorporated into the FINAL draft. The FINAL L/S O&M, shall be submitted before final completion of the project or within six months after start-up, whichever comes first. The L/S O&M manual shall be well organized (tabbed) by section, chapter, and contain complete and detailed information required to operate and maintain the lift station.

The L/S O&M shall be well organized and formatted in the following manner:

- a. Table of Contents
- b. Introduction- to include basis of design and specifications table, process description and characteristics, and operational parameters.
- c. Automatic controls and Control strategy
- d. Start-up, Operation, and Shut-down Procedures
- e. Preventative Maintenance Procedures - based on information presented in the manufacturer's equipment manuals, including preventive maintenance schedules recommended by the manufacturers. Maintenance schedules will include the maintenance task, frequency, recommended lubricants and will be cross referenced to the manufacturer's manual for further detail.
 1. Provide a Maintenance Summary Form that contains the following minimum equipment asset information and maintenance data: equipment type, model #, serial #, project no., Asset ID (where applicable and made available by CCWRD), maintenance task and frequency, materials needed, and reference to instructions.

- f. Emergency/Abnormal Conditions & Procedures
- g. Process monitoring & Troubleshooting- problem/remedy table format for common problems.
- h. Certified Pump Test Curves: factory certified pump test curve for the actual pumping units (including motors) installed at the station.
- i. Pump Starts: Provide the pump manufactures recommended for maximum start/stops per hour.
- j. Equipment list, Spare parts
- k. Manufacturer/Vendor contact information, installation certifications, and all equipment Warranty Information
 - 1. Warranty Address: ensure that the District Work Order Number and the name/address of the lift station is noted on the manuals
- l. Equipment submittals and specifications
- m. Safety hazards and hazardous work procedures
- n. As built lift station drawings (11X17 format)
- o. Force main and tributary area maps- show the collection system lines, elevations, with the station onsite and first manhole exterior to the lift station points of overflow clearly indicated(11X17 format)

The FINAL Lift Station O & M manual shall be submitted in 3 formats:

- a. 3 hard copies in 3-ring, front/spine labeled binders, not larger than 3 inches.
- b. Portable document format (pdf electronic file), which is identically sectioned and bookmarked as the hard copy
- c. 3 sets of labeled and sleeved CD disks, Label shall indicate "CCWRD", design engineer firm's logo and name, project name, project number, lift station name/number, "O&M Manual FINAL", and date.

4.1.5 Facility Acceptance by The District

- a. Recommendation for Acceptance by Owner:

After completion of the operational testing and commissioning, the substantial completion of all inspection correction list items as required by District inspection, and receipt of all required submittals

including the O & M Manuals, the Wastewater Collection Division will submit a written memorandum via the Project Manager to the CONSTRUCTION MANAGER recommending that the County issue a Notice of Completion for the station.

b. Acceptance of Operational Responsibility:

Following commissioning of the facility, District will accept operational responsibility for the station.

c. Transfer of Utility Billings at Substantial Completion:

The CONTRACTOR shall submit the NV Energy utility billing and other utility billings to the District after Substantial Completion occurs. Thereafter, the District will transmit a letter to each utility (power, telephone, water, gas, etc.) which documents Substantial Completion and request's transfer of service to the District.

d. Start of Warranty:

Equipment warranty dates shall commence on the date of the memorandum recommending acceptance of the lift station by CCWRD, as per 4.1.5.a.

4.1.6 Warranty

a. Requirements:

The Contract Document shall require the following:

1. *One-Year Warranty (for overall facility):*

The facility improvements overall will have a one-year full parts and service warranty period. The commencement of this Warranty is as per 4.1.5.d.

2. *Two-Year Warranty (for Major Equipment):*

Major equipment including motors, wastewater pumps, VFD units (if installed) and the emergency generator shall be provided with a two-year manufacturer's warranty. The commencement of this warranty is as per 4.1.5.d, not the shipping or receiving date(s), or the installation certificate date.

3. *Extended Warranty:*

Should a facility be constructed by a private development, and not require to be immediately placed in service due to the lack of subdivision occupancy, the facility overall one-year warranty

period shall commence when substantial occupancy occurs. Until that time, after commissioning the County shall regularly inspect and maintain the facility. However, the Developer shall be responsible for repair of any vandalism, and warranty repairs until the end of the extended warranty period.

4. *Warranty Service:*

The CONTRACTOR and/or equipment vendor (manufacturer's warranty) shall commence all required warranty repairs within 24 hours of notification by the District. Vendors for all major critical equipment (pumps, motors, motor control centers, VFD's, control panels, hazard warning systems, emergency generators, automatic transfer switches) shall have the capability and availability of arriving on site with equipment and personnel for emergency repairs within four hours of notification by the District.

5. *Warranty Ownership:*

Manufacturer's warranty documentation shall name both the CONTRACTOR and the CCWRD as the holder of the Warranty.

4.1.7 Facility Training

The CONTRACTOR shall provide to CCWRD personnel, a minimum of 16 hours training by factory authorized representatives in the operation and maintenance of the lift station. This training shall emphasize operation and maintenance of the lift station and equipment approved and provided, and shall utilize, reflect, and refer to the content of the Lift Station O& M Manual. All hazardous exposures, such as confined spaces, electrical hazards, and other potentially hazardous energy sources which may be encountered during O & M activities shall be identified, and control measures, means, and methods for safety hazard mitigation shall be recommended in the training. The District Safety Officer shall be required to sign off on the safety portion of the training. This training can occur in conjunction with the facility test sequence, where permitted by the District, and providing 2 weeks prior notification by the CONTRACTOR of proposed training has been provided to the District Lift Stations Supervisor or designee

4.1.8 Keying System

a. County Standard Locks:

Following County acceptance, The CONTRACTOR shall key facility locks with the County standard SPA-1 lock manufactured by Best Inc. also, the CCWRD standard lock as required. Coordinate with District

Representative for current security standard equipment and adjust as necessary.

b. Number of Key Sets:

The CONTRACTOR shall provide FIVE (5) sets of keys to all locked doors, enclosures, and equipment in the station at acceptance of the station by the County.

ATTACHMENT 1

Electrical, Instrumentation, and
Controls – Design Requirements

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EI&C Design Checklist (What Is Expected from Consultants)

30% Designs/PDR

Drawings

- Notes, Symbols and Legends
- Single line with major load list – Equipment Naming and Sizing of Distribution Equipment
- Basic P&ID – Equipment naming and process piping – Format Review
- List of major instruments & manufacturers (Flow meters, level transmitters, process analyzers, pressure transmitters, etc.)
- Communication Diagram
- Drawing list – Expected future drawings, site plans (Grounding, Power, Communications, Lighting), Equipment Schematics, connection diagrams, details

Specifications

- Specification list
 - CCWRD Provided
 - Consultant Detailed Specifications

Cost Estimate

60% Design

Drawings

- Notes, Symbols and Legends
- Single line with major wire sizes and conduit sizes
- Load Calculations
- Panel Schedules
- Generator and PV sizing
- Utility transformer size estimate with NVE Table available fault current
- Site Plans – Equipment Sized to fit in buildings and areas
- MCC or Switchgear layout results from an MFR to verify sizing for equipment pads
- Equipment Schematics
- Connection Diagrams
- Communication Diagram
- Major Details
- P&ID Complete with PLC and SCADA connections and tagging
- PLC Panel Basic layout with BOM (Latest PLC Cards, Correct order)

EI&C Design Checklist (What Is Expected from Consultants) Continued

Page 2

Specifications

- Specifications mostly complete with footers updated
- Equipment picked
- Instrument list with tag names and process limits
- Specific questions for any missing information required by District
- IO List (control split among cards)
- Verify standards and codes listed are the most current revisions

Cost Estimate

90% Design

Drawings

- Electrical Design should be as complete as possible with all information given
- Conduit Schedules
- Site Plans
- Duct Bank Schedules
- Panel Schedules
- PV & Generator Details
- Final Details
- PLC Panel layouts Complete/PLC Power Schematic
- References and callouts
- Notes

Specifications

- Specifications complete
- References in EI&C individual technical specifications to other specifications verified correct.

100% Design

- Comments picked up
- Coordination with other disciplines complete

Cost Estimate

ATTACHMENT 2

General Electrical Specifications
to Be Used as Required in The
Contract Documents

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INDEX TO
GENERAL ELECTRICAL SPECIFICATION SECTIONS
TO BE USED AS REQUIRED IN THE CONTRACT DOCUMENTS

SECTION 26 00 00 BASIC ELECTRICAL REQUIREMENTS
SECTION 26 05 00 COMMON WORK RESULTS FOR ELECTRICAL
SECTION 26 05 02 ELECTRICAL DEMOLITION
SECTION 26 0513 MEDIUM VOLTAGE CABLES
SECTION 26 05 19 CONDUCTORS AND CABLES
SECTION 26 05 26 GROUNDING AND BONDING
SECTION 26 05 29 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
SECTION 26 05 33 CONDUIT RACEWAY AND BOXES
SECTION 26 05 36 CABLE TRAYS
SECTION 26 05 43 DUCT BANKS
SECTION 26 05 48 VIBRATION AND SEISMIC CONTOLS FOR ELECTRICAL SYSTEMS
SECTION 26 05 53 ELECTRICAL IDENTIFICATION
SECTION 26 05 73 OVERCURRENT PROTECTIVE DEVICE COORDINATION AND ELECTRIC
SECTION 26 05 83 WIRING DEVICES
SECTION 26 08 00 ACCEPTANCE TESTING
SECTION 26 09 13 ELECTRICAL POWER MONITORING PCB
SECTION 26 09 19 ENCLOSED CONTROLLER
SECTION 26 09 23 LIGHTING CONTROL DEVICES
SECTION 26 11 16 SECONDARY UNIT SUBSTATIONS
SECTION 26 12 00 MEDIUM VOLTAGE TRANSFORMERS
SECTION 26 13 00 MEDIUM VOLTAGE SWITCHGEAR
SECTION 26 21 16 SERVICE ENTRANCE
SECTION 26 22 00 LOW VOLTAGE TRANSFORMER
SECTION 26 23 00 LOW VOLTAGE SWITCHGEAR
SECTION 26 24 13 SWITCHBOARDS
SECTION 26 24 16 PANELBOARDS
SECTION 26 24 19 LOW VOLTAGE MOTOR CONTROL CENTERS
SECTION 26 25 00 ENCLOSED BUS ASSEMBLIES
SECTION 26 28 13 FUSES
SECTION 26 28 16 ENCLOSED SWITCHES AND CIRCUIT BREAKERS
SECTION 26 32 13 DIESEL ENGINE GENERATOR SET
SECTION 26 32 13.1 MOBILE DIESEL ENGINE GENERATOR SET
SECTION 26 33 53 UNINTERRUPTIBLE POWER SUPPLY
SECTION 26 36 00 TRANSFER SWITCHES
SECTION 26 43 13 SURGE PROTECTIVE DEVICES
SECTION 26 51 00 INTERIOR LIGHTING
SECTION 26 52 00 EMERGENCY LIGHTING
SECTION 26 56 00 EXTERIOR LIGHTING
SECTION 26 80 00 PHOTOVOLTAIC SYSTEM

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SECTION 26 00 00

BASIC ELECTRICAL REQUIREMENTS

[CLICK HERE TO ENTER PROJECT NAME](#)

CCWRD PROJECT NO. [CLICK HERE TO ENTER CCWRD PROJECT NO.](#)

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions, apply to work of this section.

1.02 SUMMARY

- A. This section specifies the basic requirements for the electrical installations and includes requirements common to more than one section of Division 26. In addition, this section and all Division 26 specifications shall take precedence over any specifications as they relate to electrical equipment. It expands and supplements the requirements specified in sections of Division 1.
- B. Standards of the organizations listed below but referred to in the various sections by basic designation only, form a part of this specification to the extent indicated by the reference thereto:
 - 1. American Society for Testing and Materials (ASTM)
 - 2. National Fire Protection Association (NFPA)
 - 3. American National Standards Institute (ANSI) Illuminating Engineering Society (IES)
 - 4. Institute of Electrical and Electronics Engineers (IEEE)
 - 5. Insulated Cable Engineers Association (ICEA)
 - 6. National Electrical Manufacturer's Association (NEMA)
 - 7. National Electrical Contractors' Association (NECA)
 - 8. Underwriters' Laboratories, Inc. (UL)
 - 9. Factory Mutual (FM)
 - 10. Federal Specifications (FS)
 - 11. National Electrical Code (NEC) with SNEC Amendments
 - 12. ANSI TIA/EIA Telecommunication Building Wiring Standards
 - 13. International Electrical Testing Association (NETA)
- C. References shall mean to the latest edition of the standard.
- D. Conform to local ordinances and codes.

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1.03 QUALITY CONTROL

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected. CONTRACTOR shall coordinate with the appropriate supplier, vendor, or subcontractor regarding the exact and specific rough-in requirements for equipment actually supplied.
- B. Provide the Work in accordance with NFPA 70. Where required by Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.
- C. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark or label.
- D. Provide materials and equipment acceptable to AHJ for Class, Division, and Group of hazardous area indicated.

1.04 ENVIRONMENTAL CONDITIONS

- A. The following areas are classified nonhazardous and wet. Use materials and methods required for such areas.
 - 1. Outdoor above grade areas.
 - 2. Below grade, electrical manholes, hand holes, and vaults.
- B. The following areas are classified as indoor and dry:
 - 1. Electrical and Computer Rooms in Process Buildings.
 - 2. Workshop and Administration Building electrical room are indoor, dry, and industrial.
- C. Work is not anticipated in classified process areas of the facilities for this project.

1.05 ELECTRICAL INSTALLATIONS

- A. Coordinate electrical equipment and materials installation with other building components. In the event of conflicts, notify ENGINEER in writing.
- B. Verify all dimensions by field measurement. Do not scale drawings.
- C. Arrange for chases, slots, and openings in other building components to allow for electrical installations. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of ENGINEER. Carefully perform cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces to original condition.
- D. Coordinate the installation of required supporting devices and sleeves to be set in poured in place concrete and other structural components, as they are constructed.

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- E. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.
- F. Coordinate the access panel requirements with others to accommodate the installation of electrical equipment and materials.
- G. Where mounting heights are not detailed or dimensioned, install electrical services and overhead equipment to provide the maximum headroom possible.
- H. Install electrical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
- I. Coordinate the installation of electrical materials and equipment above ceilings with suspension system, mechanical equipment and systems, and structural components.
- J. CONTRACTOR shall review Mechanical, Structural, Low Voltage System and Architectural drawings, as applicable prior to bid and shall coordinate work with other trades.
- K. Final connections to equipment shall be per manufacturer's approved wiring diagrams, details and instructions. It shall be the CONTRACTOR'S responsibility to provide materials and equipment compatible with equipment actually supplied.
- L. It is the intent of these drawings and specifications to establish a standard of quality.
- M. Work shall be performed in a workmanlike manner to the satisfaction of the OWNER.
- N. CONTRACTOR shall verify and coordinate exact location of equipment to be furnished by others prior to rough-in.
- O. CONTRACTOR shall be responsible for replacing equipment or factory wiring which is damaged due to incorrect field wiring, improper handling, or improper installation procedures to equipment provided under this division.
- P. CONTRACTORS shall visit site prior to bid and verify that conditions are as indicated. CONTRACTOR shall include in their bid, costs required to make their work meet existing conditions.
- Q. Wire termination provisions for panel boards, circuit breakers, safety switches and all other electrical apparatus shall be listed as suitable for 75 degree C.
- R. Systems shall be completed as designed, tested, operable and ready for continuous operations. Lights, switches, receptacles, motors, etc., shall all be connected, tested, and operable.

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- S. Electrical equipment shall be located to maintain clear and level clearances outlined in NEC 110-26. Panel boards, switchboards, transformers, disconnects, switches, breakers, etc. shall be located to comply with NEC 110-26(a). Where the clearances outlined in NEC 110-26 cannot be obtained, the CONTRACTOR shall notify the ENGINEER prior to performing any rough-in and request resolution of conflict.
- T. Maintain separation of at least 12" between communication/signal conduits and electrical feeders, electronic ballasts, transformers, etc. to minimize electromagnetic compatibility issues.
- U. Runs that exceed 100 feet shall be provided with junction/pull boxes for every 100 feet or fraction thereof in excess of 100 feet. Boxes shall also be readily accessible and adhere to other sections of Division 26 specifications.
- V. Conduits, junction boxes, wire way, etc. required for low voltage/telecommunications, cabling shall be coordinated with telecommunications cabling CONTRACTOR prior to rough-in and shall adhere to applicable Division 26 specifications.
- W. CONTRACTOR shall not exceed 270 degrees in conduit runs between pull boxes.

1.06 Electrical Submittals

- A. Refer to the Conditions of the Contract (General and Supplementary), Division 1 and individual Sections for submittal definitions, requirements, and procedures.
- B. Required Final Hard Copy Submittals shall be submitted at one time in three ring binders and indexed as scheduled below. Partial submittals will not be accepted. (All sections might not be applicable to all projects).
 - 1. 26 05 02 – Electrical Demolition
 - 2. 26 05 10 – Electric Motors
 - 3. 26 05 13 - Medium Voltage Cables
 - 4. 26 05 19 - Conductors and Cables
 - 5. 26 05 26 - Grounding and Bonding
 - 6. 26 05 29 - Hangers and Supports for Electrical Systems
 - 7. 26 05 33 – Conduits, Raceways and Boxes
 - 8. 26 05 36 - Cable Trays
 - 9. 26 05 39 - Underfloor Raceways for Electrical Systems
 - 10. 26 05 48 - Vibration and Seismic Controls for Electrical Systems
 - 11. 26 05 53 - Electrical Identification
 - 12. 26 09 19 - Enclosed Contactors
 - 13. 26 09 13 - Electrical Power Monitoring and Control
 - 14. 26 09 23 - Lighting Control Devices
 - 15. 26 11 16 - Secondary Unit Substations
 - 16. 26 12 13 – Liquid Filled Medium Voltage Transformers
 - 17. 26 13 16 - Medium Voltage Switchgear
 - 18. 26 22 00 - Low Voltage Transformers
 - 19. 26 23 00 - Switchgear
 - 20. 26 24 13 - Switchboards

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- 21. 26 24 16 - Panelboards
- 22. 26 24 19 - Motor Control Centers
- 23. 26 25 00 - Enclosed Bus Assemblies
- 24. 26 27 26 - Wiring Devices
- 25. 26 28 13 - Fuses
- 26. 26 28 16 - Enclosed Switches and Circuit Breakers
- 27. 26 29 23 – Variable Frequency Drive Units
- 28. 26 32 13 - Packaged Engine Generator
- 29. 26 33 53 - Static Uninterruptible Power Supply
- 30. 26 36 00 - Transfer Switches
- 31. 26 41 13 - Lightning Protection
- 32. 26 43 13 - Surge Protective Device
- 33. 26 51 00 - Interior Lighting
- 34. 26 56 00 - Exterior Lighting
- 35. 26 80 00 – Photovoltaic Systems

- C. Submit shop drawings and product data grouped to include complete submittals of related systems, products and accessories in a single submittal.
- D. Identify products requiring color selections.
- E. Clearly Identify products for use on project in submittals.

1.07 PRODUCT OPTIONS AND SUBSTITUTIONS

- A. Proposed substitutions of electrical equipment or request for "or equal" or approved equal" listing shall be submitted to ENGINEER not less than ten (10) working days prior to bid. Refer to specification 01 25 00, Substitution for Or Equal Supplier Procedures for additional information.

1.08 PRODUCT LISTING

- A. Prepare listing of major electrical equipment and materials for the project.
- B. Submit this listing as a part of the submittal requirement specified in the Division 1 specifications.

1.09 NAMEPLATE DATA

- A. Provide permanent operational data nameplate on each item of power operated equipment, indicating, manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

1.10 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to project properly identified with names, model numbers, types, compliance labels and similar information needed for distinct identification; adequately packaged and protected to prevent damage during shipment, storage and handling.

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- B. Store equipment and materials at the site, unless off-site storage is authorized in writing. CONTRACTOR shall protect stored equipment and materials from damage, weather and theft per manufacturer's recommendations.
- C. Coordinate deliveries of electrical materials and equipment to minimize construction congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.
- D. Electrical Equipment shall be stored indoors, protected from excessive heat, cold or condensation.

1.11 RECORD DOCUMENTS

- A. Refer to Section 01 77 00, Closeout Procedures for requirements. The following paragraphs supplement the requirements of Division 1.
- B. Mark drawings to indicate revisions or deviations to conduit size and location both exterior and interior, actual equipment locations, dimensioned to column lines; concealed equipment, dimensioned to column lines; distribution and branch electrical circuitry; fuse and circuit breaker size and arrangement support and hanger details; Change Orders; Addendums; concealed control system devices.

1.12 OPERATION AND MAINTENANCE DATA

- A. Refer to Section 01 77 00, Closeout Procedures for procedures and requirements for preparation and submittal of maintenance manuals.
- B. In addition to the information required by Division 1 for Maintenance Data, include the following information in English.
 - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data tests, and complete nomenclature and commercial numbers of all replaceable parts.
 - 2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shut-down and emergency instructions and summer and winter operating instructions.
 - 3. Maintenance procedures for routine preventative maintenance and troubleshooting, disassembly, repair and reassembly; aligning and adjusting instructions.
 - 4. Servicing instructions and lubrication charts and schedules.
- C. CONTRACTOR installed labels/equipment marking and instruction shall be in English.

1.13 WARRANTIES

- A. Refer to Section 00 61 15, Guaranty Bond for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements.

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- B. Compile and assemble the warranties specified in Division 26, into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference.
- C. Provide complete warranty information for each item to include product or equipment, include date of beginning of warranty or bond; duration of warranty or bond; and names, addresses and telephone numbers and procedures for filing a claim and obtaining warranty services.

1.14 CLEANING

- A. Refer to Section 01 77 00, Closeout Procedures for general requirements for final cleaning.

END OF SECTION

[PROJECT NUMBER] – [PROJECT NAME]	ELECTRICAL REQUIREMENTS
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SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

[CLICK HERE TO ENTER PROJECT NAME](#) [CCWRD PROJECT NO.](#) [CLICK HERE TO ENTER CCWRD PROJECT NO.](#) [CLICK HERE TO ENTER PROJECT NAME](#)

CCWRD PROJECT NO. [CLICK HERE TO ENTER CCWRD PROJECT NO.](#)

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Drawings and general requirements of the Contract, including General and Supplementary Conditions and Division 01 Specifications Sections applicable to all electrical work. Electrical Specifications in Division 26 shall take precedence over electrical work in other specification sections.
 - 2. The work generally includes the requirements as included in Section 01 11 05, Project Requirements.

- B. Interfaces to equipment, instruments, and other components:
 - 1. The Drawings, Specifications, and overall design are based on preliminary information furnished by equipment manufacturers, which identify a minimum scope of supply from the manufacturers.
 - 2. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:
 - a. Make all changes necessary to meet the manufacturer's wiring requirements.
 - 3. Review all Drawings and Specifications, including those of other trades, in order to ensure that all items related to the electrical systems are complete. Include any such items that appear on Drawings or in Specifications from another discipline in the Scope of Work.
 - 4. Any conflicts between Drawings and Specifications shall be referred to the ENGINEER as soon as possible for resolution.

- C. All electrical equipment and systems for the entire project must comply with the requirements of Division 26.

- D. Contract Drawings:
 - 1. The electrical drawings show desired locations, arrangements, and components of the electrical work in the diagrammatic manner.
 - 2. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work.

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COMMON WORK RESULTS FOR
ELECTRICAL
26 05 00 - 1

[SUBMITTAL NAME OR ADDENDUM NUMBER]

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- a. The equipment locations and dimensions shown on plans and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all SUB-CONTRACTORS to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
 - b. CONTRACTOR may select any of the named manufacturers as identified in the individual specification sections; however, the spatial equipment layout is based upon a single manufacturer and not all named Manufacturers have confirmed that their equipment fits in the allotted space. CONTRACTOR shall ensure that the furnished equipment fits within the defined space.
3. Schematic Diagrams:
- a. All controls are shown de-energized.
 - b. Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
 - c. Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
 - d. Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated .
 - e. Control schematics are to be used as a guide in conjunction with the descriptive operating sequences when included in the Drawings or specifications. Combine all information and furnish a coordinated and fully functional control system.

E. Installation Details:

1. Contract Drawings include typical installation details, which show installation details for electrical equipment. Where a typical detail does not apply, develop details necessary for installation and submit these details to ENGINEER.

1.02 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical equipment:
1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 3. To allow right of way for piping and conduit installed at required slope.
 4. Such that connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate installation of required supporting devices and set sleeves in cast in-place concrete, masonry walls, and other structural components as they are constructed.

1.03 REFERENCES

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- A. This section specifies the basic requirements for the electrical installations and includes requirements common to more than one section of Division 26. In addition, this section and Division 26 specifications apply to the raceway systems for the low voltage structural cable plant. It expands and supplements the requirements specified in sections of Division 1.
- B. Standards of the organizations listed below but referred to in the various sections by basic designation only, form a part of this specification to the extent indicated by the reference thereto:
 - American Society for Testing and Materials (ASTM).
 - National Fire Protection Association (NFPA).
 - American National Standards Institute (ANSI).
 - Illuminating Engineering Society (IES).
 - Institute of Electrical and Electronics Engineers (IEEE).
 - Insulated Cable Engineers Association (ICEA).
 - National Electrical Manufacturer's Association (NEMA).
 - National Electrical Contractors' Association (NECA).
 - Underwriters' Laboratories, Inc. (UL).
 - Factory Mutual (FM).
 - Federal Specifications (FS).
 - National Electrical Code (NEC) with SNEC Amendments.
 - ANSI TINEIA Telecommunication Building Wiring Standards.
 - Requirements of the serving utilities.
 - National Electrical Installation Standards (NEIS).
- C. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid *governs*.
- D. Conform to local ordinances and codes.
- E. Authority Having Jurisdiction shall be recognized as the OWNER or its designated representative.

1.04 DEFINITIONS

- A. Definitions of terms and other electrical and instrumentation considerations as set forth in the:
 1. National Electrical Code (NEC).
 2. Institute of Electrical and Electronic Engineers (IEEE).
 3. International Society of Automation (ISA).
 4. National Fire Protection Association (NFPA).
 5. International Electrical Testing Association (IETA).
- B. Specific Definitions:
 1. FAT: Factory Acceptance Test.
 2. ICSC - Instrumentation and Controls SUB-CONTRACTOR.
 3. PCIS - Process Control and Instrumentation System.
 4. Space - That portion of the switchgear, motor control center, panelboard,

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switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e. provide all standoffs, bus, and hardware, as part of the space.

5. Spare: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that physically contains a device with no load connections to be made.
6. Unequipped Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.05 SYSTEM DESCRIPTION

A. General Requirements:

1. The Work includes everything necessary for and incidental to executing and completing the electrical work described in the Drawings and Specifications and reasonably inferable there from: The electrical drawings are schematic in nature; use the structural, architectural, mechanical, and civil drawings for all dimensional purposes.
2. The entire electrical power, instrumentation, and control system shall be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by CONTRACTOR, whether or not specifically mentioned but which are necessary for successful operation.
3. Provide all electrical work, including conduit, field wiring, and connections under the provisions of Division 26 for all aspects of the Work, including heating, ventilation, and air conditioning except where required to be provided in that section. All electrical work that is provided under other sections must comply with Division 26 specifications.
4. Coordinate all aspects of the Work with all SUB-CONTRACTORS before bidding in order to ensure that all costs associated with a complete installation are included. OWNER is not responsible for lack of coordination of the Work between CONTRACTOR, SUB-CONTRACTORS, or suppliers.
5. Demolition:
 - a. Where demolition is specified or shown on any drawing, prior to demolition, disconnect all associated electrical equipment and render the equipment safe.
 - b. Remove and dispose of all conduit, wire, electrical equipment, controls, etc. associated with the items and/or areas to be demolished back to source or nearest pull box or enclosure excluding junction boxes smaller than 6"x6" as indicated on the Drawings unless otherwise indicated.
 - c. Salvage electrical equipment as specified in Section 26 05 02, Electrical Demolition.

B. Conduit:

1. Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:
 - a. Remove exposed conduit to the point of encasement or burial.
 - b. Cut conduit flush, and plug or cap encased or buried conduit.

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2. Where conduits are to remain in place and removal is not indicated on the Drawings:
 - a. Cap conduit open ends or cut and cap 3 inches above finish grade next to exterior walls if only exposed conduit is to be removed. Conduits in open areas of slabs shall be cut flush with finish slab and grout filled.
 - b. Relabel empty conduits as spare, install pull string.
 - c. Remove all wire back to the source for all conduits to be removed
 - d. Provide new nameplates for modified electrical distribution equipment, motor control centers etc. to identify equipment and circuits that are no longer used as spares.
 - e. Provide new typewritten schedules for all modified panelboards.
 3. When project involves installation to, or in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
 - a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
 - b. Provide and document: interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.
- C. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the electrical work and installation.
- D. Existing System:
1. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
 2. The standards of documentation, instrument tagging, cable and conductor ferruling, terminal identification and labeling that apply to the new installation apply equally to the existing installation which forms part of the modified system.
- Protect all work from damage during construction. Cap or plug all conduits or keep drained. Provide tarps, barricades, temporary heaters, and auxiliary equipment required. Remove and replace any materials or equipment damaged.
- E. Operating facility:
1. The existing wastewater treatment plant is an operating facility. Portions of this facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines in addition to requirements identified under Section 01 14 00, Work Restrictions:
 - a. All outages must be of minimal duration and fully coordinated and agreed to by the OWNER. Adjust the construction schedule to meet the requirements of the OWNER. All changes in schedule and any needs to reschedule are included in the Work.
 - b. Coordinate the construction and power renovation; bear all costs such as generators or temporary bypasses, so that all existing facilities can continue operation throughout construction.
 2. According to individual circumstances and in compliance with the Drawings,

extend or replace conduit and cable connections from existing locations.

1.06 SUBMITTALS

- A. General:
 - 1. Refer to Section 01 33 00, Submittal Procedures.

- B. Shop drawings:
 - 1. Required for materials and equipment listed in this and other sections.
 - 2. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
 - 3. Shop drawings requirements:
 - a. Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
 - b. Locations of conduit entrances and access plates.
 - c. Component layout and identification.
 - d. Schematic and wiring diagrams with wire numbers and terminal identification.
 - e. Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
 - f. Anchoring method and leveling criteria, including manufacturer's recommendations for the project site seismic criteria.
 - g. Weight.
 - h. Finish.
 - i. Nameplates:
 - j. Refer to Section 26 05 53, Electrical Identification. Temperature limitations, as applicable.
 - 4. Product Data:
 - a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
 - b. Include:
 - 1) Catalog cuts.
 - 2) Bulletins.
 - 3) Brochures.
 - 4) Quality photocopies of applicable pages from these documents.
 - 5) Identify on the data sheets the project name, applicable specification section, and paragraph.
 - 6) Identify model number and options for the actual equipment being furnished.
 - 7) Neatly cross out options that do not apply or equipment not intended to be supplied.
 - 8) Manufacturer's time-current characteristic curves for all fuses, circuit breakers, and protective relays.
 - 9) Detailed sequence of operation for all equipment or systems. Adhere to the wiring numbering scheme outlined in Section 26 05 53, Electrical Identification throughout the project:
 - c. Uniquely number each wire.
 - d. Wire numbers must appear on all equipment drawings.

- 1) Only use equipment and instrument tags, as specified, and as depicted on the drawings, for all submittals.
 - 2) Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
 - a. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
- C. Roof Penetrations:
1. Submit details of all portions of the electrical installation that penetrate the roof. Include details showing support of the penetrating component, and the sealing means to be utilized.
- D. Installation Recommendations:
1. Submit manufacturer's printed recommendations for installation of electrical equipment.
 2. Submit seismic anchorage and bracing drawings and cut sheets, as required by Section 01 81 02, Seismic Design Criteria.
- E. Test Reports:
1. Include the following:
 - a. A description of the test.
 - b. List of equipment used.
 - c. Name of NETA accredited testing agency and NETA accredited technician conducting the test.
 - d. Date and time the test was conducted.
 - e. All raw data collected.
 - f. Calculated results.
 2. Each report signed by the person responsible for the test
 - a. All testing certifications and additional requirements for acceptance test reports are listed in Section 26 08 00, Acceptance Testing.
- F. Calculations:
1. Where required:
 - a. Because these calculations are being provided by a Registered Professional Engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.
 - b. Submit seismic anchorage and bracing calculations as required in Section 01 81 02, Seismic Design Criteria.
- G. Factory Acceptance Test: Where identified in equipment specifications in Division 26,
1. Include complete test procedure and all forms to be used during test per Section 26 08 00, Acceptance Testing.

1.07 QUALITY CONTROL

- A. Comply with Section 01 45 00, Quality Control.

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- B. Furnish all equipment listed by and bearing the label of Underwriters' Laboratories, Incorporated (UL) or of an independent testing laboratory acceptable to ENGINEER and the Authority Having Jurisdiction.
- C. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected. CONTRACTOR shall coordinate with the appropriate supplier, vendor, or SUB-CONTRACTOR regarding the exact and specific rough-in requirements for equipment actually supplied.
- D. Conduits, junction boxes, wireways, etc. required for low voltage/telecommunications, cabling shall be coordinated with telecommunications cabling CONTRACTOR prior to rough-in.

1.08 DELIVERY, STORAGE, AND PROTECTION

- A. Comply with Section 01 66 00, Product Storage and Handling Requirements.
- B. Shipping Precautions:
 - 1. After completion of shop assembly and successful factory acceptance test, pack all equipment in protective crates, and enclose in heavy-duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
 - 2. Place dehumidifiers, when required, inside the polyethylene coverings.
 - 3. Skid-mount the equipment for final transport.
 - 4. Provide lifting rings for moving without removing protective covering.
 - 5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.
- C. Delivery and Inspection:
 - 1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.
- D. Special Instructions:
 - 1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.
- E. Coordinate deliveries of electrical materials and equipment to minimize construction congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

1.09 PROJECT OR SITE CONDITIONS

- A. Site Conditions:
 - 1. Provide an electrical, instrumentation and control system, including all equipment, raceways and any other components required for a complete installation that meets the environmental conditions for the site.
 - 2. Seismic classification:
 - a. Provide all electrical equipment and construction techniques suitable for

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the seismic requirements for the site, as specified in Section 01 81 02, Seismic Design Criteria.

3. Wind:
 - a. Provide all electrical equipment and construction techniques suitable for the site wind loading criteria, as specified in Section 01 81 04, Wind Design Criteria.
 4. Altitude and temperature:
 - a. Altitude: 2000 feet above mean sea level.
 - b. Temperature: High 122 degrees F; Low 20 degrees F
 - c. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating factors applied.
 - d. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to ambient temperatures, of 122 degrees Fahrenheit to 20 degrees Fahrenheit as determined by the equipment manufacturer's guidelines.
 5. Outdoor installations:
 - a. Provide electrical, instrumentation and control equipment suitable for operation in the specified ambient conditions where the equipment is located.
 - b. Provide heating, cooling, and de-humidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified for the equipment including.
- B. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or SUB-CONTRACTOR furnishing the equipment, that meet the requirements outlined in NEMA Standard 250 for the following types of enclosures:
1. NEMA 1 Enclosures: Intended for indoor use in buildings designed as office type occupancy, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
 2. NEMA 3R Enclosures: Intended for indoor or outdoor use in all areas other than process areas. In process areas NEMA 3R enclosures shall only be used in those areas designed as separated electrical rooms that incorporate ventilation, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.
 3. NEMA 4X Enclosures: Made from corrosion resistant materials (316 Stainless Steel) and are intended for indoor or outdoor use in all process areas including pump rooms, galleries and tunnels, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion.
 4. NEMA 12 Enclosures: Intended for indoor use only in non-corrosive, unclassified areas such as ventilated electrical rooms, maintenance shops and the like, primarily to provide a degree of protection from dust, falling dirt.
 5. NEMA 7 Enclosures: For indoor use in locations classified as Class I, Groups A, B, C, or D and shall be capable of withstanding the pressures and temperatures from internal gas explosions.
- C. In the event the CONTRACTOR needs to core or cut concrete, CONTRACTOR shall schedule coring or cutting operations with the OWNER, 1 week in advance.

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CONTRACTOR shall create a work plan and schedule a meeting prior to work to review work to be done with ENGINEER.

1.10 SYSTEM START-UP

- A. Comply with Sections 01 75 05, Testing Training and Startup, and 26 08 00, Acceptance Testing.

1.11 MAINTENANCE

- A. Before Substantial Completion, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.
- B. Furnish all spare parts as required by other sections of the Specifications.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Provide similar items of same manufacturer throughout the electrical and instrumentation portion of the project.
- B. Allowable manufacturers are specified in individual electrical and equipment specifications.

2.02 MATERIALS

- A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the Specifications.
- B. Provide materials complying with the applicable industrial standard in accordance with the General Conditions.
- C. Provide only PVC Coated Rigid Steel Conduit, Fittings, Supports, and 316 Stainless Steel Hardware in chemical environments, outdoor and wet/damp locations including tunnels, pump rooms and galleries.
- D. Stainless Steel:
 - 1. Where stainless steel is indicated or used for any portion of the electrical work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
 - 2. Provide exposed screws of the same alloys.
 - 3. Provide finished material free of any burrs or sharp edges.
 - 4. Use only stainless steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.
 - 5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA 4X construction.

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Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

6. Dissimilar metals shall be separated with dielectric material/tape.
- E. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- F. Sleeves for Rectangular Openings: Galvanized sheet steel.
 1. Minimum Metal Thickness :
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).
- G. Sleeve seals: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Calpico, Inc.
 - b. Metraflex Co.
 - c. Pipeline Seal and Insulator, Inc.
 2. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 3. Pressure Plates: Carbon steel. Include two for each sealing element.
 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.03 WARRANTIES

- A. Refer to the Division 1- General Requirements for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements.
- B. Compile and assemble the warranties specified in Division 26, into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference.
- C. For each product or equipment provide complete warranty information for each item to include date of beginning of warranty or bond; duration of warranty or bond; and names, addresses and telephone numbers and procedures for filing a claim and obtaining warranty Clark County Water Reclamation services.

2.04 SOURCE QUALITY CONTROL

- A. Comply with Section 01 45 00, Quality Control.

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- B. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products. Where required arrange with all manufacturers of the electrical equipment, to allow ENGINEER to inspect and witness the testing of the equipment at the site of fabrication:
 - 1. Testing includes the cabinets, special control systems, power equipment, conductors, cable and other pertinent systems and devices.
- C. Factory testing is specified in the individual sections of the Electrical Specifications.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- B. If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements. No equipment or conduit shall be installed directly underneath any luminaire without authorization. Install all conduit and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:
 - 1. Install all conduits and equipment in accordance with working space requirements as outlined in Article 110, Requirements for Electrical Installations of the National Electrical Code.
 - 2. Where the Drawings do not show dimensions for locating equipment, install equipment in approximate locations as indicated on the Drawings. Adjust locations shown on the Drawings as necessary to avoid any obstruction or interferences.
 - 3. Where an obstruction interferes with equipment operation or safe access, relocate the equipment as reviewed and accepted by the ENGINEER.
 - 4. Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details shown in the Drawings.
 - 5. All conduits, indoors or outdoors to be installed parallel and perpendicular to building lines.
- C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- D. Right of Way: Give to piping systems installed at a required slope.
- E. Equipment locations shown on electrical drawings may change due to variations in equipment size or minor changes made by others during construction:
 - 1. Verify all dimensions as indicated on the Drawings:
 - a. Actual field conditions govern all final installed locations, distances, and levels.

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2. Review all Contract Documents and approved equipment shop drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
 3. Make minor changes in location of equipment before rough in, as directed by ENGINEER.
- F. Install all material and equipment in accordance with the manufacturer's installation instructions:
1. Where CONTRACTOR asks to deviate from the manufacturer's recommendations, such changes must be reviewed and accepted by ENGINEER and manufacturer before installation.
- G. Cutting and Patching:
1. Perform all cutting, patching, channeling, core drilling, and fitting required for the electrical Work, except as otherwise directed:
 - 1) Secure the permission of ENGINEER before performing any operation likely to affect the strength of a structural member:
 - 2) Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:
 - a) Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.
 - b) Use tone-locate system or X-ray to ensure that area is clear of obstructions.
 - c) Verify area free from fire-rated penetration requirements
 2. Review the complete drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
 3. Perform all patching and clean and/or paint to the same quality and appearance as the original Work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
 - a. 3M CP25 Caulk.
 - b. 3M 303 Putty.
 - c. T&B S-100 Caulk.
 - d. T&B FS-500 Putty.
 - e. T&B FST-601 Putty.
 4. Seal around conduit penetrations of below grade walls with a waterproof, non shrink, non-metallic grout, unless otherwise indicated on the typical installation details:
 - a. Use the installation details provided in the drawings as a guide for acceptable sealing methods.
- H. Earthwork and concrete:
1. Install all trenching, shoring, concrete reinforcement, backfilling, grading and resurfacing associated with the Electrical Work:
 - a. Requirements as specified in the Contract Documents Division 26 and Division 31.
- I. Roof penetrations:
1. Make all roof penetrations, and seal around all conduits. Use pitch pockets and flashings.

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- J. Terminations:
 - 1. Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.

- K. Miscellaneous installation requirements:
 - 1. Location of manholes and pullboxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pullboxes with mechanical and civil work.
 - 2. Provide additional manholes or pullboxes to those shown where they are required to make a workable installation.
 - 3. Circuits of different service voltage:
 - a. Voltage and service levels:
 - 1) Medium voltage: greater than 600V to 15kV.
 - 2) Low voltage: 120V to 600V.
 - 3) Instrumentation: less than 50VDC.
 - 4) Install conductors in separate raceways, junction boxes, manholes, hand holes, and pullboxes. Conductors of circuits with voltages of 120VAC to 600VAC may be run in separate conduits in the same ductbank.

- L. Conductors with differing voltages and separately derived systems shall be installed in separate raceways, conduits, Pull and/or Junction Boxes.

- M. Refer to required separation of control, data, fire and power systems.

- N. Labeling:
 - 1. Provide all nameplates and labels as required in Sections 26 00 53, Electrical Identification.

- O. Equipment Tie-Downs:
 - 1. Anchor all instruments, control panels, and equipment by methods that comply with drawings details and seismic and wind bracing criteria, which apply to the site.
 - 2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., must be permanently mounted and tied down to structures in accordance with the drawing details and project seismic criteria.

3.02 FIELD QUALITY CONTROL

- A. Inspection:
 - 1. CONTRACTOR and AHJ shall perform inspection of electrical system installation in accordance with Section 01 45 00, Quality Control, these specifications and drawings.
 - 2. CONTRACTOR and AHJ inspections may include, but are not limited to, the following:
 - a. Inspect equipment and materials for physical damage.
 - b. Inspect installation for compliance with drawings and Specifications.
 - c. Inspect installation for obstructions and adequate clearances around equipment.

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- d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
 - e. Inspect equipment nameplate data to verify compliance with design requirements.
 - f. Inspect raceway installation for quality workmanship and adequate support.
 - g. Inspect cable terminations.
 - h. Schedule structural engineer to inspect all mounting of electrical devices and all penetration and connections to structures.
3. Inspection activities conducted during construction do not satisfy inspection or testing requirements outlined in Section 26 08 00, Acceptance Testing.
- B. Field Testing:
- 1. Notify ENGINEER when the electrical work is ready for field acceptance testing. Coordinate schedule to allow AHJ at testing site during testing.
 - 2. Perform the acceptance tests in accordance with Section 26 08 00, Acceptance Testing.
 - 3. Record results of the required tests along with the date of test:
 - a. Use conduit identification numbers to indicate portion of circuit tested.
- C. Workmanship:
- 1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
 - a. Neatly coil and label spare wiring lengths.
 - b. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by ENGINEER.

3.03 CLEANING

- A. Refer to Section 01 77 00, Closeout Procedures.
 - 1. General Requirements: Remove all foreign material and restore all damaged finishes to the satisfaction of the ENGINEER and OWNER.
- B. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust or other matter before energization of the equipment or system start up:
 - 1. Use of compressors or air blowers for cleaning is not acceptable.
 - 2. Clean all current carrying elements prior to being energized.
- D. Clean and re-lamp all new and existing luminaires that were used in the areas affected by the construction, and return all used lamps to the OWNER.
- E. As specified in other sections of the Contract Documents.

3.04 DEMONSTRATION AND TRAINING

- A. Furnish all personnel and equipment necessary to conduct the demonstration and training requirements as specified in the individual specification sections.

3.05 PROTECTION

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- A. Protect all work from damage or degradation until substantial completion.
- B. Maintain all surfaces to be painted in a clean and smooth condition.

END OF SECTION

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COMMON WORK RESULTS FOR
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SECTION 26 05 02

ELECTRICAL DEMOLITION

[CLICK HERE TO ENTER PROJECT NAME](#)

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PART 1 GENERAL

1.01 SUMMARY

- A. This Section includes basic requirements for demolition of electrical materials, equipment and installations. The CONTRACTOR shall be responsible for visiting the site prior to bid to determine the actual conditions, which might affect the bid or contract price. No allowance will be made subsequently resulting from the neglect to visit the site and make such determinations.
- B. Electrical items that are to be replaced with other equipment in the same locations are covered by this section.
- C. Electrical items that are to be removed in their entirety, or are to be relocated to another place, are covered by this section.

1.02 REFERENCES

- A. National Electrical Code (NEC):
- B. General provisions of the contract, including General and Supplementary Conditions apply to this specification.
- C. Division 26.

1.03 SUBMITTALS

- A. Furnish Submittals in accordance with Sections 01 14 00 Work Restrictions, 01 33 00 Submittal Procedures, and 26 05 00 Common Work Results for Electrical.
- B. Assets which are to be replaced or removed are to be documented with the Asset Management Forms.

1.04 QUALITY CONTROL

- A. Comply with NFPA, NEC, OSHA, and NV Energy Requirements.
- B. Coordinated electrical system demolition with other systems being demolished.

1.05 WARRANTY

- A. Refer to Document 00 61 15, Guaranty Bond.

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1.06 UTILITY SERVICES

- A. Maintain existing utility services. Where necessary to cut existing conduits, wires, cables, etc. of utility services or fire protection systems, they shall be cut and capped at suitable places as shown or where directed by the ENGINEER.
- B. Electrical service in demolition area shall be reduced to a minimum and identified to eliminate uncertainty about which circuits are energized.
- C. The CONTRACTOR shall notify the ENGINEER in writing of any planned utility interruptions including interruptions of power to communications and fire protection systems as specified in Section 01 14 00, Work Restrictions. The request shall state the reason, date, beginning time, and expected duration of such interruptions. No interruptions shall be made without the OWNER's written concurrence and such interruptions shall be coordinated with the OWNER to cause the least inconvenience to the OWNER's operations. Service interruptions which cannot wait for written approval may be granted with verbal approval from the ENGINEER. After verbal approval is granted, written confirmation shall be issued by the CONTRACTOR as soon as practical.
- D. When utility lines are encountered that are not indicated on the Drawings, notify ENGINEER prior to further work in that area.
- E. Coordinate all phases of power and lighting demolition with all trades.
- F. Existing equipment and circuiting shown are based upon limited field surveys. Verify existing conditions and make all necessary adjustments.
- G. Provide Temporary lighting and power as required to maintain safety and security.
 - 1. Provide minimum lighting levels as required for safety purposes.
 - 2. 150 watts spaced 20 feet on centers each way throughout buildings
 - 3. 150 watts at each landing and story in each stairway.
 - 4. Unless otherwise indicated, mount temporary lighting at a maximum height of 10 feet above each floor level.
 - 5. All scaffold systems shall have adequate light to meet existing codes.
- H. Coordinate final disconnection of electric services with NV Energy or ENGINEER.
- I. Remove and abandon all site manholes, vaults, and raceway system unless otherwise noted. Systems to be abandoned shall be filled with grout to avoid collapse.
- J. Inaccessibly Concealed raceways identified as abandoned: Cut off and abandon in place.
- K. Exposed or Concealed Above Accessible Ceilings: Remove.
- L. Raceways and Cabling Scheduled for Future Use: Install pull string, cap/seal and tag.

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- M. Relocating Equipment: Run new wiring from the source.
- N. Where the existing raceway is concealed, clean outlet box and install a blank cover plate.
- O. Where the concealed raceway is uncovered remove raceway (or extend to new location if appropriate).

1.07 PROTECTIVE MEASURES

- A. Provide the following protective measures:
 1. Wherever existing roofing surfaces are penetrated by electrical conduit, they shall be protected against water infiltration. Water leaks shall be repaired immediately upon discovery when they occur.
 2. Temporary protection against damage for all portions of existing structures and grounds where work is to be done, materials handled, and equipment moved or relocated.
 3. CONTRACTOR shall patch and fill openings in floors, walls and ceilings for removed equipment or piping with the same material, fire and structural integrity that would have existed prior to the penetration including concrete, block, gyp wallboard, exterior walls, roof membranes, etc. for steel and wood beams which shall have the openings capped with similar material.
 4. Protect existing ceiling tiles in electrical rooms where shown on Drawings during work at equipment. In case of damage to tiles, replace in kind.
 5. Dust and Debris Control:
 6. Prevent the spread of dust and debris to occupied portions of the buildings and avoid the creation of a nuisance or hazard in the surrounding area. Do not use water if it results in hazardous or objectionable conditions such as, but not limited to, ice, flooding, or pollution.
 7. Where pedestrian and driver safety is endangered in the area of removal Work, use traffic barricades with flashing lights.
- B. The CONTRACTOR shall be responsible for contacting utilities or locating services and obtaining locations of all underground services in the general area of demolition works.
- C. Provide temporary weather protection during interval between removal of existing exterior surfaces and installation of new to ensure that no water leakage or damage occurs to structure or interior areas of existing building.
- D. Ensure that structural elements are not overloaded as a result of or during performance of the Work. Responsibility for additional structural elements or increasing the strength of existing structural elements as may be required as a result of any Work performed under this Contract shall be that of the CONTRACTOR. Repairs, reinforcement, or structural replacement must have ENGINEER's approval.
- E. Do not overload pavements.
- F. Protection of Personnel:

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1. Provide temporary barricades and other forms of protection to protect OWNER's personnel and the general public from injury due to demolition Work.
2. Provide protective measures as required to provide free and safe passage of OWNER's personnel and the general public to occupied portions of the structure.

PART 2 PRODUCTS

2.01 EQUIPMENT AND MATERIALS

- A. The CONTRACTOR shall provide all equipment and materials necessary for the removal or relocation of electrical equipment.
- B. Materials used in restoration or repairing work related to demolition and relocation shall conform in type, quality, and function to that of the original existing construction or as otherwise indicated.
- C. Store equipment and material designated to be reused in a location designated by OWNER.
- D. Equipment and material designated to be reused shall be cleaned, serviced and checked for proper operability before being put back into service.
- E. ENGINEER will determine condition of equipment and materials prior to removal.

2.02 DISPOSAL AND RETENTION

- A. Materials and equipment resulting from work and removed from the building or structures, or parts thereof, shall become the property of the CONTRACTOR and shall be removed from the site by the CONTRACTOR except as requested by the OWNER prior to demolition.
- B. Items removed or noted to be retained by the OWNER but which are declined to be retained by the OWNER shall be removed from the site by the CONTRACTOR.
- C. OWNER will not be responsible for the condition or loss of, or damage to, property scheduled to become CONTRACTOR's property after ENGINEER's authorization to begin demolition. Materials and equipment shall not be viewed by prospective purchasers or sold on the site.
- D. Combustible waste material and rubbish shall not be stored or allowed to accumulate within a building or its vicinity, but shall be kept in a suitable trash container for subsequent removal or shall be removed from the premises as rapidly as practical.
- E. All hazard waste shall be properly disposed of by a licensed hazard waste disposal facility. Items shall include but not limited to fluorescent lamps, diesel fuel, radiator coolant, etc.

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- F. Recyclable material shall be gathered, sorted and delivered to recycle facilities as appropriate.

PART 3 EXECUTION

3.01 EXECUTION

- A. Remove or relocate all items indicated on the drawings or as otherwise indicated.
- B. Where the installation of new or existing equipment requires the relocation of other existing equipment, the other existing equipment shall be removed or relocated as though it was specifically noted to be removed or relocated.
- C. Wherever electrical materials have been removed from surfaces of the building or structure, those surfaces shall be patched and repaired.
- D. Existing work or equipment to be altered or extended and found to be defective shall be reported to the ENGINEER before it is disturbed or any further work is performed on it.
- E. Where electrical equipment is indicated to be removed or relocated, the work shall include the complete disconnection from its source, dismantling as necessary, and removal or installation of all conduit, wires, cables, etc. Unless noted otherwise, wires shall be removed from conduits back to the last utilization device or to the panelboard. No wiring shall be removed that prevents operation of other equipment not scheduled or indicated to be removed.
- F. Schedule all demolition work with other trades as necessary for the efficient progress and flow of the work.
- G. Debris and rubbish shall be removed from affected facilities, and structures. Debris and rubbish shall be removed and transported in a manner that prevents spillage on streets or adjacent areas. Local regulations regarding hauling and disposal shall apply.

END OF SECTION

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SECTION 26 05 13

MEDIUM VOLTAGE CABLES

[CLICK HERE TO ENTER PROJECT NAME](#)

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PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes cables and related splices, terminations, and accessories for medium- voltage electrical distribution systems.

1.03 DEFINITIONS

- A. NETA ATS: Acceptance Testing Specification.

1.04 SUBMITTALS

- A. Product Data: For each type of cable and accessory indicated. Include splices and terminations for cables and cable accessories. Include manufacturer, type, voltage class, gauge, conductor material, stranding, insulation type and level, shielding, temperature rating, and jacket material.
- B. Samples: 16-inch (400-mm) lengths of each type of cable indicated.
- C. Material Certificates: For each cable and accessory type, signed by manufacturers.
- D. Cable Pulling Calculations for medium voltage pulls that cannot be hand pulled: Ensure submitted and reviewed 2 weeks before cable installation.
- E. Source quality-control test reports.
- F. Field quality-control test reports.

1.05 QUALITY CONTROL

- A. Splices will only be permitted after approved submittals of all materials and the work plan is approved by ENGINEER.
 - 1. Cable splicers must have minimum 5 years' experience splicing medium voltage cable.
 - 2. Refer to Section 26 05 33, Conduits, Raceways and Boxes for guidelines for new in-ground vault and pull box installations

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3. Splicing is to be prevented if possible.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association and that is acceptable to authorities having jurisdiction.
 1. Testing Agency's Field Supervisor: Person currently accredited by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
 2. Testing agency's technician currently accredited by NETA
 - C. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.
 - D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
 - E. Comply with IEEE C2 and NFPA 70.

1.06 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by OWNER or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 1. Notify OWNER 2 weeks in accordance with the General Conditions and Special Conditions of the Contract, or earlier as indicated in Section 01 14 00, Work Restrictions.
 2. Do not proceed with utility interruptions without OWNER's written permission.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Cables:
 - a. American Insulated Wire Corp.; a Leviton Company.
 - b. General Cable Technologies Corporation.
 - c. Kerite Co. (The); Hubbell Incorporated.
 - d. Okonite Company (The).
 - e. Pirelli Cables & Systems NA.
 - f. Rome Cable Corporation.
 - g. Southwire Company.
 2. Cable Splicing and Terminating Products and Accessories:
 - a. Raychem Corp.; Telephone Energy and Industrial Division; Tyco International Ltd.
 - b. RTE Components; Cooper Power Systems, Inc.
 - c. Scott Fetzer Co. (The); Adalet.
 - d. Thomas & Betts Corporation.

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- e. Thomas & Betts Corporation/Elastimold.
- f. 3M; Electrical Products Division.

2.02 CABLES

- A. Cable Type: MV105.
- B. Comply with UL 1072, AEIC CS 8, ICEA S-93-639, and ICEA S-97-682.
- C. Conductor: Copper.
- D. Conductor Stranding: Concentric lay, Class B compact round stranded in accordance with ASTM B3, ASTM B8, and ASTM B496.
- E. Conductor Screen: Extruded, semiconducting EPR in accordance with NEMA WC 74 and AEIC CS 8.
- F. Strand Filling: Conductor interstices are filled with impermeable compound.
 - 1. Conductor Insulation: Ethylene-propylene rubber, (EPR) containing no polyethylene, 220 mil, in accordance with ICEA S093-639 / NEMA WC 71, and AEIC CS 8.
 - 2. Insulation Screen: Thermosetting, semiconducting ethylene-propylene rubber (EPR), extruded directly over insulation in accordance with NEMA WC 74 and AEIC CS 8.
 - 3. Voltage Rating: 15 kV.
 - 4. Insulation Thickness: 133 percent insulation level.
- G. Shielding: Copper tape, helically applied over semiconducting insulation shield with 25% overlap minimum.
- H. Cable Jacket: Sunlight-resistant PVC compound applied in accordance with NEMA WC 71 or NEMA WC 74.
- I. Operating Temperature: 105 degrees C continuous normal operations, 130 degrees C emergency operating conditions, and 250 degrees C short-circuit conditions.

2.03 SPLICE KITS

- A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.
- B. Splicing Products: If necessary and approved by ENGINEER with an approved work plan containing written recommended, by splicing kit manufacturer, specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.

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2.04 SOLID TERMINATIONS

- A. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.
 - 1. Class 1 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.
 - 2. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.

2.05 SEPARABLE INSULATED CONNECTORS

- A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
- B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
- C. Load-Break Cable Terminators: Elbow-type units with 200-A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated complete with test point on terminator body that is capacitance coupled.
- D. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated complete with test point on terminator body that is capacitance coupled.
- E. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.
 - 1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
 - 2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
 - 3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
 - 4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.
- F. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with

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self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

- G. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.06 ARC-PROOFING MATERIALS

- A. Tape for First Course on Metal Objects: 10-mil- (250-micrometer-) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
- B. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, compatible with cable jacket.
- C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2 inch (13 mm) wide.

2.07 FAULT INDICATORS

- A. Indicators: Automatically reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.
- B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.08 SOURCE QUALITY CONTROL

- A. Test and inspect cables according to ICEA S-97-682 before shipping.
- B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).
- C. Provide test results to OWNER through submittal process.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install cables according to IEEE 576.
- B. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions, sidewall pressure values and bending radii. Any electric or hydraulic pulling equipment must be equipped with a load tension gauge.
 1. Where necessary, use manufacturer-approved pulling compound or lubricant (Yellow 77 prohibited) that will not deteriorate conductor or insulation.
 2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
 3. Provide pulling calculations for approval by ENGINEER prior to installation.
 4. Use pulley, sheave and other approved means to install.

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- C. Support cables according to Division 26 Section 26 05 33, Conduits, Raceways and Boxes.
- D. Install "buried-cable" warning tape 12 inches (305 mm) above top of duct bank.
- E. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag. Arrange cables to avoid interference with duct entrances. Provide minimum of 10' of spare cable length in each manhole pull up or cable vault.
- F. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits.
- G. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc- proofing tape manufacturer's written instructions, apply arc proofing as follows :
 - 1. Clean cable sheath.
 - 2. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
 - 3. Smooth surface contours with electrical insulation putty.
 - 4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
 - 5. Band arc-proofing tape with 1-inch- (25-mm-) wide bands of half-lapped, adhesive, glass-cloth tape 2 inches (50 mm) o.c.
- H. Install fault indicators on each phase where indicated.
- I. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated- connector fittings, and hardware.
- J. Identify cables according to Section 26 05 53, Electrical Identification.

3.02 FIELD QUALITY CONTROL

- A. Testing: Engage a qualified testing and inspecting agency as required by 1.5 QUALITY CONTROL of this section to perform the following field tests and inspections and prepare test reports:
 - 1. Perform each visual, mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
 - 2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
- B. Remove and replace malfunctioning units in whole, not in part, and retest as specified above.

END OF SECTION

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SECTION 26 05 19

CONDUCTORS AND CABLES

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PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
1. Building wires and cables rated 600 V and less.
 2. Connectors, splices, and terminations rated 600 V and less.
 3. Sleeves and sleeve seals for cables.
- B. Related Sections include the following:
1. Section 26 05 13, Medium-Voltage Cables for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.

1.03 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene monomer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated including manufacturer, type, voltage class, gauge, conductor material, stranding, insulation type and level, shielding, temperature rating, and jacket material.
- B. Cable Pulling Calculations for the following, ensure submitted and reviewed 2 weeks before cable installation:
1. 600-volt cable sizes larger than 2/0 AWG and pulling lengths longer than 200 feet.
 2. Power and control conductor, and control and instrumentation cable installations in ductbanks for pulling lengths longer than 500 feet.

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C. Field quality-control test reports.

1.05 QUALITY CONTROL

- A. Splices will only be permitted after approved submittals of all materials and the work plan is approved by ENGINEER.
 - 1. Cable splicers must have minimum 5 years' experience splicing cable.
 - 2. Refer to Section 26 05 33, Conduit, Raceway and Boxes for guidelines on for new in-ground vault and pull box installations.
 - 3. Splicing is to be prevented unless necessary.

- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently accredited by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
 - 2. Testing agency's technician currently accredited by NETA.

- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

- D. Comply with NFPA 70.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Conductors:
 - a. General Cable Technologies Corporation
 - b. Okonite Company (The)
 - c. Alpha Wire Corporation
 - d. Belden
 - e. Southwire Company
 - 2. Conductor Accessories:
 - a. ILSCO
 - b. Burndy; Insulug
 - c. Scott Fetzer Co. (The); Adalet
 - d. Thomas & Betts Corporation
 - e. 3M; Electrical Products Division
 - f. Brady
 - g. Raychem

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2.02 600-VOLT RATED CONDUCTORS AND CABLES (POWER AND CONTROL)

- A. Conductors shall be annealed copper with conductivity of no less than 98% pure copper.
- B. Aluminum conductors are not permitted.
- C. Copper Conductors: Comply with NEMA WC 70.
- D. Conductor Insulation: Comply with NEMA WC 70 for Type XHHW-2.

2.03 VARIABLE FREQUENCY DRIVE POWER CABLE – TYPE VFD

- A. Conductors:
 - 1. Class B, stranded coated copper.
 - 2. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW-2.
 - 3. Grounding Conductors: Insulated stranded copper.
- B. Sheath:
 - 1. UL 1277 Type TC, 90 degrees C.
 - 2. Continuous shield, A1/polyester foil, drain wires, overall copper braid.
- C. Outer Jacket: Polyvinyl chloride (PVC) per UL 1569.
- D. Manufacturers and Products:
 - 1. Alpha Wire; Series V.
 - 2. Belden; Series 29500
 - 3. LAPP USA; OLFLEX VFD Slim.

2.04 CONDUCTORS (COMMUNICATION AND INSTRUMENTATION)

- A. Type RS-485 Cable, 300V:
 - 1. No. 24 AWG, multi twisted pairs with a common overall shield, designed for use as low capacitance computer cable for EIA RS-485 applications.
 - 2. Cable:
 - a. Type: Custom cable; no exceptions.
 - b. Configuration: Molded cable assembly with factory installed connector on one end, capped cable on one end; no exceptions.
 - c. Length: Continuous length of cable (with molded connector), factory assembled and tested; length as required for application.
 - d. Documentation: Furnished with cable.
 - 3. Conductors:
 - a. 24 AWG, seven-strand.
 - b. Tinned copper, insulated, twisted pairs.
 - c. Cable Shield: Overall aluminum-polyester shield.
 - d. 24 AWG stranded, tinned copper drain wire.
 - e. Overall tinned copper braid shield, 90-percent coverage.
 - f. Jacket: Chrome PVC.
 - g. Insulation: Polyethylene.
 - h. Number of pairs: 4, or as required by the application.
 - i. Outside Diameter: 0.45 inches, maximum.

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- j. Belden Color Code: Chart No. 5.
- 4. Connectors:
 - a. Type: Factory molded D-Subminiature (one-end only).
 - b. Number of Pins and gender as required.
 - c. Retention System: Screw, horizontal slide lock or vertical slide lock.
 - d. Connector Style: Straight handled, right-angled or angled.
- 5. Manufacturers: Belden No. 9844, or as required by the application.

- B. Type Ethernet Cable, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 300V:
 - 1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568 C Category 6 requirements.
 - 2. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
 - 3. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket.
 - 4. NFPA 70 Plenum (CMP) rated; comply with flammability plenum requirements of NFPA 70 and NFPA 262.
 - 5. Cable shall withstand a bend radius of 1 inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.
 - 6. Manufacturer and Product: Belden; 7852A.

2.05 CONNECTORS

- A. Description: Factory-fabricated connectors of size, ampacity rating, material, type, and class for application and service indicated.

2.06 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and conduit.
 - 1. Sealing Elements: EPDM interlocking links shaped to fit surface of conduit. Include type and number required for material and size of raceway.
 - 2. Pressure Plates: Plastic Carbon steel. Include two for each sealing element.
 - 3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Stranded for No. 10 AWG and smaller; stranded for No. 8 AWG and larger, except as indicated below.

CONDUCTOR	<u>120/208</u> <u>VAC</u>	<u>480VAC</u>	<u>24V DC</u>	120 VAC Control/ Power
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Phase 1	Black	Brown	Blue	Red
Phase 2	Red	Orange	(-) Blue w/ white stripe	
Phase 3	Blue	Yellow		
Neutrals	White	Grey		White

1. Use standard conductors for control circuits.
2. Use conductor not smaller than 14 AWG for control circuits.
3. Use 10 AWG conductors for 20 ampere, 120 volt branch circuits longer than 75 feet (25 m).
4. Use 10 AWG conductors for 20 ampere, 277 volt branch circuits longer than 200 feet (160 m).

- B. Branch Circuits: Stranded copper for No. 10 AWG and smaller, minimum size #12 AWG; stranded for No. 8 AWG and larger.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type XHHW-2, single conductors in raceway.
- B. Exposed Feeders: Type XHHW-2, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, below raised floors and Crawlspace: Type XHHW-2, single conductors in raceway
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and underground: Type XHHW-2, single conductors in raceway.
- E. Exposed Branch Circuits, Including in Crawlspace: Type XHHW-2, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type XHHW-2.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway
- H. Branch Circuits Installed below Raised Flooring: Type XHHW-2, single conductors in raceway.
- I. Class 1 Control Circuits: Type XHHW-2, in raceway.
- J. Class 2 Control Circuits: Type XHHW-2, in raceway

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3.03 INSTALLATION OF CONDUCTORS AND CABLES

- A. Use manufacturer-approved pulling compound or lubricant (Yellow 77 prohibited) where necessary; compound used must be water based and not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- B. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.
- C. Support cables according to Section 26 05 29, Hangers and Supports for Electrical Systems, 26 05 48 Section Vibration and Seismic Controls for Electrical Systems, and 26 05 33, Conduit, Raceways and Boxes.
- D. Identify and color-code conductors and cables according to Section 26 05 53, Electrical Identification.

3.04 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque- tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 4868.
- B. Make approved and planned splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors. Non-preventable splices are allowed in pullboxes only. Do not splice motor feeders, panel feeders, or service entrance feeders.
- C. Wiring at Outlets: Install conductor at each outlet, with a minimum length to extend 6 inches (150 mm) beyond outlet opening, per NEC requirements.
- D. Splice submersible cable in pullboxes with approved and planned waterproof splices.

3.05 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of applicable specified firestopping systems.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Rectangular Sleeve Minimum Metal Thickness:
 - 1. For sleeve rectangle perimeter less than 50 inches (1270 mm) and no side greater than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).

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2. For sleeve rectangle perimeter equal to, or greater than, 50 inches (1270 mm) and 1 or more sides equal to, or greater than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).
- E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
 - F. Cut sleeves to length for mounting flush with both wall surfaces.
 - G. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
 - H. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and conduit unless sleeve seal is to be installed.
 - I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
 - J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint and in coordination with related specification sections.
 - K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with fire stop materials and in coordination with related specification sections.
 - L. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.
 - M. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - N. Underground Exterior-Wall Penetrations: Install schedule 40 galvanized pipe "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.06 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground exterior-wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for conduit material and size. Position conduit in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

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3.07 FIRESTOPPING

- A. Apply fire stopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly in coordination with related fire stop specification sections.

3.08 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a NETA accredited testing agency to perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance, feeder conductors, and branch circuits #10 AWG and larger, for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each connection and termination in cables and conductors No. 10 AWG and larger. Remove box and equipment covers so connections and terminations are accessible to portable scanner.
 - a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
 - b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.
- C. Test Reports: Prepare a written report to record the following :
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D. Remove and replace malfunctioning units and conductors that fail in whole, not in part, and retest as specified above.

END OF SECTION

E.

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SECTION 26 05 26

GROUNDING AND BONDING

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PART 1 GENERAL

1.01 SUMMARY

- A. Section includes requirements for:
 - 1. Grounding electrodes.
 - 2. Grounding electrode conductors.
 - 3. Equipment grounding conductors.
 - 4. Main bonding jumper.
 - 5. Ground connections.
 - 6. General requirements for grounding.

1.02 REFERENCES

- A. Refer to Sections 01 42 19, Reference Standards, 26 05 00, Common Work Results for Electrical, and 26 05 33, Conduit Raceways and Boxes.
- B. NEC Article 250.

1.03 DEFINITIONS

- A. Refer to General Conditions and Section 26 05 00, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.
- B. Provide an electrical grounding system as indicated on the Drawings and as specified.
- C. Provide complete grounding system including but not limited to:
 - 1. Grounding electrodes.
 - 2. Bonding jumpers.
 - 3. Ground connections.
- D. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.

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1. The ground system resistance (electrode to ground) of the completed installation, as determined by tests required by Section 26 08 00, Acceptance Testing shall be: 5 ohms or less for industrial systems.

1.05 SUBMITTALS

- A. Furnish submittals in accordance with Sections 01 33 00, Submittal Procedures, and 26 05 00, Common Work Results for Electrical.
- B. Product Data.
 1. Catalog Cut Sheets.
- C. Testing Resume:
 1. Submit a written resume for the individual who will perform the grounding tests detailing experience and qualifications.
 2. Submit detailed information concerning test instrument, and tester's qualifications to perform the specified tests.

1.06 QUALITY CONTROL

- A. Refer to Sections 01 45 00, Quality Control, 26 05 00, Common Work Results for Electrical, and 26 05 33, Conduit Raceways and Boxes.
- B. Testing Agency Qualifications: Member company of NETA or an NRTL.
 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise onsite testing.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with UL 467 for grounding and bonding materials and equipment.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Sections 01 66 00, Product Storage and Handling Requirements, and 26 05 00, Common Work Results for Electrical.

1.08 WARRANTY

- A. Refer to Document 00 61 15, Guaranty Bond, and Section 26 05 00, Common Work Results for Electrical.

1.09 SYSTEM START UP

- A. Refer to Sections 01 75 05, Testing Training and Startup, and 26 05 00, Common Work Results for Electrical.

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PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Compression Connectors: One of the following or equal:
 - 1. FCI Burndy.
 - 2. Thomas and Betts.
 - 3. O.Z. Gedney

- B. Exothermic Connectors: One of the following or equal:
 - 1. Cadweld.
 - 2. Harger.
 - 3. Burndy Weld.

- C. Ground Rods: One of the following or equal:
 - 1. Erico.
 - 2. Harger.
 - 3. Conex.

- D. Ground Cable: One of the following or equal:
 - 1. Nehring.
 - 2. Harger.
 - 3. Southwire.

2.02 MATERIALS

- A. Ground Rod:
 - 1. Minimum: 3/4 inch diameter, 10 feet long.
 - 2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core:
 - a. The copper-to-steel bond shall be corrosion resistant.
 - 3. Conforming to UL 467.
 - 4. Fit the top of the rod with a coupling and steel-driving stud.

- B. Ground Cable:
 - 1. Requirements:
 - a. Soft drawn (Annealed).
 - b. Concentric lay, coarse stranded.
 - c. Bare copper.
 - d. 98 percent conductivity.
 - 2. Size is as indicated on the Drawings, but not less than required by the NEC.
 - 3. Ground Grid and Grounding Electrode conductors are 4/0 AWG minimum.

- C. Compression Connectors:
 - 1. Manufactured of high copper alloy specifically for the particular grounding application.
 - 2. Suitable for exposed connections. Do not use for direct buried connections.
 - 3. Identifying compression die number inscription to be impressed on compression fitting.

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- D. Exothermic Welds:
 1. Current carrying capacity equal to that of the conductor.
 2. Permanent molecular bond that cannot loosen or corrode over time.
 3. Will not deteriorate with age and must be suitable for direct burial.

- E. Equipment Grounding Conductors:
 1. Conductors shall be the same type and insulation as the load circuit conductors.
 2. The minimum size shall be as required by the National Electrical Code.
 3. Provide in all raceways. The conduit system is not an allowable equipment ground.

- F. Grounding Electrode Conductors:
 1. The minimum size shall be as required by National Electrical Code. Conductors shall be No.4/0.

- G. Main Bonding Jumpers and Bonding Jumpers:
 1. The minimum size shall be as required by National Electrical Code or as specified by this standard and the Authority Having Jurisdiction, for example; Minimum equipment grounding conductor and bonding jumper for all signal/communication systems will be #12AWG Stranded either bare or identified with green insulation as dictated by the application.

PART 3 EXECUTION

3.1 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 1. Feeders and branch circuits.
 2. Lighting circuits.
 3. Receptacle circuits.
 4. Single-phase motor and appliance branch circuits.
 5. Three-phase motor and appliance branch circuits.
 6. Flexible raceway runs.
 7. Armored and metal-clad cable runs.
 8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
 10. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

- B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

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- C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- D. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
- E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
- F. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
 - 1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 - 2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch grounding bus.
 - 3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
 - 4. The minimum size shall be as required by National Electrical Code or as specified by this standard and the Authority Having Jurisdiction, for example; Minimum equipment grounding conductor and bonding jumper for all signal/communication systems will be #12AWG Stranded either bare or identified with green insulation as dictated by the application.
- G. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate uninsulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.02 INSTALLATION

- A. Refer to Section 26 05 00, Common Work Results for Electrical.
- B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
 - 1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.

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2. Provide a separate grounding conductor in each individual raceway for parallel feeders.
- C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
1. When grounding motors driven by Variable Frequency Drives (VFD) comply with the requirements of the VFD Manufacturer.
- D. Provide a grounding type bushing with lug for connection of grounding conductor for all Conduits that originate from each MV Switch Line-up, Pad Mount Switch, Load Center, MCC Section, Switch board, Disconnect Safety Switch, PLC Cabinet, Panel board, or Electrical Enclosure to include wire ways and Communications and Data. Electrical Device boxes are to be bonded using the branch circuit equipment grounding conductor.
- E. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system for those conduits terminating into all cabinets and enclosures via Meyers Hub, use grounding bushing that have a seat to mechanically connect a chair lug to and land the bonding conductor to.
- F. For Electrical Device Box Grounding use green insulated wire, no smaller than #12 AWG solid, to bond box to Electrical Device Ground Screw and equipment grounding conductor. Attach #12 AWG solid green insulated bonding jumper to box using Green Grounding Screw intended for that purpose. Make sure there is a good mechanical connection.
- G. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only after a transformer.
- H. Connect surge arrestor ground terminals to equipment ground bus in electrical equipment enclosure where installed.
- I. Duct Bank Ground System:
1. Provide a minimum 4/0 Bare Copper Grounding Conductor the entire length of each duct bank, embedded in the concrete of the duct bank as detailed on the Drawings and Specifications.
 2. Bond duct bank ground conductors together by means of exothermic weld where duct banks join, merge, intersect or split.
 3. All splices should be done by means of exothermic weld.
 4. Install ground rods at all pull boxes.
 5. Make connections to all equipment, enclosures, and structures.
- J. Grounding at Service (600V or Less): Provide grounding at service as follows:
1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.
- K. Ground Connections:

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1. All connections to the ground grid system, the duct bank grounding system, ground rods, etc., shall be made using exothermic welds or compression type grounding connectors as indicated on the Drawings, UL listed, and labeled for the application.
 - a. All underground and concrete embedded grounding connections shall be exothermic weld type.
 - b. All above ground connections from the ground grid system to equipment, etc. shall be made using compression type grounding connections as indicated on the Drawings.
 - c. Refer to the grounding details as indicated on the Drawings for specific connections to be used at specific locations.
2. Make ground connections in accordance with the manufacturer's instructions.
3. Do not conceal or cover any ground connections until the ENGINEER or authorized representative has established and provided written confirmation that every grounding connection conforms to the Drawings and Specifications.

L. Grounding Electrode System:

1. Ground Ring:
 - a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
 - b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, Minimum Size 4/0 AWG.
 - c. Minimum burial depth 36 inches or as indicated on the Drawings.
 - d. Re-compact disturbed soils to original density in 6-inch lifts.
2. Ground Rods:
 - a. Locations as indicated on the Drawings.
 - b. Length of rods forming an individual ground array shall be equal in length.
 - c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
 - d. Pre-crimp all ground rods, as recommended by the manufacturer, before crimping connector to ground rod.
3. Metal Water Pipe:
 - a. Bond metal domestic water pipe to grounding electrode system.
4. Metal Frame of Building or Structure:
 - a. Bond metal frame of building or structure to grounding electrode system.
5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
6. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment or enclosures are installed.

M. Shield Grounding:

1. Shielded instrumentation cable shall have its shield grounded at one end only unless shop drawings indicate otherwise:
 - a. The grounding point shall be at the control panel or at the power source end of the signal carried by the cable.
2. Terminate the shield drain wire on a dedicated terminal block.
3. Use manufacturer's terminal block jumpers to interconnect ground terminals.
4. Connection to the panel main ground bus shall be via a green No. 12 conductor to the main ground bus for the panel.

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N. Install ground rods in precast ground wells as specified or detailed on the Drawings.

3.03 LABELING

- A. Comply with requirements in Section 26 05 53, Electrical Identification Article for instruction signs. The label or its text shall be green.
 - 1. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
 - a. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.04 FIELD QUALITY CONTROL

- A. Refer to Sections 01 45 00, Quality Control, and 26 05 00, Common Work Results for Electrical.
- B. Testing Agency: Engage a NETA Accredited testing agency to perform tests and inspections.
 - 1. Testing Agency must employ NETA Accredited Technicians.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where a maximum ground resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 - 4. Prepare dimensioned Drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- E. Grounding system will be considered defective if it does not pass tests and inspections. Modifications must be made to the grounding system to allow it to pass the inspections and tests.

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- F. Prepare test and inspection reports.
- G. Report measured ground resistances that exceed the following values:
 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 2. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
 3. Substations and Pad-Mounted Equipment: 5 ohms.
 4. Manhole Grounds: 10 ohms.
- H Excessive Ground Resistance: If resistance to ground exceeds specified values, notify ENGINEER promptly and include recommendations to reduce ground resistance.

3.05 ADJUSTING

- A. Under the direction of ENGINEER, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:
 1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

END OF SECTION

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SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

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PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.03 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. FMC: Flexible Metallic Conduit
- C. LFMC: Liquid-Tight Flexible Metal Conduit
- D. PVC-GRS: PVC Coated Rigid Steel
- E. GRC: Galvanized Rigid Steel Conduit.

1.04 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified Nevada licensed professional engineer, using performance requirements and design criteria indicated.
- B. Design supports for multiple raceways capable of supporting combined operating weight of supported systems, equipment, components and its contents.
- C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

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1.05 SUBMITTALS

A. Product Data: For the following:

1. One-Hole Straps
2. One-Hole Conduit Straps with Clamp Backs
3. Conduit Hangers
4. I-beam Clamps
5. Channel Clamps
6. Round Steel/Stainless Steel Rods
7. Drop-in Anchors
8. Wedge Type Anchors
9. Toggle Bolts
10. Through-Wall and Floor Seals
11. Cable Supports
12. Slotted U-Channel Systems

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include Product Data for components.
2. Stainless Steel and Galvanized Steel slotted channel systems. Include Product Data for components.
3. Nonmetallic slotted channel systems. Include Product Data for components. Only acceptable for inside of medium voltage equipment rated 2kV-15kV and pull boxes.
4. Equipment supports.

1.06 QUALITY CONTROL

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

B. Comply with NFPA 70.

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1.07 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3, where applicable. Cast in place J-bolts shall not be allowed in any installation.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations specified in other sections.

PART 2 PRODUCTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Stainless and Galvanized Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper 8-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
 - h. Hilti
 - 2. Metallic Construction:
 - a. Stainless Steel Strut and Hardware to be used in the following areas with no exceptions.
 - 1. Pump Rooms
 - 2. Galleries
 - 3. All outdoor locations
 - 4. All below grade locations
 - b. Hot Dipped Galvanized Strut and Hardware to be used in the following areas with no exceptions.
 - 1. Indoors of Electrical Rooms
 - 2. Indoors of Mechanical Rooms
 - 3. Maintenance shops
 - 4. All District Facilities designed as an office type environment
 - 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4. Painted Strut not accepted.
 - 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 5. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

2.02 U-CHANNEL STRUT SYSTEM

- A. Provide U-Channel strut system for supporting electrical equipment, constructed of 12 gauge 316 stainless steel, PVC coated, or hot dipped galvanized of sizes

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indicated; constructed with slots 2" O.C. Use supports, fasteners and other associated materials that mate and match with U-Channel.

- B. Selection of U-Channel strut material shall be as follows:
 - 1. 316 Stainless steel and PVC coated shall be used in all outdoor, damp, wet and corrosive areas to include pump room, gallery, below grade and process areas.
 - 2. Hot dipped galvanized shall only be used indoors where ventilation exists such as electric rooms, maintenance shops, mechanical rooms and facilities designed as office type environments.

2.03 PVC COATED U-CHANNEL STRUT SYSTEM

- A. Provide stainless steel hardware and the following fittings and materials that mate and match with PVC Coated U-Channel Strut systems.
 - 1. PVC Coated Strut Nuts
 - 2. PVC Coated Conduit Straps
 - 3. PVC Coating and Touch-Up Compound

2.04 STAINLESS STEEL U-CHANNEL STRUT SYSTEM

- A. Provide stainless steel hardware and the following fittings and materials that mate and match with Stainless Steel U-Channel Strut systems.
 - 1. Stainless Fixture Hangers
 - 2. Stainless Channel Hangers
 - 3. Stainless Beam Clamps
 - 4. Stainless End Caps
 - 5. Stainless Strut Nuts
 - 6. Stainless Wiring Stud Nuts
 - 7. Stainless Post Bases
 - 8. Stainless Couplings
 - 9. Stainless Angles
 - 10. Stainless Braces
 - 11. Stainless Conduit Clamps
 - 12. Stainless U-Bolts
 - 13. Stainless Square Washers

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install hangers, anchors, sleeves and seals as indicated, in accordance with manufacture's written instructions and with recognized industry practices to insure supporting devices comply with requirements. Comply with requirements of NECA and NEC for installation of supporting devices.
- B. Coordinate with other electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices with other work.
- C. Install hangers, supports, clamps and attachments to support piping properly from building structure. Arrange for grouping of 2 or more parallel runs of conduits to be

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supported together on channel type hangers where possible. Install supports with spacing indicated and in compliance with NEC requirements.

- D. Torque sleeve seal nuts, complying with manufacturer's recommended values. Ensure that sealing grommets expand to form watertight seal.
- E. Comply with manufacturer's recommendations for touch up of field cut ends or damaged PVC coated U-channel and fittings.
- F. Remove burrs and field cut stainless steel U-channel strut

END OF SECTION

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SECTION 26 05 33

CONDUITS, RACEWAYS AND BOXES

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PART 1 GENERAL

1.01 SUMMARY

- A. Section includes requirements for:
 - 1. Metallic Conduits:
 - a. Rigid Galvanized Steel (GRC).
 - b. PVC Coated Rigid Steel (PVC-GRS).
 - c. Liquid-Tight Flexible Metal Conduit (LFMC).
 - d. Flexible Metallic Conduit (FMC)
 - e. Electrical Metallic Tubing (EMT)
 - 2. Nonmetallic Conduits:
 - a. Rigid Nonmetallic (PVC).
 - 3. Conduit bodies.
 - 4. Conduit fittings and accessories.
 - 5. Conduit installation.

1.02 REFERENCES

- A. Refer to Sections 01 42 19, Reference Standards and 26 05 00, Common Work Results for Electrical.
- B. American National Standards Institute (ANSI):
 - 1. C80.1 - Rigid Steel Conduit - Zinc Coated.
 - 2. C80.3 - Steel Electrical Metallic Tubing.
- C. National Electrical Manufacturer's Association (NEMA):
 - 1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
 - 2. TC2 - Electrical Plastic Tubing and Conduit.
 - 3. TC3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing.
 - 4. TC13 - Electrical Nonmetallic Tubing.
- D. Underwriters Laboratories (UL):
 - 1. 1 - Standard for Safety for Flexible Metal Conduit.
 - 2. 6 - Standard for Safety for Rigid Metal Conduit.
 - 3. 360 - Standard for Safety for Liquid-Tight Flexible Steel Conduit.
 - 4. 651 - Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit.
 - 5. 1653 - Standard for Safety for Electrical Nonmetallic Tubing.
 - 6. 94VO - Standard for Vertical Flame Test.

E. National Electrical Contractors Association

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1. NECA-1.

1.03 DEFINITIONS

Refer to Section 26 05 00, Common Work Results for Electrical.

- A. Specific definitions and abbreviations:
1. Conduit Bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to: shapes C, E, LB, T, X, etc.
 2. Conduit Fitting: An accessory that serves primarily a mechanical purpose. Includes, but not limited to: bushings, locknuts, hubs, couplings, reducers, etc.
 3. Splice Box: Any fabricated box installed above ground, in ground, in walls, in ceilings, etc. for the sole purpose of splicing branch circuit conductors. Panel feeders and service entrance cables shall not be spliced.
 4. Pull Box: An in-ground box such as a hand hole or vault whose sole purpose for installation is for ease of pulling cable such as panel feeders or service entrance cables. A wire-way shall be considered a pull box. No splices shall exist in a pull box.
 5. LFMC: Sealtight - Liquid-Tight Flexible Metallic Conduit.
 6. NPT: National Pipe Thread.
 7. Outdoor or Corrosive areas shall include those areas below grade (Tunnels and Galleries).

1.04 SYSTEM DESCRIPTION

- A. Provide conduits, conduit bodies, fittings, junction boxes and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.
- B. Use existing conduit, provided it is 1 inch or larger, where available, to route new conductors. Verify that the existing conduit meets all NEC requirements including fill and size for the specified cables. Install new conduits and extend existing conduits where necessary to make a complete raceway system. Document the raceway system and label the conduits as required.
- C. Acceptable conduit sizes are 1", 2", 4", 6" whether Metallic or Non-Metallic. Fractional size conduits, other than specific 1/2", and 3/4" LFMC and FMC use, are not acceptable for new install. All motor operated equipment contained in process areas or in equipment rooms will be connected via LFMC.
- D. MC type cable is not acceptable for use anywhere except for connecting Lights and motor operated equipment concealed above ceilings in an office type setting.
- E. Electrical Metallic Tubing(EMT) is not acceptable for use in any area of any CCWRD project other than those buildings designed as an office type setting, and then shall be limited to only those areas outside the boundaries of the HVAC/Mechanical room, Electrical Room, IDF/Data Room, Boiler room, or any shop that is attached to the building. Boundaries shall be defined as the outermost wall surface of the rooms listed above. EMT may be installed concealed in walls and above ceilings except those that create the boundary of the rooms listed above. EMT is not to be installed

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in the ceiling above any of the rooms listed above. Rigid Conduit, or PVC Coated Rigid Steel conduit shall be the only acceptable conduit material allowed in the walls, ceilings, or surface mounted inside the rooms as described above.

- F. All conduit not in electrical, control, storage and office locations shall be considered Wet, damp and corrosive locations and require PVC-GRS Conduit.
- G. Polymer Concrete boxes and Lids are prohibited from use on any CCWRD Project.
- H. All in ground pull, splice, or junction box shall be reinforced concrete with a minimum rating of H-20 lid.

1.05 SUBMITTALS

- A. Furnish submittals in accordance with Sections 01 33 00, Submittal Procedures, and Section 26 05 00, Common Work Results for Electrical.
- B. Product Data:
 - 1. Furnish complete manufacturer's catalog sheets identifying every type and size of conduit, fitting, conduit body, and accessories to be used on the project.
 - 2. Furnish complete manufacturer's recommended special tools to be used for installation if required.
 - 3. Certified test results for PVC coated metallic conduit showing the adhesive bond stronger than the tensile strength of the PVC.
- C. Certifications:
 - 1. Furnish PVC coated conduit manufacturer's certification for each installer.
- D. As Built Documents:
 - 1. Refer to Section 01 78 39 As-Built Documents.
 - 2. Incorporate all changes in conduit routing on As-Built conduit Drawings.
 - 3. Dimension underground and concealed conduits from building lines. At minimum, all conduits in slab, under slab and underground shall have GPS coordinates recorded for change in direction whether vertical or horizontal.
 - 4. Identify and record size and location of existing conduits and stub-ups used to make connections to new or existing equipment.
 - 5. Record conductors with number and size routed in new or existing conduit and update conduit schedule in As-Built drawings. If Conduit Schedule is not provided in drawing set; the Contractor shall be responsible for creating said schedule and keeping it up to date.
 - 6. Furnish hard copy Drawings and electronic files in AutoCAD format and PDF.
- E. Contractor's Conduit Schedule:
 - 1. Furnish a hard copy and an Excel file conduit schedule for review before submitting the installation drawings.
- F. Installation Drawings
 - 1. Installation Drawings including individual conduit numbers, routing, termination drawings, conduit sizes, circuit numbers contained in each conduit, and number and size of wires in each conduit. CONTRACTOR shall submit these drawings to

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the ENGINEER for approval. The drawings shall show detailed conduit routing before installation of conduit. These drawings shall be used as the “as-built” record drawings, with all field corrections noted. They shall detail the underground duct banks, showing where they terminate and stub up in trenches, etc. The drawings shall also contain cross-section layouts of the conduits where more than eight conduits are included in one duct bank. The CONTRACTOR shall also detail exposed conduit routing and show the routing of pipes, HVAC ducts, etc., clearly indicating that the conduit routing will not have interference as required by the drawings specifying these layouts. The drawings shall be a minimum of 24 inches by 36 inches. These drawings are to be submitted and approved before any conduit installation is begun. Installation drawings shall use conduit schedules to identify both new and existing raceways for new conductors. Conduit schedule shall identify each conduit section with a specific and unique conduit designation.

1.06 QUALITY CONTROL

- A. Refer to Sections 01 45 00, Quality Control, and 26 05 00, Common Work Results for Electrical.
- B. All conduits, conduit bodies, and fittings shall be UL listed and labeled and of same material type as material to be installed with.
- C. Every installer of PVC coated Rigid Steel (PVC-GRS) conduits shall be trained for proper installation of the conduit.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Sections 01 66 00, Product Storage and Handling Requirments, and 26 05 00, Common Work Results for Electrical.
- B. Do not expose type PVC to direct sunlight.
- C. Do not store conduit in direct contact with the ground.

1.08 PROJECT OR SITE CONDITIONS

- A. Refer to Section 26 05 00, Common Work Results for Electrical.

1.09 SEQUENCING

- A. Before installing any conduit or locating any device box:
 - 1. Examine the complete set of Drawings and Specifications, and all applicable shop drawings.
 - 2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

1.10 WARRANTY

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- A. Refer to Sections 00 61 15, Guaranty Bond and 26 05 00, Common Work Results for Electrical.

1.11 SYSTEM START-UP

- A. Refer to Sections 01 75 05, Testing Training and Startup, and 26 05 00, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Galvanized rigid steel conduit (GRC):
 - 1. One of the following or equal:
 - a. Western Tube and Conduit.
 - b. Allied Tube and Conduit.
 - c. Wheatland Tube Co.

- B. Polyvinyl chloride-coated rigid steel conduit (PCS):
 - 1. One of the following or equal:
 - a. Robroy Industries.
 - b. OCAL, Inc.
 - c. Perma Kote.

- C. Sealtight liquid-tight flexible metallic conduit (LFMC):
 - 1. One of the following or equal:
 - a. Southwire.
 - b. AFC Cable Systems.
 - c. Electriflex.
 - d. Anaconda.

- D. Rigid nonmetallic polyvinyl chloride conduit (PVC):
 - 1. One of the following or equal:
 - a. Carlon.
 - b. Cant
 - c. Triangle Conduit and Cable.

- E. Electrical metal tubing (EMT):
 - 1. One of the following or equal:
 - a. Western Tube and Conduit.
 - b. Allied Tube and Conduit.
 - c. Wheatland Tube Co.

- F. Flexible metallic conduit (FMC):
 - 1. One of the following or equal:
 - a. Southwire.
 - b. AFC Cable Systems.
 - c. Electriflex.
 - d. Anaconda.

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- G. Conduit bodies:
 - 1. One of the following or equal:
 - a. Crouse-Hinds.
 - b. Appleton.
 - c. O-Z / Gedney .
 - d. Ocal.
 - e. Robroy.
 - f. Carlon.

- H. Galvanized rigid steel conduit expansion fittings:
 - 1. One of the following or equal:
 - a. Crouse-Hinds.
 - b. Appleton.
 - c. O-Z / Gedney.

- I. Conduit sleeve:
 - 1. One of the following or equal:
 - a. Crouse-Hinds.
 - b. Appleton.
 - c. O-Z / Gedney.

- J. Conduit seals:
 - 1. One of the following or equal:
 - a. Appleton.
 - b. Crouse-Hinds.
 - c. O-Z / Gedney.

- K. Conduit thruwall seals:
 - 1. The following or equal:
 - a. O-Z / Gedney, Type "WSK."

- L. Boxes
 - 1. Pressed steel boxes:
 - a. Steel City.
 - b. Appleton.
 - c. Crouse - Hinds.
 - d. Thomas & Betts.
 - 2. Plastic coated steel boxes:
 - a. Rob Roy.
 - b. OCAL.
 - 3. Cast device boxes:
 - a. Appleton.
 - b. Crouse - Hinds.
 - c. OZ Gedney.
 - 4. Conduit Seal Bushings:
 - a. Appleton.
 - b. Crouse - Hinds.
 - c. OZ Gedney.
 - 5. Formed steel enclosures:
 - a. Hoffman.

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- b. Rittal.
- c. Saginaw
- d. Hubbell-Wiegmann
- 6. Stainless steel enclosures:
 - a. Hoffman.
 - b. Rittal.
 - c. Saginaw
 - d. Hubbell-Wiegmann
- 7. Pressed steel boxes and concrete boxes:
 - a. Appleton.
 - b. Steel City.
 - c. Cooper/Crouse Hinds.
 - d. OZ Gedney.

2.02 COMPONENTS

- A. Galvanized rigid steel conduit and couplings (GRC):
 - 1. All Threads: NPT standard conduit threads with a 3/4-inch taper per foot:
 - a. Running conduit threads are not acceptable.
 - 2. Hot-dip galvanized inside and out:
 - a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
 - b. Electro-galvanizing is not acceptable.
 - 3. Manufactured in accordance with:
 - a. UL6.
 - b. ANSI C801.
- B. PVC coated steel conduit and conduit bodies (PVC-GRS):
 - 1. PVC Coated Rigid Steel Conduit and fittings shall be used in all process areas, tunnels, exposed outdoors whether or not they are classified as Wet, Damp, or Corrosive areas.
 - 2. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for type GRC. Coated conduit conforms to NEMA Standard RN-1:
 - a. The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
 - 3. Factory Bonded PVC Jacket:
 - a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
 - b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictate otherwise.
 - c. PVC coating on conduit and associated fittings shall have no sags, blisters, lumps, or other surface defects and free of holes and holidays.
 - d. The PVC adhesive bond on conduit and fittings shall be greater than the tensile strength of the PVC plastic coating:
 - 1) Confirm bond with certified test results.
 - 4. A urethane coating shall be uniformly and consistently applied to the interior of all conduit and fittings:
 - a. Nominal thickness of 0.002 inch.

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- b. Conduit having areas with thin or no coating is not acceptable.
- c. All threads shall be coated with urethane.
- 5. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
- 6. PVC-GRS conduit bodies:
 - a. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.
 - b. The PVC Coating on the outside of conduit bodies shall be 0.040 inches thick and have a series of longitudinal ribs to protect the coating from tool damage during installation.
 - c. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.

C. Liquid-tight flexible metallic conduit (LFMC):

- 1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
 - a. General purpose:
 - 1) Temperature range -20 degrees Celsius to +80 degrees Celsius.
 - b. Oil resistant:
 - 1) Temperature range -20 degrees Celsius to +60 degrees Celsius.
- 2. Sunlight resistant, weatherproof, and watertight.
- 3. Manufactured from single strip steel, hot dip galvanized on all 4 sides before conduit fabrication.
- 4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
- 5. Overall polyvinyl chloride jacket.
- 6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 4 inch.

D. Rigid nonmetallic polyvinyl chloride conduit (PVC):

- 1. Extruded from virgin polyvinyl chloride compound:
 - a. Schedule 40 unless otherwise indicated.
 - b. Schedule 80 extra heavy wall where indicated.
- 2. Rated for 90 degrees Celsius conductors or cable.
- 3. Listed for above ground and underground use.

E. Conduit bodies:

- 1. Material consistent with conduit type:
 - a. Malleable iron bodies and covers when used with type GRC conduit.
 - b. PVC coated malleable iron bodies and covers when used with type PCS.
- 2. Conduit bodies to conform to Form 8, Mark 9, or Mogul Design:
 - a. Mogul design conforming to NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire bending space.
- 3. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.
- 4. PVC coated malleable iron conduit bodies and covers:
 - a. Bodies before coating shall meet requirements for malleable iron conduit

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- bodies.
- b. 0.040-inch exterior PVC coating and 0.002 inch interior urethane coating as required for type PCS conduit and fittings.
- c. Utilize the PVC coating as an integral part of the gasket design.
- d. Stainless steel cover screws heads shall be encapsulated with plastic to assure corrosion protection.

2.03 FITTINGS AND BOXES

- A. General:
 1. Cast and malleable iron fittings for use with metallic conduit shall be the threaded type with 5 full threads.
 2. Fittings and boxes shall have neoprene gaskets and non-magnetic stainless steel screws. Covers shall be attached by means of holes tapped into the body of the fitting. Covers for fittings attached by means of clips or clamps will not be acceptable.
 3. Boxes larger than standard cast or malleable types shall be 316 stainless steel, NEMA 4X for all outdoor, below grade (tunnels, galleries, pump rooms), and corrosive areas. NEMA 12 for non-listed areas.
 4. All conduits shall be terminated in raintight hubs as manufactured by Myers, O.Z. Gedney, Appleton, or equal. Sealed locknuts and ground bushings shall be used.
 5. Conduit, fittings, and boxes in hazardous locations shall be suitable for the Class and Division indicated. Conduits terminated in NEMA 7 boxes shall include the use of a male bushing, Adalet Type PEM, inside the box.
 6. All cabinets, enclosures, pull/junction boxes (4"x4"x4" and larger) shall have continuous, piano hinge with stainless steel pin doors with locking means.

2.04 CABLE TRAYS

- A. Cable tray systems shall be composed of straight sections, fittings, and accessories as defined in the latest NEMA Standards publication VE-1 - Ventilated Cable Tray and per NEC 392 and UL labeled.
 1. The cable tray and fittings shall be 316 stainless steel.
 2. Cable tray shall be ladder type with 9-inch spacing, ventilated trough. Tray sizes shall have 4-inch minimum usable load depth.
 3. Loading capacities shall meet NEMA weight classification with a safety factor of 1.5.
 4. In corrosive locations, cable trays shall be 316 stainless steel.
 5. Cable trays and fittings shall be as manufactured by Husky, B-Line, T.J. Cope, or equal.
 6. No barrier strips are allowed. Power and Communications cable will be in separate cable trays. Each piece of Metallic Cable tray shall be bonded to each other with Bonding jumper no smaller than #4 AWG and the entire tray system will be bonded to grounding system via equipment grounding conductor routed to the nearest means of system ground.

2.05 WIREWAY

- A. General:

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1. Wireway shall be of the lay-in type and be NEMA rated for the area installed per Section 26 05 00. Power, control, signal and communications shall be run in separate wireways.
 2. Fittings and sections shall have non-magnetic stainless steel screws. Covers shall be attached by hinges and clamps to the bodies. Covers attached by means of clips or screws will not be acceptable.
 3. Covers and bodies shall be a minimum of 14 gauge for steel construction.
 4. Steel wireway bodies shall be grounded.
- B. All conduits terminating in the top, sides, or bottom of any electrical enclosure or cabinet shall be done via rain-tight hubs such as Myers "Ground Hub".

2.06 SURFACE RACEWAYS

- A. Surface Metal Raceways: Galvanized steel with snap-on covers. Prime coating, and finish painting before installation. Plastic raceways are not to be used on the surface of any CCWRD Projects.
1. Available Manufacturers: Subject to compliance with requirements, Manufacturer's offering products that may be incorporated into the Work include, but are not limited to, the following:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Thomas & Betts Corporation.
 - b. Walker Systems, Inc.; Wiremold Company (The).
 - c. Wiremold Company (The); Electrical Sales Division.
 3. Any Surface raceways that match the description as outlined above shall only be permitted to be used in buildings and structures designed for office use. They shall not be permitted for use in any plant process areas even those that have office type rooms attached to the process area.

2.07 ACCESSORIES

- A. Connectors and fittings:
1. Manufactured with compatible materials to the corresponding conduit.
- B. Insulated throat metallic bushings:
2. Construction:
 - a. Malleable iron or zinc plated steel when used with steel conduit.
 - b. Positive metallic conduit end stop.
 - c. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees Celsius.
- C. Insulated grounding bushings:
1. Construction:
 - a. Malleable iron or steel, zinc plated, with a positive metallic end stop.
 - b. Integrally molded non-combustible phenolic insulated surfaces rated 150 degrees Celsius.
 - c. Tin-plated copper grounding saddle for use with copper conductors.
- D. Electrical unions (Erickson Couplings):

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1. Construction:
 - a. Malleable iron for use with steel conduit.
 - b. Concrete tight, 3-piece construction.
- E. PVC coated rigid steel conduit (PVC-GRS) fittings:
1. All hollow conduit fittings, which serve, as part of the PVC-GRS conduit system must be coated with an exterior PVC coating and interior urethane coating as described for the conduit.
 2. The conduit fitting, before coating, shall be new, unused material and shall conform to appropriate UL standards.
 3. A PVC sleeve extending 1 pipe diameter or 2 inches, whichever is less, shall be formed at every female conduit opening on fittings except unions:
 - a. The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
 4. Flexible overlapping sleeves on all hubs and couplings shall provide a vapor and moisture tight seal at every connection.
 5. Antisieze/Noalox shall be applied to threads.
- F. Liquid-Tight flexible metallic conduit (LFMC) fittings:
1. Construction:
 - a. Malleable iron.
 - b. Furnished with locknut and sealing ring.
 - c. Liquid-tight, rain-tight, oil-tight.
 - d. Insulated throat.
 - e. Furnish as straight, 45-degree elbows and 90-degree elbows.
 - f. Designed to prevent sleeving:
 - 1) Verify complete bonding of the raceway jacket to the plastic gasket seal.
 - g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device if inserted into raceway and directly in contact with conductors shall have rolled over edges for sizes under 5 inches.
 - h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture resistant/oil resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.
- G. Corrosion resistant and outdoor liquid-tight flexible conduit (LTFC) fittings:
1. Construction:
 - a. PVC coated liquid-tight fittings with a bonded 0.040-inch thick PVC coating on the metal connector to form a seal around the conduit.
 - b. Connectors shall have an insulated throat and an integral sealing ring.
- H. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
1. Construction:
 - a. Shall have an insulated throat.
 - b. When used in damp, wet or corrosive areas shall be PVC coated.
 - c. Ground bushing.
 - d. Recessed neoprene O-ring to assure watertight and dust tight connector.
 2. Usage:

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- a. All conduits entering any cabinet or enclosure shall use threaded hubs and ground bushings for connections.
- I. Sealing Fittings:
- 1. Construction:
 - a. 40 percent wire fill capacity.
 - b. PVC coated when used in damp, wet and corrosive areas.
 - c. Malleable ductile iron with steel conduit.
 - d. Crouse-Hinds Type EYD where drains are required.
 - e. Crouse-Hinds Type EYS where drains are not required.
 - f. UL listed for use in Class 1, Division 1, Groups A, B, C, D; Class 1, Division 2, Groups A, B, C, D; Class 2, Divisions 1 and 2; Groups E, F, and G.
- J. PVC fittings:
- 1. Shall include the following:
 - a. Couplings.
 - b. Terminal Adapters.
 - c. Female Adapters.
 - d. Caps.
 - e. Reducer Bushings.
 - f. Duct Couplings.
 - g. End Bells.
 - h. Expansion Couplings.
 - i. Duct Couplings 5 degree.
 - 2. Materials:
 - a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.
 - b. All metal hardware shall be stainless steel.
- K. Through Wall and Floor Seals:
- 1. Materials:
 - a. Body - casting of malleable or ductile iron with a hot dip galvanized finish.
 - b. Grommet - neoprene.
 - c. Pressure rings - PVC coated steel.
 - d. Disc material- PVC coated steel.
- L. Expansion/deflection couplings:
- 1. Use to compensate for movement in any directions between 2 conduit ends that they connect.
 - 2. Shall allow movement of 3/4-inch from the normal in all directions.
 - 3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
 - 4. Materials:
 - a. End couplings - Bronze or galvanized ductile iron.
 - b. Sleeve - Neoprene.
 - c. Bands - Stainless Steel.
 - d. Bonding Jumper - Tinned copper braid.
 - 5. These fittings shall be constructed in such a manner that will provide the continuity of the ground path in each conduit system or raceway.

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M. Expansion couplings:

1. Shall allow for expansion and contraction of conduit:
 - a. Permitting 8-inch movement, 4 inches in either direction.
2. Constructed to maintain electrical continuity of the conduit system providing the continuity of the ground path in each conduit or raceway.
3. Materials:
 - a. Head - Malleable or ductile iron.
 - b. Sleeve - Steel.
 - c. Insulating Bushing - Phenolic.
 - d. Finish - Hot dip galvanized.

N. Conduit markers:

1. In accordance with Section 26 05 53, Electrical Identification.

O. Conduit Sealing Bushings:

1. Used on cord fed pumps and instrumentation equipment in a wetwell or sump pit.
2. Used in conjunction with 18 inches of free air space to seal the boundary between Class 1 Div 1 and Class 1 Div 2 locations.
3. Construction:
 - a. Slotted PVC coated steel discs
 - b. Neoprene Sealing Ring
 - c. Stainless Steel Socket thread machine screws
 - d. Hot dipped Galvanized Malleable or ductile lock ring
 - e. Optional lay-in-lug grounding wire connector
4. Intended for use on PVC Coated Rigid Steel or Galvanized Rigid Steel Conduit and Nipples

2.08 SOURCE QUALITY CONTROL

- A. Refer to Sections 01 45 00, Quality Control, and 26 05 00, Common Work Results for Electrical.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Refer to Section 26 05 00, Common Work Results for Electrical.

B. General:

1. Conduit routing:
 - a. The Electrical Drawings are diagrammatic in nature:
 - 1) Install conduit runs in accordance with schematic representation indicated on the Drawings and as specified.
 - a) All conduits shall be installed parallel and perpendicular to building and grade lines.
 - 2) Modify conduit runs to suit field conditions, as accepted by ENGINEER:
 - a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routed to bypass obstructions.

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- b) Make changes in conduit routing due to the relocation of electrical equipment.
 - 3) The Electrical Drawings do not indicate all required junction boxes and pull boxes:
 - a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
 - (1) To meet cable manufacturer's pulling tension requirements.
 - (2) To limit total conduit bends between pull locations.
 - b) Install junction boxes and pull boxes at locations acceptable to ENGINEER.
 - c) All in-ground pull boxes and electrical vaults shall be routed in such a manner that eliminates the need to splice panel feeders and service entrance cables.
 - d) All in-ground conduits that terminate in a pullbox, handhole, vault, wireway, shall end with a bell end.
 - 4) CONTRACTOR is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by ENGINEER:
 - a) ENGINEER is the sole source in determining whether the change is constituted as a deviation:
 - b) Perform any changes resulting in additional conduits, or extra work from such deviations.
 - c) Incorporate any deviations on the Record Documents.
- 2. Use only tools recommended by the conduit manufacturer for assembling conduit system.
- 3. Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:
 - a. Clearances of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
 - b. Clearances of 12 inches from surfaces greater than 149 degrees Fahrenheit.
 - c. Keep conduit at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings and 12 inches from fuel lines and gas lines.
 - d. Where it is necessary to route conduit close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
- 4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
 - a. Do not run conduit within water-bearing walls unless otherwise indicated on the Drawings.
- 5. Run exposed conduits Parallel and Perpendicular to structural members, walls, lines of the building and finish grade:
 - a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
 - b. Make changes in direction with long radius bends or with conduit bodies.
- 6. Install conduit with total conduit bends between pull locations less than or equal to 270 degrees.
- 7. Route all exposed conduit to preserve headroom, access space and work space and to prevent tripping hazards and clearance problems:

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- a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and not block or interfere with ingress or egress, including equipment removal hatches.
- b. Route conduit to avoid drains or other gravity lines. Where conflicts occur, relocate conduit as required.
8. No conduits larger than 1 inch shall be run in concrete members, or slabs. If the conduit exceeds 1/3 the thickness of the concrete member or slab, it shall not be allowed without approval by the ENGINEER and the OWNER.
 - a. Locate conduit in the center of the concrete or where the minimum concrete cover will be a minimum 1 conduit diameter.
 - b. Space conduits at least 3 diameters apart on centers.
 - c. As a general rule, conduit may not cross other conduit or pipe in concrete members or slabs unless the necessary spacing requirements listed above are satisfied.
 - d. Interrupted rebar shall be replaced with size and quantity equal to interrupted bar.
 - e. All conduit runs in concrete shall be documented, include a tracer wire and shall have all bends and change of direction GPS coordinated with GIS.
 - 1) Tracer wire shall be #14AWG, Stranded, XHHW-2 Pink Insulated conductor.
 - 2) Tracer shall be labeled as "TRACER" at both ends, additionally tracer conductor will be terminated at the ground bus in all electrical equipment that have such and capped off with twist-on type wire connector at all junction boxes and pullboxes.
 - 3) At no time shall this tracer conductor be used as an equipment grounding conductor.
9. When installing conduit through existing slabs or walls make provisions for locating any possible conflicting items where conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into existing conduit, piping, cables, post-tensioning cables, reinforcing members, etc.
10. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
11. Install conduit thru wall seals where conduits pass through walls.
12. For existing and new 2 inch and larger conduit runs, snake conduits with conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of conduit:
 - a. Remove and replace conduits through which mandrel will not pass.
13. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically shown on the Drawings.
14. Install complete conduit systems before any conductors are installed.
15. Metallic conduits terminating in transformers, Switchgear, Motor Control Centers, or other enclosures shall include water-tight hubs such as Myers, with ground bushings. Ground with a minimum #6AWG copper stranded ground wire.
16. Underground and embedded conduits:
 - a. Make underground conduit size transitions at pullboxes and manholes.
 - b. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and pullboxes.

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- c. Any directional transition of underground raceways, whether vertical or horizontal, shall be made using PVC Coated Rigid Steel or Galvanized Rigid Steel Factory made Elbows and Ells. Galvanized Rigid Steel Elbows and Ells, if used, shall be wrapped a minimum of 2 times with 20 Mil PVC Tape.
 - d. All conduits that emerge from underground shall transition from PVC to PVC Coated Rigid Steel or PVC Wrapped Galvanized Rigid Steel Conduit at the point of connection to the underground conduit up and through finished grade, or slab on grade. This also applies to conduit runs that feed equipment pads.
- C. Lighting and Receptacle Conduits:
- 1. Install conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings:
 - a) Minimum conduit size:
 - 1) 1 inch for exposed conduits.
 - 2) 1 inch for underground or in slab conduits.
 - 2. Provide conduit materials for the installed location as specified in Section 26 05 00, Common Work Results for Electrical.
- D. Conduit usage:
- 1. Exposed conduits:
 - a. Rigid conduit:
 - 1) Install the rigid conduit type for each location as specified in Section 26 05 00, Common Work Results for Electrical, and indicated in the Conduit Schedule.
 - 2) Minimum Size: 1-inch.
 - b. Flexible conduit:
 - 1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment or where required for equipment servicing.
 - 2) Minimum size: 1-inch:
 - a) ½- inch LFMC when required for connection to an instrument.
 - 3) Maximum length: 72 inches.
 - 2. Underground and embedded conduits:
 - a. Type PVC Schedule 40 and PVC-GRS as specified below:
 - 1) Use Type PVC-GRS in underground and embedded installation as follows:
 - a) Stub-up and risers to grade, finish floor or equipment of any kind from nonmetallic conduits.
 - b) Entering and exiting underground or embedded conduit runs a minimum 12 inches above and below grade or finished
 - c) For any and all bends where the total deflection is greater than 30 degrees.
 - b. Minimum size:
 - 1) 2-inch in duct banks unless otherwise indicated.
 - 2) 1-inch for in slab conduits unless otherwise indicated.
 - 3. Galvanized rigid steel conduit (GRC).
 - a. Conduit shall be cut square and reamed before threading.
 - 4. Nonmetallic conduit (PVC):
 - a. PVC conduit shall not be installed in above ground applications.

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E. Conduit joints and bends:

1. General:

- a. Where conduit is underground, under slabs on grade, exposed to the weather or in NEMA 4 or NEMA 4X locations, make joints liquid-tight.
- b. Keep bends and offsets in conduit runs to an absolute minimum.
- c. All bends shall be symmetrical.
- d. For all types of high voltage conductors, provide bends as required for lead-covered conductors of equivalent outside diameter. The following conduit systems shall use large radius sweep elbows:
 - 1) Underground conduits.
 - 2) Conduits containing medium voltage cables.
 - 3) Conduits containing shielded cables.
 - 4) Conduits containing fiber optic cables.
- e. Make field bends with a radius of not less than the requirements found in the NEC:
 - 1) The minimum bending radius of the cable must be less than the radius of the conduit bend.
 - 2) Make all field bends with power bending equipment or manual benders specifically intended for the purpose:
 - a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
 - b) For the serving utilities, make bends to meet their requirements.
- f. Replace all deformed, flattened, or kinked conduit.
- g. PVC conduit shall not use field bends.

2. Threaded conduit:

- a. Cut threads on rigid metallic conduit and PVC-GRS with a standard conduit cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
- b. Thoroughly ream conduit after threads have been cut to remove burrs.
- c. Use ground bushings or conduit fittings at conduit terminations.
- d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing "Galvabar" or CRC "Zinc It."
- e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
 - 1) Use KOPR-Shield as manufactured by T&B on threads of ferrous conduit.
 - 2) Apply to the male threads and tighten joints securely.
 - 3) Clean excess sealant from exposed threads after assembly.
- f. Securely tighten all threaded connections.
- g. Any exposed threaded surface must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.

3. Nonmetallic (PVC):

- a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray type cement is not allowed.

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- b. Heat bends are not acceptable.
- c. Vertical or Horizontal transitions shall be made using factory made PVC coated Rigid Steel Elbows and Ells.

F. Conduit sealing and drainage:

1. Conduit drainage and sealing other than required for hazardous and classified areas, shall be done in accordance with the NEC:
 - a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above grade conduit runs at the points at which the conduit enter buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
 - b. Provide seal fittings with drains in vertical drops directly above grade for exterior, above grade conduit runs that are extended below grade.
 - c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
 - 1) Where portions of an interior raceway pass through walls, ceilings or floors that separate adjacent areas having widely different temperatures.
 - d. Provide conduit seals similar to O/Z Gedney (Type CSB series) on all conduits between corrosive and non-corrosive areas.
 - a. In classified areas that have a sump pit or actual sewage wet well that contain submersible cord fed pumps and other interchangeable cord fed equipment the use of conduit seal bushing (CSB) along with the introduction of 18 inches of free air space will be substituted to eliminate the boundary between classified locations. Conduit seal-offs will be used on the conduits that lead to anything that produces an arc, spark, or flash for example MCC, Panel board, Disconnect, etc.
 - b. Seal all conduits at entry into electrical rooms and control panels to keep corrosive gasses out of electrical devices.
 - c. Seal one end only of all underground conduits at highest point with O/Z Gedney sealing (non-hazardous) filling, or equal.
 - d. Install duct seal in all conduit openings in electrical cabinets and enclosures, as well as at conduits that penetrate through the floor, and in-ground and above-ground pull boxes.
2. Install seals with drains at all control panels, junction boxes, pullboxes, low points of conduit, or any place where moisture may condense and accumulate:
 - a. Provide Crouse-Hinds Type EYD or approved equal, where drains are required.
 - b. Provide Crouse-Hinds Type EYS or approved equal, where drains are not required.

G. Expansion or expansion/deflection fittings:

1. General:
 - a. Align expansion coupling with the conduit run to prevent binding.
 - b. Follow manufacturer's instructions to set the piston opening.
 - c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
 - d. Furnish fittings of the same material as the conduit system.

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2. For metallic conduit (PVC-GRS and GRC) provide expansion or expansion/deflection couplings, as appropriate, where:
 - a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.
3. For PVC provide expansion or expansion/deflection couplings, as appropriate, where length change due to temperature variation exceeds 2 inches:
 - a. Rigidly fix the outer barrel of the expansion coupling so it cannot move. Mount the conduit connected to the piston loosely enough to allow the conduit to move as the temperature changes.

H. Empty conduits:

1. Provide a factory weaved or braided tape with measurement markings and 1250 pound tensile strength in each empty conduit more than 10 feet in length.
2. Seal ends of all conduit with approved, manufactured conduit seals, caps or plugs immediately after installation:
 - a. Keep ends sealed until immediately before pulling conductors.
3. Empty conduits shall be tagged at both ends to indicate the final destination. Where it is not possible to tag the conduit, destination shall be identified by a durable marking on an adjacent surface. This shall apply to conduits in floors, panels, manholes, equipment, etc. Empty conduits that terminate below grade, in vaults, manholes, handholes, and junction or pullboxes shall have a removable plug installed.
 - a. Conduits shall be identified at ends and pulling points. Identification shall be the unique conduit number assigned in the Contract Documents. Conduits other than 120 VAC panelboard circuits not assigned a unique number in the Contract Documents shall have a unique number assigned by the CONTRACTOR following the numbering scheme used in the Contract Documents. Conduits for 120 VAC panelboard circuits shall have a unique number assigned by the CONTRACTOR similar to the cable numbering scheme used in the Contract Documents. Conduit identification shall be by a stamped or engraved non-corroding metal tag attached to the conduit. Markings with a pen or paint will not be accepted.
3. Pullboxes and junction boxes shall be identified. Identification shall be the unique pullbox number assigned in the Contract Documents or by a unique number assigned by the CONTRACTOR following the numbering scheme used in the Contract Documents. Box identification shall be by a stamped or engraved non-corroding metal tag per the requirements of Section 26 05 53, Electrical Identification, attached to the box or enclosure with screws, sealed pop rivets or by an acceptable submitted method. Markings with a pen or paint will not be accepted.
4. Conduit for data cables shall be provided in accordance with the equipment manufacturer's recommendations, especially regarding separation from low and medium voltage power raceways.
5. PVC conduit is to be protected for extended periods of direct sunlight. Sun burned PVC conduit will be rejected by authority having jurisdiction.

I. BOXES

1. Provide materials and construction suitable for environmental conditions at the location of the box as indicated in Section 26 05 00.
2. Provide outlet box materials to match the conduit system:
 - a. GRC - Cast Ferrous Boxes.

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- b. PCS - PVC Coated Cast Ferrous Boxes.
3. Solid Type Gang Boxes:
 - a. For more than 2 devices.
 4. Support all wall mounted NEMA 4 or NEMA 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
 - a. Use machined spacers to maintain air space; built-up washers are not acceptable.
 - b. Use nylon or 316 Stainless Steel materials for spacers.
 5. Use cast malleable iron boxes when box must support other devices.
 6. Boxes serving luminaires or devices:
 - a. Use as pull boxes wherever possible, but do not combine conductor from separately derived systems in the same box.
 7. Fit all cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
 8. In terminal boxes, furnish terminals as indicated on the Drawings, with a minimum of 50 percent spare terminals:
Furnish wireways for discrete and analog/DC wiring.
 - b. Separate analog wiring from 120V discrete or power wiring.
 9. Size boxes to meet NEC requirements and to provide sufficient room for the future components and cables indicated on the Drawings.
 10. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.
- J. Outlet Boxes:
1. Locate outlet boxes as indicated on the Drawings:
 - a. Adjust locations so as not to conflict with structural requirements or other trades.
 2. Use deep threaded-hub malleable iron:
 - a. Where exposed to the weather, boxes shall be weather proof type.
 - b. In unheated areas.
 - c. Where subject to mechanical damage:
 - 1) Defined as exposed boxes less than 10 feet above the floor.
- K. Pull boxes and junction boxes:
1. Size pull boxes to meet NEC requirements and to provide sufficient room for any future conduits and cables as indicated on the Drawings.
 2. Install pull boxes such that access to them is not restricted.
 3. All in-ground pull boxes and electrical vaults shall be routed in such a manner that eliminates the need to splice panel feeders and service entrance cables.
- L. For boxes not indicated:
1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 26 05 00.
 2. Outlet, switch, and junction boxes for flush-mounting in general purpose locations:
 - a. One-piece, galvanized, pressed steel and 2 ¼ inches deep.
 - b. Extension rings or extension boxes are not permitted.

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3. Ceiling boxes for flush mounting in concrete:
 - a. Deep, galvanized, pressed steel.
 4. Outlet, switch, and junction boxes where surface mounted in exposed Locations other than electrical rooms shall be treated as wet locations.
 5. Outlet, control station, and junction boxes for installation in corrosive locations:
 - a. Nema 4X
 - b. Furnished with mounting lugs.
 6. Boxes for concealed conduit system:
 - a. Non-fire rated construction:
 - 1) Depth: To suit job conditions and comply with the NEC.
 - 2) For Luminaries: Use outlet boxes designed for the purpose:
 - a) 50 pounds or less: Box marked "FOR FIXTURE SUPPORT."
 - b) More than 50 pounds: Box listed and marked with the weight of the fixture to be supported (or support luminaire independent of the box.)
 - 3) For junction and pull boxes: Use galvanized steel boxes with flush covers.
 - 4) For switches, receptacles, etc:
 - a. Plaster or cast-in-place concrete walls: Use 4 inch or 4-11/16 inch galvanized steel boxes with device covers.
 - b. Walls other than plaster or cast-in-place concrete: Use type of galvanized steel box which will allow wall plate to cover the opening made for the installation of the box.
 7. Recessed boxes in fire rated (2 hour maximum) bearing and nonbearing wood or steel stud walls (gypsum wallboard facings):
 - a. Use listed single and double gang metallic outlet and switch boxes. The surface area of individual outlet or switch boxes shall not exceed 16 square inches.
 - b. Suitable fireproofing shall be used on device boxes.
 - c. Securely fasten boxes to the studs. Verify that the opening. in the wallboard facing is cut so that the clearance between the box and the wallboard does not exceed 1/8 inch.
 - d. Separate boxes located on opposite sides of walls or partitions by a minimum horizontal distance of 24 inches. This minimum separation distance may be reduced when wall opening protective materials are installed according to the requirements of their classification.
 - e. Use wall opening protective material in conjunction with boxes installed on opposite sides of walls or partitions of staggered stud construction in accordance with the classification requirements for the protective material.
- M. Miscellaneous:
1. Provide flashings and counter flashings or pitch pockets for waterproofing of raceways, outlets, fittings, and other items that penetrate the roof.
 2. Running threads and threadless couplings are not allowed.
 3. Replace any conduit installed that ENGINEER determines does not meet the requirements of this Specification.

3.02 FIELD QUALITY CONTROL

- A. Refer to Sections 01 45 00, Quality Control, and 26 05 00, Common Work Results for Electrical.

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3.03 PROTECTION

- A. Refer to Section 26 05 00, Common Work Results for Electrical.
- B. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to paint finishes with matching touchup coating recommended by manufacturer.

3.04 CLEANING

- A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.
- B. Vacuum and clean all debris from junction/pullboxes, and cabinets/enclosures. Compressed air to assist in cleaning is not permitted.

END OF SECTION

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SECTION 26 05 36

CABLE TRAYS

[CLICK HERE TO ENTER PROJECT NAME](#)

CCWRD PROJECT NO. [CLICK HERE TO ENTER CCWRD PROJECT NO.](#)

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes metallic cable trays and accessories.

1.03 SUBMITTALS

- A. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.
- B. Shop Drawings: For each type of cable tray.
 - 1. Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
- C. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements. Show the following:
 - 1. Vertical and horizontal offsets and transitions.
 - 2. Clearances for access above and to side of cable trays.
 - 3. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
- D. Field quality-control reports.
- E. Operation and Maintenance Data: For cable trays to include in emergency, operation, and maintenance manuals.

1.04 QUALITY CONTROL

- A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories : Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Cable tray shall be stored in a dry location, indoors, loosely stacked, elevated off the ground to prevent staining, scratching, marring of finish during storage.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers : Subject to compliance with requirements, provide products by one of the following :
 - 1. Chalfant Manufacturing Company
 - 2. Cooper B-Line, Inc.
 - 3. Cope, T. J., Inc.; a subsidiary of Allied Tube & Conduit.
 - 4. GS Metals Corp.; GLOBETRAY Products
 - 5. MONO-SYSTEMS, Inc.
 - 6. MPHusky
 - 7. PW Industries
 - 8. Thomas & Betts Corporation

2.02 MATERIALS AND FINISHES

- A. Cable Trays, Fittings, and Accessories: Steel, complying with NEMA VE 1.
 - 1. Mill galvanized before fabrication, complying with ASTM A 653/A 653M, G90 (Z275) coating; with hardware galvanized according to ASTM B 633.
 - 2. Electrogalvanized before fabrication, complying with ASTM B 633; with hardware galvanized according to ASTM B 633.
 - 3. Hot-dip galvanized after fabrication, complying with ASTM A 123/A 123M, Class 82; with chromium-zinc, ASTM F 1136, hardware.
- B. Sizes and Configurations: Refer to Drawings for specific requirements for types, materials, sizes, and configurations.
 - 1. Center-hanger supports may be used only when specifically indicated.

2.03 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
- B. Covers: Solid type of same materials and finishes as cable tray.
- C. Barrier Strips: Same materials and finishes as cable tray.
- D. Install Cable tray supports, connectors, and bonding jumpers, as recommended by cable tray manufacturer.

2.04 WARNING SIGNS

- A. Lettering: 1-1/2-inch- (40-mm-) high, black letters on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL." Install 1 per every 10 ft.
- B. Materials and fastening are specified in Division 26 Section "Electrical Identification."

2.05 SOURCE QUALITY CONTROL

- A. Perform design and production tests according to NEMA VE 1.

PART 3 EXECUTION

3.01 CABLE TRAY INSTALLATION

- A. Comply with recommendations in NEMA VE 2. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees, crosses and bonding jumpers.
- B. Remove burrs and sharp edges from cable trays.
- C. Fasten cable tray supports to building structure and install seismic restraints.
 - 1. Locate and install supports according to NEMA VE 1.
- D. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independent of fittings. Do not carry weight of cable tray on equipment enclosure.
- E. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed 80 feet. Space connectors and set gaps according to NEMA VE 1.
- F. Make changes in direction and elevation using standard fittings.
- G. Make cable tray connections using standard fittings.

- H. Seal penetrations through fire and smoke barriers according to Firestop Systems specifications.
- I. Sleeves for Future Cables: Install capped sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- J. Workspace: Install cable trays with enough space to permit access for installing cables.
- K. Install separate cable trays to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.
- L. Cable trays shall be bonded to the grounding electrode system at the point where the cable tray is closest to the grounding electrode system.
- M. Metallic cable trays that have solid bottom and sides shall have conduit entries via water tight hubs and cable entries via cable grip with integral strain relief of metallic web sock type.
 - 1. Cable grip shall be aluminum with stainless wire mesh strain relief grip.

3.02 CABLE INSTALLATION

- A. Install cables only when cable tray installation has been completed and inspected.
- B. Fasten cables on horizontal runs with cable clamps or cable ties as recommended by NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket
- C. On vertical runs, fasten cables to tray every 18 inches (457 mm). Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
- D. In existing construction, remove inactive or dead cables from cable tray and all the way back to the source.
- E. Install covers after installation of cable is completed.
- F. Provide and install seismic bracing every 10 feet.

3.03 BONDING REQUIREMENTS

- A. Ground cable trays according to manufacturer's written instructions.
- B. Install an insulated equipment grounding conductor with cable tray, in addition to those required by NFPA 70.

3.04 FIELD QUALITY CONTROL

- A. After installing cable trays and after electrical cable has been installed, survey for compliance with requirements. Perform the following field quality-control survey:
1. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.
 2. Verify that the number, size, and voltage of cables in cable tray do not exceed that permitted by NFPA 70. Verify that communication or data-processing circuits are separated from power circuits by separate cable tray.
 3. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.
 4. Remove deposits of dust, industrial process materials, trash of any description, and any blockage of tray ventilation.
 5. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
 6. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
 7. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable tray.
 8. Measure ground resistance of each system of cable tray from the most remote element to the joint where connection is made to service disconnect enclosure grounding terminal. Record resistance in ohms at the time of test.
- B. Report results in writing.

3.05 PROTECTION

- A. Protect installed cable trays.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray manufacturer.
 3. Install temporary protection for cables in open trays to protect exposed cables from falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or any non-metallic materials until the risk of damage is over.

END OF SECTION

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SECTION 26 05 43

DUCT BANKS

[CLICK HERE TO ENTER PROJECT NAME](#)

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PART 1 GENERAL

1.01 SUMMARY

- A. Section includes requirements for:
 - 1. Electrical underground duct banks.
 - 2. Duct spacing and terminations.
 - 3. Steel reinforcing of concrete.
 - 4. Excavation and patching.
 - 5. Coordination with other underground utilities.
 - 6. Concrete.

1.02 REFERENCES

- A. Refer to Sections 01 42 19, Reference Standards, 26 05 00, Common Work Results for Electrical, and 26 05 33 Conduit Raceway and Boxes.

1.03 DEFINITIONS

- A. Refer to Section 26 05 00, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. Provide trenching forming, rebar, spacers, conduit, bonding, concrete, backfill, and compaction necessary for the complete installation of the duct banks.
- B. Provide reinforced concrete duct banks for all conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

1.05 SUBMITTALS

- A. Furnish submittals in accordance with Sections 01 33 00, Submittal Procedures, and 26 05 00, Common Work Results for Electrical.
- B. Product Data:
 - 1. PVC conduit spacers.
 - 2. Detectable underground marking tape.
 - 3. Marker balls.
 - 4. Conduit submittals for PVC conduit and Rigid Steel, PVC-GRS and Elbows must be approved.

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- C. Provide applicable submittal documents as required in:
 - 1. Section 03 30 00, Cast in Place Concrete.
- C. Shop Drawings:
 - 1. Submit site plan drawings of duct banks including. underground profiles indicating all underground utilities per Section 01 33 00, Submittal Procedures.

1.06 QUALITY CONTROL

- A. Refer to Sections 01 45 00, Quality Control, 26 05 00, Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Sections 01 66 00, Product Storage and Handling Requirements, and 26 05 00, Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. Refer to Section 26 05 00, Common Work Results for Electrical.
- B. Field Conditions and Related Requirements:
 - 1. Subsurface Utility Engineering by CONTRACTOR is required.

1.09 WARRANTY

- A. Refer to Document 00 61 15, Guaranty Bond, and Section 26 05 00, Common Work Results for Electrical.

1.10 SYSTEM STARTUP

- A. Refer to Sections 01 71 05, Testing Training and Startup, and 26 05 00, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Conduit Spacers:
 - 1. One of the following or equal:
 - a. Carlon Snap-LoCo
 - b. Cantex.
 - c. Osburn Associates, Inc.
- B. Detectable Underground Marking Tape:
 - 1. One of the following or equal:
 - a. Blackburn Manufacturing Company.
 - b. Brady - Identoline.
 - c. Thomas and Betts - Protect-A-Line.
 - d. Panduit - Underground Hazard Tape.

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- C. Pull Line:
 1. One of the following or equal:
 - a. Arnco.
 - b. Greenlee.
 - c. Osburn Associates, Inc.

2.02 MATERIALS

- A. For conduit requirements, refer to Section 26 05 33, Conduit Raceway and Boxes:
 1. Use duct suitable for use with 90 degree Celsius rated conductors.
- B. Use minimum Number 4 reinforcing steel.

2.03 MANUFACTURED UNITS

- A. Conduit Spacers:
 1. Provide conduit spacers recommended by the conduit manufacturer or listed above.
 2. Saddle type.
 3. Non-metallic, non-corrosive, non-conductive.
 4. Interlocking Type:
 - a. Vertical interlocking.
 - b. Horizontal interlocking.
 5. Suitable for concrete encasement.
 6. Molded-in rebar holder.
 7. Accommodates 2-inch through 6-inch conduit sizes.
 8. Relieves the conduit from both horizontal and vertical stresses.
- B. Pull Line:
 1. Minimum 1/2- inch wide, flat design.
 2. Factory Weaved or Braided Nylon.
 3. Minimum pulling strength 1,250 pounds.
 4. Sequential footage markings.
- C. Detectable Marking Tape:
 1. Provide a detectable tape, locatable by a cable or metal detector from above the undisturbed grade.
 2. Aluminum core laminated between polyester.
 3. Six-inch wide Red tape imprinted with black lettering "CAUTION – BURIED ELECTRIC UTILITIES."

2.04 MIXES

- A. Refer to Section 03 30 00 for concrete mixes requirements.
- B. Provide a red-oxide conduit encasement coloring agent (10lbs per 1 cubic yrd). Reference Section 03 30 00 for additional requirements.
- C. 3000 PSI concrete.

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PART 3 EXECUTION

3.01 INSTALLATION

- A. Refer to Section 26 05 00, Common Work Results for Electrical.
- B. Duct banks:
1. Install duct banks encased in concrete at least 24 inches to top of duct bank below finish grade, unless otherwise indicated on the Drawings.
 2. Damage minimization:
 - a. Conduit should not be left exposed in an open trench longer than is necessary.
 - b. Protect all underground duct banks against damage during pouring of concrete or backfilling.
 3. All plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
 4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system and all cabinets and enclosures in accordance with the Drawings.
 5. No. 4/0 American Wire Gauge bare copper ground wire shall enter and exit all vaults and pull boxes and be exothermically welded to a ground rod located within each vault and pull box.
 6. Install watertight underground ducts:
 - a. Slope duct banks away from buildings to manholes.
 - b. Slope duct banks uniformly from manholes to manholes or both ways from high points between manholes.
 - c. Slope a minimum of 1/2 inch per 10 feet.
 7. All conduits entering new or existing manholes, or pull boxes will be done using bell ends.
 8. Install pull line in spare conduits:
 - a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
 - b. Cap above ground spare conduit risers at each end with screw-in conduit plugs.
 9. All duct banks entering or exiting a building shall be dowelled into the building foundation.
 10. Communication and power duct banks shall always be physically separated.
 11. Any transitions in any direction, whether it be horizontal or vertical, of any conduit in the underground duct-bank will be done using PVC Coated Rigid Steel, or Galvanized Rigid Steel elbows and bells. Furthermore, any conduit emerging from underground Duct-bank to finish grade or to finish slab on grade will be done using PVC Coated Rigid Steel or Galvanized Rigid Steel from the point of connection to Non-metallic conduit in the Duct-bank continuously through to the point of emergence. Note Galvanized Rigid Steel if used shall be wrapped to 40mil thickness.
 12. The use of Fiberglass Reinforced Plastic or FRP Elbows and Ells is not acceptable.

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- C. Trenching:
 1. Trench must be uniformly graded with the bottom, rock free and covered with select material.
 2. Whenever possible, use the walls of the trench as forms for concrete encasement:
 - a. Forms are required where the soil is not self-supporting.
 3. Avoid damaging existing ducts, conduits, cables, and other utilities.

- D. Duct spacing:
 1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 1.5 inches unless otherwise shown.
 - a. Separate medium voltage ducts a minimum of 7.5 inches on center.
 2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour, unless otherwise shown. Install spacers on 8 foot maximum intervals:
 - a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
 - 1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
 - a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
 3. Spacers should not be located at the center of a bend:
 - a. Locate spacer in the tangent, free of the coupling on fabricated bends.
 - b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.

- E. Terminating:
 1. Use bell ends in duct at entrances into cable vaults.
 2. Make conduit entrances into cable vaults tangential to walls of cable vault.
 3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
 4. New manhole or hand hole applications, provide a single opening or "window" per duct bank, sized to accommodate the duct bank envelope.
 5. All Duct-banks shall be doveled into building foundations, all manholes and cable vaults.

- F. Concrete:
 1. Refer to Section 03 30 00 and this section for concrete installation requirements. Concrete curing process of this section shall supersede that of Section 03 30 00.
 - a. Provide nonferrous tie wires to prevent displacement of the conduits during pouring of concrete: Tie wire shall not act as a substitute for spacers.
 2. Install minimum 3-inch cover around conduit and rebar, unless otherwise shown.
 3. Consolidate encasement concrete around duct banks. Method of Consolidation must be approved for conditions.
 4. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.
 5. Add red dye for color, 10lbs per cubic yard.

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6. After concrete installation, CONTRACTOR shall apply curing agent or minimum 4 to 6 inches of backfill on top of concrete to help facilitate concrete cure. Duct-bank shall not be completely back filled until 3 days after concrete is installed.

G. Marking tape:

1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

H. For conduit installations beneath building slabs:

1. Install steel reinforced concrete duct banks under all building slabs as indicated on the Drawings:
a. Concrete for encasement under building slabs need not be colored red.
b. All Duct-banks shall be doveled into building foundations.

I. Restore all surfaces to their original unless otherwise specified.

J. Marker balls:

1. Manufacturer: 3M Company, Scotchmark Electronic Marker System, Series 1400.
2. Tempo, Omni Markers Electronic Marker, red in color.
3. High-density polyethylene shell impervious to minerals, chemicals and temperatures normally found in underground environments.
4. Range: Maximum 5 foot bury depth.
5. Markers shall comply with APWA Uniform Color Code (ANSI Z 353.1) and have 169.8 kHz signal frequency for Electrical Power lines, cables, conduit, and lighting cables.

K. Marker posts as specified in Section 33 05 26 (if included and shown).

3.02 FIELD QUALITY CONTROL

A. Refer to Sections 01 45 00, Quality Control and 26 05 00, Common Work Results for Electrical.

3.03 CLEANING

A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.04 PROTECTION

A. Refer to section 26 05 00, Common Work Results for Electrical.

B. Provide shoring and pumping to protect the excavation and safety of workers.

C. Protect excavations with barricades as required by applicable safety regulations.

END OF SECTION

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SECTION 26 05 48

VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

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PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Isolation pads.
 - 2. Spring isolators.
 - 3. Restrained spring isolators.
 - 4. Channel support systems.
 - 5. Restraint cables.
 - 6. Hanger rod stiffeners.
 - 7. Anchorage bushings and washers.
 - 8. Anchor bolts and concrete anchors
- B. Related Sections include the following:
 - 1. Division 26 Section "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.03 DEFINITIONS

- A. The IBC: International Building Code.

1.04 PERFORMANCE REQUIREMENTS

- A. Seismic-Restraint Loading:
 - 1. Site Class as Defined in the IBC: D, unless otherwise determined in geotechnical report.
 - 2. Assigned Seismic Use Group or Building Category as Defined in the IBC: III.
 - a. Typical Component Importance Factor: 1.25
 - b. Emergency Component Importance Factor: 1.5.
 - c. Equipment Response Modification Factor: 2.5.
 - d. Raceway Response Modification Factor: 3.5.
 - e. Lighting Fixture Response Factor: 1.25
 - f. Component Amplification Factor: 1.0
 - 3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.641.
 - 4. Design Spectral Response Acceleration at 1.0-Second Period: 0.192.

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1.05 SUBMITTALS

- A. Product Data: For the following:
 - 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 - 2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.
 - 3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.
 - 4. Anchor bolts and concrete anchors.

- B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified Nevada licensed professional engineer responsible for their preparation.
 - 1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
 - a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 Sections for equipment mounted outdoors.
 - 2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
 - 3. Field-fabricated supports.
 - 4. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

- C. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

- D. Welding certificates.

- E. Manufacturer's field reports.

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1.06 QUALITY CONTROL

- A. Comply with seismic-restraint requirements in the IBC.
- B. Welding: Qualify procedures and personnel according to AWS 01.1/01.1M, "Structural Welding Code - Steel."
- C. Comply with NFPA 70.
- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval by an agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified Nevada licensed professional engineer.

PART 2 PRODUCTS

2.01 VIBRATION ISOLATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Amber/Booth Company, Inc.
 - 2. Kinetics Noise Control.
 - 3. Mason Industries.
 - 4. M.W. Sausse.
- B. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and hot dipped galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 - 1. Resilient Material: Oil- and water-resistant neoprene or hermetically sealed compressed fiberglass.
- C. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
 - 1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
 - 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

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- D. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit- stop restraint.
 - 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 - 2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
 - 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.02 SEISMIC-RESTRAINT DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Amber/Booth Company, Inc.
 - 2. Cooper B-Line, Inc.; a division of Cooper Industries.
 - 3. Hilti Inc.
 - 4. Mason Industries.
 - 5. TOLCO Incorporated; a brand of NIBCO INC.
 - 6. Unistrut; Tyco International, Ltd.
 - 7. M.W. Sausse.
- B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
 - 1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion- resistant coating; and rated in tension, compression, and torsion forces.
- D. Restraint Cables: ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
- E. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod. Do not weld stiffeners to rods.
- F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

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- G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.
- H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
- J. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.
- K. Cast in place anchors shall follow local engineering standards and codes; J-bolt anchors shall not be allowed in any application. Anchor bolts shall be ASTM F1554, Grade 55, with weldability supplement S1, unless otherwise noted.
- L. All anchoring systems shall be designed for cracked concrete and for seismic applications. Prefabricated anchors, mechanical as well as adhesive anchors, shall have a current ICC Evaluation Report demonstrating that they are certified for seismic applications and for use in cracked concrete.

2.03 FACTORY FINISHES

- A. Finish: Manufacturer's standard prime-coat finish ready for field painting.
- B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
 - 1. Powder coating on springs and housings.
 - 2. All hardware shall be galvanized. Hot-dip galvanizes metal components for exterior use.
 - 3. Baked enamel or powder coat for metal components on isolators for interior use.
 - 4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance .
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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- C. Proceed with installation only after unsatisfactory conditions have been corrected to the satisfaction of the Authority having jurisdiction.

3.02 APPLICATIONS

- A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction. Provide seismic support every 10 feet, minimum.
- B. Hanger Rod Stiffeners: Install hanger rod stiffeners where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits. Future loadings shall be considered as full use of supporting system capability, e.g. maximum number of conduits that may fit on a support.

3.03 SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Equipment and Hanger Restraints:
 - 1. Install restrained isolators on electrical equipment.
 - 2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
 - 3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.
- B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- D. Drilled-in Anchors:
 - 1. Scan or GPR to identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines. Coring of reinforced concrete elements is prohibited unless specifically authorized in writing by the Engineer.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

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4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive. Temperature limitations imposed by the manufacturer shall be strictly followed; setting time requirements of installation based on temperature shall also be followed.
5. Set anchors to manufacturer's recommended torque, using a torque wrench, must be witnessed by Authority having jurisdiction and torque wrench must have certificate showing calibration within 1 year of torque wrench use.
6. Install zinc-coated steel anchors for interior applications that are located in ventilated, non-corrosive, dry areas.
7. Install stainless-steel anchors in all other locations, for example all process areas, below grade, corrosive, wet, damp and exterior applications.

3.04 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.05 ADJUSTING

- A. Adjust isolators after isolated equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION

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SECTION 26 05 53

ELECTRICAL IDENTIFICATION

[CLICK HERE TO ENTER PROJECT NAME](#)

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PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Identification for raceway and metal-clad cable.
 - 2. Identification for conductors and communication and control cable.
 - 3. Underground-line warning tape.
 - 4. Warning labels and signs.
 - 5. Instruction signs.
 - 6. Equipment identification labels.
 - 7. Miscellaneous identification products.

1.03 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.
- C. Samples of each color, lettering style and other graphic representation required for each identification material or system.

1.04 MANUFACTURERS

- A. Subject to compliance with requirements, manufacturers offering electrical identification products maybe incorporated in the work include, but not limited to, the following:
 - 1. Brady, W.H. Co.
 - 2. Ideal Industries, Inc.
 - 3. Panduit Corp.

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1.05 QUALITY CONTROL

- A. Comply with ANSI A 13.1 and ANSI C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.145.
- D. Comply with applicable requirements of UL Std. 969, "Marking and Labeling Systems", pertaining to electrical identifications systems.
- E. Comply with applicable requirements of NEMA Std. No's WC-1 and WC-2 pertaining to identification of power and control conductors.

1.06 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 PRODUCTS

2.01 RACEWAY IDENTIFICATION MATERIALS

- A. Comply with ANSI A 13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Conduit tags shall be 1-1/2-inch diameter, round, brass or stainless steel tags, laser engraved or standard engraving with the conduit number. Punched or stamped lettering is not allowed. Font shall be 1/4-inch Arial or Helvetica. The conduit tags shall be manufactured by Brady, Catalog No. 23210 or equal.
- C. Each Conduit tag shall be attached with nylon-coated 48-mil stainless steel wire and fastener, as manufactured by Brady, Catalog No. 38091, and zinc wire clamps, double ferrule design, as manufactured by Brady Catalog No. 38090 to secure the stainless steel wire or equal.

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- D. Snap-Around, Color-Coding Bands: Slit, pre-tensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.02 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
- B. Marker Tapes: Heat shrink Type, 1 full size larger than the conductor, with circuit identification legend machine printed by thermal transfer or equivalent process.
- C. Metal Tags: Brass or Stainless, 1-1/2-inch diameter, round, brass or stainless steel tags, laser engraved or standard engraving with the conduit number. Punched or stamped lettering is not allowed. Font shall be 1/4-inch Arial or Helvetica. The conduit tags shall be manufactured by Brady, Catalog No. 23210 or equal. Tag shall be attached with nylon-coated 48-mil stainless steel wire and fastener, as manufactured by Brady, Catalog No. 38091, and zinc wire clamps, double ferrule design, as manufactured by Brady Catalog No. 38090 to secure the stainless steel wire or equal.

2.03 UNDERGROUND-LINE WARNING TAPE

- A. Description: Permanent, bright-colored, continuous-printed, detectable (traceable), foil type tape.
 - 1. Not less than 6 inches (150 mm) wide by 4 mils (0.102 mm) thick.
 - 2. Compounded for permanent direct-burial service.
 - 3. Embedded continuous metallic strip or core.
 - 4. Printed legend shall indicate type of underground line.

2.04 WARNING LABELS AND SIGNS

- A. Safety Signs: Comply with NFPA 70 and 29 CFR 1910.145.
- B. Baked-Enamel Warning Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting.
- C. Metal-Backed, Butyrate Warning Signs for Exterior Use: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting.
- D. Warning label and sign shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

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2.05 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
 - 1. Engraved legend with white letters on black face for normal power. White letters on red face for emergency power.
 - 2. Punched or drilled for mechanical fasteners.

2.06 EQUIPMENT IDENTIFICATION LABELS

- A. Install photoetched aluminum sign on each major unit of electrical equipment in building; including central or master unit of each electrical system including communication-control-signal systems, unless unit is specified with its own self-explanatory identification or signal system. Except as otherwise indicated, provide single line of text, 1/2" high lettering on 1-1/2" high sign (2" high where 2 lines are required). Provide text matching terminology and numbering of the contract documents and shop drawings. Provide signs for each unit of the following categories of electrical work:
 - 1. Panelboards, electrical cabinets and enclosures.
 - 2. Access panel/doors to electrical facilities.
 - 3. Major electrical switchgear.
- B. Install signs at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment. Secure to substrate with brass or stainless steel screws, except use adhesive where screws should not or cannot penetrate the substrate.

2.07 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength: 50 lb (22.6 kg), minimum.
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 EXECUTION

3.01 APPLICATION

- A. Accessible Raceways and Metal-Clad Cables More Than 600 V: Identify with "DANGER- HIGH VOLTAGE" in black letters at least 2 inches (50 mm) high, with self-adhesive vinyl labels or paint. Repeat legend at 10-foot (3-m) maximum intervals.
- B. Accessible Raceways, 600 V or Less, for Service, Feeder, and Branch Circuits More Than: Identify with orange self-adhesive vinyl label, paint, or self-adhesive vinyl tape applied in bands.

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- C. Accessible Raceways of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands or paint:
1. Color coding for raceways shall be as follows:

Color Service	Band	Minimum Band Width
Security Access Control System	Purple	2'
EMCS	Navy Blue	2'
Airlines Communication	Light Blue	2'
Telephone	Black	2'
Power	Yellow	2'
Life Safety/Fire Alarm	Red	2'
Emergency Power	White	2'
Fiber Optic	Orange	2'
CCTV	Dark Brown	2"

- D. Power-Circuit Conductor Identification: For primary and secondary conductors in vaults, pull and junction boxes, manholes, and hand holes use conduit as described in 2.3 of this specification. Conductors shall be of color code insulation. For single cables identify as referenced in 2.3 of this specification.
- E. Branch-Circuit Conductor Identification: Where there are conductors for different branch circuits in same junction or pull box, labels of the heat shrink type to identify circuit number and sources. Labels shall be one size larger than the conductor they are applied to after shrinking. Identify each ungrounded conductor and associated neutral according to source and circuit number. Conductors to Be Extended in the Future: Attach heat shrink tags to conductors and list source and circuit number.
- F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

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3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.
- G. Locations of Underground Lines: Identify with underground-line warning tape of the foil type with tracer wire for power, lighting, communication, and control wiring and optical fiber cable.
- H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply baked-enamel warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
 - a. Power transfer switches.
 - b. Controls with external control power connections.
 2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.
 3. All panels: label with voltage indicated
- I. Instruction Signs:
1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
 2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer load shedding.
- J. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Install photoetched aluminum sign on each major unit of electrical equipment in building; including central or master unit of each electrical system including communication-control-signal systems, unless unit is specified with its own self-explanatory identification or signal system. Except as otherwise indicated, provide single line of text, 1/2" high lettering on 1-1/2" high sign (2" high where 2 lines are required). Provide text matching terminology and numbering of the contract documents and shop drawings. Provide signs for each unit of the following categories of electrical work:
 - a. Panelboards, electrical cabinets and enclosures.
 - b. Access panel/doors to electrical facilities.
 - c. Major electrical switchgear.
 2. Install signs at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment. Secure to substrate with brass or stainless steel

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screws, except use adhesive where screws should not or cannot penetrate the substrate.

3. Labeling Instructions:
 - a. Indoor non-major electrical equipment: Photoetched aluminum, Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where 2 lines of text are required, use labels 2 inches (50 mm) high.
 - b. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
4. Equipment to Be Labeled:
 - a. Panelboards, electrical cabinets, and enclosures.
 - b. Access doors and panels for concealed electrical items.
 - c. Electrical switchgear and switchboards.
 - d. Transformers.
 - e. Electrical substations.
 - f. Emergency system boxes and enclosures.
 - g. Motor-control centers.
 - h. Disconnect switches.
 - i. Enclosed circuit breakers.
 - j. Motor starters.
 - k. Push-button stations.
 - l. Power transfer equipment.
 - m. Contactors.
 - n. Remote-controlled switches, dimmer modules, and control devices.
 - o. Battery inverter units.
 - p. Fire-alarm control panel and annunciators.
 - q. Uninterruptible power supply equipment.
 - r. Rectifiers.
 - s. Battery racks.
 - t. Power-generating units.
 - u. Telephone switching equipment.
 - v. Security-monitoring master station or control panel.

3.02 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

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- F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.
 - 1. Color shall be factory applied or, for sizes larger than No. 14 AWG, field applied].
 - 2. Colors for 208/120-V 3 Phase Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White
 - e. Ground: Green
 - 3. Colors for 240/120-V 3 Phase Circuits:
 - a. Phase A: Black.
 - b. Phase B: Orange.
 - c. Phase C: Blue.
 - d. Neutral: White
 - e. Ground: Green
 - 4. Colors for 480/277 -V 3 Phase Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - d. Neutral: Gray
 - e. Ground: Green
 - 5. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- H. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 12 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.
- I. Painted Identification: Prepare surface and apply paint.

3.03 AUTOMATIC EQUIPMENT WARNING SIGNS

- A. Permanent warning signs shall be mounted at all mechanical equipment that may be started automatically or from remote locations. Signs shall be in accordance with OSHA regulations and shall be suitable for exterior use. The warning signs shall be fastened with round head brass screws or bolts, located and mounted in a manner acceptable to the Engineer and Authority Having Jurisdiction.
- B. Warning signs shall be 7 inches high by 10 inches wide, colored yellow and black, on not less than 18 gauge vitreous enameling stock. Sign shall read:

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**CAUTION
THIS EQUIPMENT STARTS
AUTOMATICALLY
BY REMOTE CONTROL**

3.04 HIGH VOLTAGE SIGNS

- A. Permanent and conspicuous warning signs shall be mounted at all equipment, doorways to equipment rooms, pull boxes, manholes, where voltage exceeds 600 volts.
- B. Signs shall be in accordance with OSHA regulation, and shall be suitable for exterior use. The warning signs shall be fastened with round head brass screws or bolts, located in a manner acceptable to the Engineer and Authority Having Jurisdiction.
- C. Signs shall be 7 inches high by 10 inches wide, colored red and white, on not less than 18 gauge vitreous enameling stock. Sign shall read:

**WARNING
HIGH VOLTAGE
KEEP OUT**

- D. Manhole and in ground pull/junction box lids will be identified with the words High Voltage, Electric, Communication, Signal, or Fiber Optic cast into the lid. The only alternative to cast in words will be welded words.

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SECTION 26 05 73

**OVERCURRENT PROTECTIVE DEVICE COORDINATION
AND ELECTRICAL SYSTEM STUDIES**

[CLICK HERE TO ENTER PROJECT NAME](#)

CCWRD PROJECT NO. [CLICK HERE TO ENTER CCWRD PROJECT NO.](#)

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes computer-based, fault-current and overcurrent protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study. The Arc-Flash Hazard Study is included in this section.
- B. Include a minimum of two meetings with the OWNER to review the short-circuit analysis, protective device coordination study and arc-flash analysis. The first meeting will review the reports and the second meeting will be after updates to review final reports and provide 2 hrs of OWNER training on the system model.

1.03 SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals shall be in digital form.
 - 1. Coordination-study input data, including completed computer program input data sheets.
 - 2. Study and Equipment Evaluation Reports.
 - 3. Coordination-Study Report.
 - 4. Setting Report.
 - 5. Software copy of the Model used for coordination.
 - 6. An AutoCad drawing of the Single line used in the Model.

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1.04 SYSTEM DESCRIPTION

A. General study requirements

1. Scope:

- a. The short-circuit fault analysis, protective device coordination and arc flash hazard studies shall include all new and modified equipment in the power distribution system, including but not limited to:
 - 1) Switchgear.
 - 2) Transformers: Including all dry-type transformers.
 - 3) Motor Control Centers.
 - 4) Disconnect Switches.
 - 5) Motors.
 - 6) Panelboards:
Including all 120, 208, 240 and 480 volt systems.
 - 7) Vendor Control Panels.
 - 8) HVAC Equipment.
 - 9) Lighting Control Panels
 - 10) Solar Inverters
- b. Study Scenarios:
 - 1) The studies shall include all possible electrical system configurations, for example:
 - a) Operation on normal (utility) source.
 - b) Main-breakers closed, tiebreaker open.
 - c) Either main-breaker open, tiebreaker closed.
 - d) Generator if applicable.
2. Obtain, for all equipment (existing and new), the required data for preparation of the study, including, but not limited to:
 - a. Transformer kilovolt-ampere and impedances.
 - b. Bus withstand ratings.
 - c. Cable and bus data.
 - d. Protective device taps, time dials, instantaneous pickups, and time delay settings.
3. Obtain Electric Utility, CCWRD, and CRC information as required on the minimum and maximum available fault current, minimum and maximum utility impedances, utility protective device settings including manufacturer and model number, interrupting ratings, X/R ratios, and model information to the point of the utility connection:
 - a. Utility tolerances and voltage variations.
4. The individual performing the studies shall visit the site and collect all necessary field data in order to perform and complete comprehensive electrical system studies.
5. Obtain equipment layouts and configurations from the manufacturer's final submittal requirements and project layout drawings as required.
6. Bus and conductor data:
 - a. Use impedances of the actual installed or specified conductors, unless otherwise indicated.
 - b. Use cable and bus impedances calculated at 25 degrees Celsius, unless otherwise indicated.
 - c. Use 600-volt cable reactance based on typical dimensions of actual

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- installed or specified conductors, unless otherwise indicated.
- d. Use bus withstand values for all equipment having buses.
- e. Use medium voltage cable reactances based on typical dimensions of shielded cables with 133 percent insulation levels, unless otherwise indicated.
- 7. Motors:
 - a. Each motor shall be individually modeled:
 - 1) Grouping of motors for fault contribution current is not acceptable.
 - b. Motors with variable frequency drives may be assumed to have no contribution to fault current.
- 8. Use the equipment, bus, and device designations as indicated on the Drawings for all studies.

B. Hazard Study Additional Requirements:

1. Include the calculated arc-flash boundary and incident energy (calories/square centimeter) at each piece of equipment in the distribution system:
 - a. Perform Arc-flash calculations for both the line side and load side of switchgear, motor control center and panelboard main breakers.
 - b. Perform arc-flash calculations for all short-circuit scenarios with all motors on for 3 to 5 cycles and with all motors off.
 - c. Protective device clearing time shall be limited to 2 seconds, maximum.
2. Provide executive summary of the study results.
3. Provide a detailed written discussion and explanation of the tabulated outputs.
4. Provide alternative device settings to allow OWNER to select the desired functionality of the system:
 - a. Minimize the arc-flash energy by selective trip and time settings for equipment maintenance purposes.
 - b. Identify the arc-flash energy based upon the criteria of maintaining coordination and selectivity of the protective devices.
5. Perform the arc flash study calculations using both IEEE 1584 and NFPA 70E. Provide both studies in the final report. Provide summary based upon worst case results between IEEE 1584 and NFPA 70E.
6. Obtain a copy of existing short circuit and arc flash analysis for FWRC from the OWNER in order to obtain fault currents expected.

1.05 QUALITY CONTROL

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.
- B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 1. Professional ENGINEER, licensed in the State of Nevada, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of ENGINEER.

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- C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.
- D. Comply with IEEE 399 for general study procedures.

PART 2 PRODUCTS

2.01 COMPUTER SOFTWARE DEVELOPERS

- A. Computer Software Developers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ETAP Operation Technology, Inc.

2.02 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

- A. Comply with IEEE 399.
- B. Analytical features of fault-current -study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- C. Computer software program shall be capable of plotting and diagramming time-current- characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
 - 1. Optional Features:
 - a. Arcing faults.
 - b. Simultaneous faults.
 - c. Explicit negative sequence.
 - d. Mutual coupling in zero sequence.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance.
 - 1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.
 - 2. When applicable, coordinate with the serving utility and obtain utility data required for the study.
 - 3. Where new equipment is connected to existing equipment, obtain all information from existing equipment by actual field verification.

3.02 POWER SYSTEM DATA

- A. Gather and tabulate the following input data to support coordination study:

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1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of existing electrical system at point of interconnection.
CONTRACTOR to obtain value from ENGINEER.
 - a. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:
 - b. Circuit-breaker and fuse-current ratings and types.
 - c. Relays and associated power and current transformer ratings and ratios.
 - d. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
 - e. Generator kilovolt amperes, size, voltage, and source impedance.
 - f. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
 - g. Busway ampacity and impedance.
 - h. Motor horsepower and code letter designation according to NEMA MG 1.
3. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
 - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
 - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
 - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
 - d. Generator thermal-damage curve.
 - e. Ratings, types, and settings of utility company's overcurrent protective devices.
 - f. Special overcurrent protective device settings or types stipulated by utility company.
 - g. Time-current-characteristic curves of devices indicated to be coordinated.
 - h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
 - i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
 - j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

3.03 FAULT-CURRENT STUDY

- A. Available Fault currents shall be attained from Power Utility, Power Utility fault current tables or the current system model.
- B. Hazard Study Additional Requirements:
 1. Include the calculated arc-flash boundary and incident energy (calories/square centimeter) at each piece of equipment in the distribution system:

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- a. Perform Arc-flash calculations for both the line side and load side of switchgear, motor control center and panelboard main breakers.
- b. Perform arc-flash calculations for all short-circuit scenarios with all motors on for 3 to 5 cycles and with all motors off.
- c. Protective device clearing time shall be limited to 2 seconds, maximum.
2. Provide executive summary of the study results.
3. Provide a detailed written discussion and explanation of the tabulated outputs.
4. Provide alternative device settings to allow OWNER to select the desired functionality of the system:
 - a. Minimize the arc-flash energy by selective trip and time settings for equipment maintenance purposes.
 - b. Identify the arc-flash energy based upon the criteria of maintaining coordination and selectivity of the protective devices.
5. Perform the arc flash study calculations using both IEEE 1584 and NFPA 70E. Provide both studies in the final report. Provide summary based upon worst case results between IEEE 1584 and NFPA 70E.

3.04 COORDINATION STUDY

- A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.
 1. Calculate the maximum and minimum 1/2-cycle short-circuits currents.
 2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.
 3. Calculate the maximum and minimum ground-fault currents.
- B. Comply with IEEE recommendations for fault currents and time intervals.
- C. Transformer Primary Overcurrent Protective Devices:
 1. Device shall not operate in response to the following:
 - a. Inrush current when first energized.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
 2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
- D. Motors served by voltages more than 600 V shall be protected according to IEEE 620.
- E. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

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- F. Coordination-Study Report: Prepare an electronic and a bound written report indicating the following results of coordination study:
 - 1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
 - a. Device tag.
 - b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
 - c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
 - d. Fuse-current rating and type.
 - e. Ground-fault relay-pickup and time-delay settings.
 - f. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
 - 1) Device tag.
 - 2) Voltage and current ratio for curves.
 - 3) Three-phase and single-phase damage points for each transformer.
 - 4) No damage, melting, and clearing curves for fuses.
 - 5) Cable damage curves.
 - 6) Transformer inrush points.
 - 7) Maximum fault-current cutoff point.
 - 2. Copy of data entered into program.
- G. Completed data sheets for setting of overcurrent protective devices.

3.05 FIELD SETTINGS

- A. Manufacturer's Field Service: Engage a factory-authorized service representative, of electrical distribution equipment being set and adjusted, to set overcurrent protective devices within equipment.
- B. Testing: Engage a qualified NETA accredited testing agency with NETA accredited technicians to perform the following device setting and to prepare test reports.
- C. Testing: Perform the following device setting and prepare reports:
 - 1. After installing overcurrent protective devices and during energizing process of electrical distribution system, perform the following:
 - a. Verify that overcurrent protective devices meet parameters used in studies.
 - b. Adjust devices to values listed in study results.
 - 2. Adjust devices according to recommendations in Chapter 7, ".Inspection and Test Procedures," and Tables 10.7 and 10.8 in NETA ATS.
- D. CONTRACTOR to provide and post Arc-Flash Hazard Labels on all equipment:
 - 1. Dimensions:
 - a. Minimum 5 inches by 3.5 inches.
 - 2. Materials:

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- a. Polyester with polyvinyl polymer over-laminate.
- b. Self-adhesive.
- c. Resistant to:
 - 1) UV.
 - 2) Chemicals and common cleaning solvent resistant.
 - 3) Scuffing.
 - 4) Wide temperature changes.
- 3. Contents:
 - a. Short-circuit bus identification.
 - b. Calculated incident energy (calories/square centimeter) range and working distance.
 - c. Nominal System Voltage
 - d. Arc-flash protection boundary.
 - e. Shock Hazard Boundary.
 - f. Description of the combined level of personnel protective equipment.
 - g. Upstream device information may be provided on separate label.
- 4. Color Scheme:
 - a. For locations above 40 calories/square centimeter:
 - 1) White label with red "DANGER" strip across the top.
 - 2) Black lettering.
 - b. For locations below 40 calories/square centimeter:
 - 1) White label with orange "WARNING" strip across the top.
 - 2) Black lettering.

END OF SECTION

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WIRING DEVICES

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PART 1 GENERAL

1.01 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

A. This Section includes the following:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Receptacles with integral surge suppression units.
4. Wall-box motion sensors.
5. Isolated-ground receptacles.
6. Snap switches and wall-box dimmers.
7. Wall-switch and exterior occupancy sensors.
8. Pendant cord-connector devices.
9. Cord and plug sets.

1.03 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.
- E. TVSS: Transient voltage surge suppressor.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.05 QUALITY CONTROL

- A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Obtain all wiring devices and associated wall plates from a single manufacturer and one source.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

1.06 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 1. Cord and Plug Sets: Match equipment requirements.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Cooper Wiring Devices; a division of Cooper Industries, Inc.
 - 2. Hubbell Incorporated; Wiring Device-Kellems
 - 3. Leviton Mfg. Company Inc.
 - 4. Pass & Seymour/Legrand; Wiring Devices & Accessories

2.02 STRAIGHT BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WO 1, NEMA WO 6 configuration 5-20R, and UL 498.

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 6350 (single), 6352 (duplex)
 - b. Hubbell; HBL2162 (duplex)
 - c. Leviton; 16341 (single), 16362 (duplex)
 - d. Pass & Seymour; 26361 (single), 26362 (duplex)

Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WO 1, NEMA WO 6 configuration 5-20R, and UL 498.

2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; CR IG2162
 - b. Leviton; 163621G
 - c. Pass & Seymour; IG6362-HG
 - d. Cooper; IG8362
3. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.03 GFCI RECEPTACLES

- A. General Description: Straight blade, non-feed-through type. Comply with NEMA WO NEMA WO 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.
- B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
 1. Products: Subject to compliance with requirements, provide one of the following :
 - a. Cooper; GF20
 - b. Pass & Seymour; 2084
 - c. Leviton; 8898-HG
 - d. Hubbell; GF20

2.04 HAZARDOUS (CLASSIFIED) LOCATION RECEPTACLES

- A. Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cooper Crouse-Hinds
 - b. EGS/Appleton Electric
 - c. Killark; a division of Hubbell Inc

2.05 TWIST-LOCKING RECEPTACLES

- A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WO 1, NEMA WD 6 configuration L5-20R. and UL 498.
 - 3. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; L520R.
 - b. Hubbell; HBL2310.
 - c. Leviton; 2310.
 - d. Pass & Seymour; L520-R.

- A. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - e. Hubbell; IG2310.
 - f. Leviton; 2310-IG.

 - 2. Description: Comply with NEMA WO 1, NEMA WO 6 configuration L5-20R, and UL 498. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.06 PENDANT CORD-CONNECTOR DEVICES

- A. Description: Matching, locking-type plug and receptacle body connector; NEMA WO 6 configurations L5-20P and L5-20R, heavy-duty grade.
 - 1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.

 - 2. External Cable Grip: Woven wire-mesh type made of high-strength stainless-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.07 CORD AND PLUG SETS

- A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
 - 1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.

 - 2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.08 SNAP SWITCHES

A. Comply with NEMA WO 1 and UL 20.

B. Switches, 120/277 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; DECB120 (single pole), DECB220 (two pole), DECB320 (three way), DECB420 (four way)
 - b. Hubbell; 2121 (single pole), 2122 (two pole), 2123 (three way), 2124 (four way)
 - c. Leviton; 5621 (single pole), 5622 (two pole), 5623 (three way), 5624 (four way)
 - d. Pass & Seymour; 2621 (single pole), 2622 (two pole), 2623 (three way), 2624 (four way)

C. Pilot Light Switches, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221PL for 120 V and 277 V
 - b. Hubbell; HPL1221PL for 120 V and 277 V
 - c. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V
 - d. Pass & Seymour; PS20AC1-PLR for 120 V
2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

D. Key-Operated Switches, 120/277 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221L
 - b. Hubbell; HBL1221L
 - c. Leviton; 1221-2L
 - d. Pass & Seymour; PS20AC1-L
2. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 1995
 - b. Hubbell; HBL1557
 - c. Leviton; 1257
 - d. Pass & Seymour; 1251

F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

2. Products: Subject to compliance with requirements, provide one of the following:

- a. Cooper; 1995L
- b. Hubbell; HBL1557L
- c. Leviton; 1257L
- d. Pass & Seymour; 1251L

2.09 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

C. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.

1. 1000 W minimum rated, higher ratings, as required by load.

D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.10 OCCUPANCY SENSORS

A. Long-Range Wall-Switch Sensors:

2. Products: Subject to compliance with requirements, provide one of the following:

- a. Hubbell; ATD1600WRP
- b. Leviton; ODW12-MRW
- c. Watt Stopper (The); DT-200

B. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft. (111 sq. m).

2.11 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

B. Plate-Securing Screws: Metal with head color to match plate finish.

- C. Wet-Location, Weatherproof-while-in-use cover plates: NEMA 250, complying with type 3R weather- resistant. die-cast aluminum with lockable cover.

2.12 FLOOR SERVICE

- A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
- B. Compartments: Barrier separates power from voice and data communication cabling.
- C. Service Plate: Rectangular solid brass with satin finish.
- D. Power Receptacle: NEMA WO 6 configuration 5-20R, gray finish, unless otherwise indicated.
- E. Voice and Data Communication Outlet: Openings for modular data cabling jacks.

2.13 POKE-THROUGH ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Hubbell Incorporated; Wiring Device-Kellems
 - 2. Pass & Seymour/Legrand; Wiring Devices & Accessories
 - 3. Square D/ Schneider Electric
 - 4. Thomas & Betts Corporation
 - 5. Wiremold Company (The)
- B. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
 - 1. Service Outlet Assembly: Flush type with two simplex receptacles and space for two RJ-45 jacks.
 - 2. Size: Selected to fit cored holes in floor and matched to floor thickness.
 - 3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
 - 4. Closure Plug: Arranged to close unused cored openings and reestablish fire rating of floor.
 - 5. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four, 4-pair, Category 5e voice and data communication cables.

2.14 FINISHES

- B. Color: Wiring device catalog numbers in Section Text do not designate device color.
 - 1. Wiring Devices Connected to Normal Power System: As selected by Architect, unless otherwise indicated or required by NFPA 70 or device listing.
 - 2. Wiring Devices Connected to Emergency Power System: Red.
 - 3. TVSS Devices: Blue.
 - 4. Isolated-Ground Receptacles: As specified above, with orange triangle on face.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
 - 1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
 - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 - 1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
 - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
 - 4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.

- b. Straighten conductors that remain and remove corrosion and foreign matter.
- c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length. All conductors of like colors in receptacle and switch device boxes that feed through to in line switches or receptacles, shall be pigtailed, braided and secured with twist-on type wire connectors.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten all unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact. Wrap around with electrical tape to cover termination screws.
10. Mounting heights shall be as follows unless noted:
 - a. Receptacles: 18" A.F.F. measured to bottom.
 - b. Switches: 48" A.F.F. measured to bottom.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the left.

2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.
- F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening. Position screw slots vertical or horizontal.
- G. Dimmers:
1. Install dimmers within terms of their listing.
 2. Verify that dimmers used for fan speed control are listed for that application.
 3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
- H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.
- J. Decorative plates are not to be used to provide tension to wall. Box spacers shall be used to obtain proper flush mount depth.

3.02 IDENTIFICATION

- A. Comply with Division 26 Section "Electrical Identification."
1. Receptacles: Identify panelboard and circuit number from which served on back of device plate.

3.03 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
1. Test Instruments: Use instruments that comply with UL 1436.
 2. Test Instrument for Convenience Receptacles: Digital Volt/Amp Meter
- B. Tests for Convenience Receptacles:
1. Line Voltage: Acceptable range is 105 to 132 V.
 2. Percent Voltage Drop under 15-A Load: A value of 5 percent or higher is not acceptable.
 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.

5. The tests shall be diagnostic; indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions; remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION

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SECTION 26 08 00

ACCEPTANCE TESTING

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PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Basic requirements for acceptance testing.

B. Related Specification Sections include but are not necessarily limited to:

1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
2. Division 01 - General Requirements.
3. Division 26 Specifications.

1.02 QUALITY ASSURANCE

A. Referenced Standards:

1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a 400, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems.
 - b 400.3, Guide for Partial Discharge Testing of Power Cable Systems in a Field Environment.
2. National Electrical Testing Association (NETA):
 - c ATS, Standard for Acceptance Testing Specifications for Electric Power Equipment and Systems, latest version.
3. Nationally Recognized Testing Laboratory (NRTL).
4. Telecommunications Industry Association/Electronic Industries Alliance/American National Standards Institute (TIA/EIA/ANSI):
 - d 455-78-B, Optical Fibers - PART 1-40: Measurement Methods and Test Procedures - Attenuation.

B. Qualifications:

1. Testing firm qualifications:
 - a Corporately and financially independent organization functioning as an unbiased testing authority.
 - b Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.
 - c Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.

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- d Supervising engineer accredited as Certified Electrical Test Technologist by NICET or NETA and having a minimum of 5 years' testing experience on similar projects.
 - e Registered Professional Engineer to provide comprehensive Project report outlining services performed, results of such services, recommendations, actions taken, and opinions.
 - f In compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories or a full member company of NETA.
 - g Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.
 - h Test instrument calibration shall be in accordance with NETA ATS.
2. Field personnel:
 - a Shall be NETA Certified
 3. Analysis personnel:
 - a Shall be NETA Certified
- C. Phasing Diagram:
1. Coordinate with Utility Company for phase rotations and Phase A, B and C markings.
 - a Create a phasing diagram showing the coordinated phase rotations with generators and motors through the transformers.

1.03 SUBMITTALS

- A. Shop Drawings:
1. See Specification Section 01 33 00, Submittal Procedures for requirements for the mechanics and administration of the submittal process.
- B. Informational Submittals:
1. See Specification Section 01 33 00, Submittal Procedures for requirements for the mechanics and administration of the submittal process.
 2. Submit 30 days prior to performing inspections or tests:
 - a Schedule for performing inspection and tests.
 - b List of references to be used for each test.
 - c Sample copy of equipment and materials inspection form(s).
 - d Sample copy of individual device test form.
 - e Sample copy of individual system test form.
 3. Prior to energizing equipment:
 - f Coordinated phasing diagram.
 - g Photocopies of continuity tests.
 - h Acceptance testing reports of all conductors, and equipment to be energized
 4. Within two (2) weeks after successful completion of Demonstration Period (Commissioning Period):
 - a Single report containing:
 - 1) Summary of Project.
 - 2) Information from pre-energization testing.
 - 3) Operation and Maintenance Data: After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.

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- 4) Programmable Settings: At completion of Performance Demonstration Test, submit final hardcopy printout and electronic files on compact disc of as-left set points, programs, and device configuration files for protective relays, power monitoring devices, communication modules.

PART 2 PRODUCTS

2.01 FACTORY QUALITY CONTROL

- A. Provide Electrical equipment with all factory tests required by the applicable industry standards or NRTL.
- B. Factory testing will not be accepted in lieu of field acceptance testing requirements specified in this Specification Section

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

- A. General:
 1. Complete electrical testing in three (3) phases:
 - b Pre-energization testing phase.
 - c Equipment energized with no load.
 - d Equipment energized under load.
 2. Perform testing in accordance with this Specification Section and latest NETA ATS.
 3. Provide field setting and programming of all adjustable protective devices and meters to settings as determined by the approved coordination study.
- B. Equipment Monitoring and Testing Plan: See Specification Section 01 14 00, Work Restrictions.
- C. Electrical Equipment and Connections Testing Program:
 1. See individual Division 26 Specification Sections for equipment specific testing requirements.
 2. Test all electrical equipment.
 - a Perform all required NETA testing.
 - b Perform all required NETA testing plus the optional testing identified with each specific type of equipment in Article 3.2 of this Specification Section.
 3. See Schedule at the end of PART 3 for equipment to be tested and specific test requirements.

3.02 SPECIFIC EQUIPMENT TESTING REQUIREMENTS

- A. Switchgear and Switchboards:
 1. Perform visual inspections and electrical tests per NETA ATS.
 2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.
 3. Perform the following additional tests:
 - a. Closure attempt of device when door is in OPEN position.

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- b. Opening attempt of door when device is in ON position.
 - c. Check key interlocking systems for:
 - 1) Key captivity when device is in ON or CLOSED position.
 - 2) Key removal when device is in ON or CLOSED position.
 - 3) Closure attempt of device when key has been removed.
 - 4) Correct number of keys in relationship to number of lock cylinders.
 - 5) Existence of Other Keys Capable of Operating Lock Cylinders: Destroy duplicate sets of keys.
 - d. Check nameplates for proper identification of:
 - 1) Equipment title and tag number with latest one-line diagram.
 - 2) Circuit breaker.
 - 3) Indicating meter.
 - 4) Surge Protective Device counter.
 - e. Verify fuse and circuit breaker ratings, sizes, and types conform to those specified.
 - f. Check bus and cable connections for high resistance by low resistance ohmmeter applied to bolted joints. Ohmic value to be zero.
 - g. Check operation and sequencing of electrical and mechanical interlock systems by:
 - 1) Closure attempt for locked open devices.
 - 2) Opening attempt for locked closed devices.
 - 3) Key exchange to operate devices in OFF-NORMAL positions.
 - h. Verify performance of each control device and feature.
 - i. Control Wiring:
 - 1) Compare wiring to local and remote control and protective devices with elementary diagrams.
 - 2) Proper conductor lacing and bundling.
 - 3) Proper conductor identification.
 - 4) Proper conductor lugs and connections.
 - j. Exercise active components.
 - k. Perform phasing check on double-ended equipment to ensure proper bus phasing from each source.
 - l. Weatherproof switchgear/switchboards:
 - 1) Verify correct location, operation and current draw of heaters.
 - 2) Verify correct operation of thermostat.
4. Electrical Tests:
- a. Insulation Resistance Tests:
 - 1) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
 - 2) Each phase of each bus section.
 - 3) Phase-to-phase and phase-to-ground for 1 minute.
 - 4) With switches and breakers open.
 - 5) With switches and breakers closed.
 - 6) Control wiring except that connected to solid state components.
 - 7) Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
 - a. Overpotential Tests:
 - 1) Applied voltage and test procedure in accordance with NETA ATS, Table 100.2.
 - 2) Each phase of each bus section.

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- 3) Phase-to-phase and phase-to-ground for 1 minute.
- 4) Test results evaluated on a pass/fail basis.
- a. Current Injection Tests:
 - 1) For entire current circuit in each section.
 - 2) Secondary injection for current flow of 1 ampere.
 - 3) Test current at each device.
- a. Apply secondary voltage to control power and potential circuits.
 - 4) Check voltage levels at each point on terminal boards and each device terminal.

B. Panelboards:

- 1. Perform visual inspections and electrical tests per NETA ATS.
- 2. Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:
 - a. Insulation Resistance Tests:
 - 1) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
 - 2) Each phase of each bus section.
 - 3) Phase-to-phase and phase-to-ground for 1 minute.
 - 4) With breakers open.
 - 5) With breakers closed.
 - 6) Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
 - b. Ground continuity test ground bus to system ground.

C. Transformers - Small Dry Type:

- 1. Perform visual inspections and electrical tests per NETA ATS.
- 2. Perform the following additional tests:
 - a. Record phase-to-phase, phase-to-neutral, and neutral-to-ground voltages at no load after energizing, and at operating load after startup.
- 3. Adjust tap connections as required to provide secondary voltage within 2-1/2 percent of nominal under normal load after approval of Engineer.
- 4. Record as-left tap connections.
- 5. Electrical Tests:
 - a. Insulation Resistance Test: Apply megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
 - 1) Winding-to-winding.
 - 2) Winding-to-ground.
 - b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
 - c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
 - d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
 - e. Insulation resistance test results to compare within 1 percent of adjacent windings.

D. Transformers - Large Dry Type:

- 1. Perform visual inspections and electrical tests per NETA ATS.
- 2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.

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3. Perform the following additional tests:
 - a. Record phase-to-phase, phase-to-neutral, and neutral-to-ground voltages at no load after energizing, and at operating load after start-up.
 4. Adjust tap connections as required to provide secondary voltage within 2-1/2 percent of nominal under normal load.
Record as-left tap connections.
 5. Electrical Tests:
 - a. Insulation Resistance Test: Apply megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
 - 1) Winding-to-winding.
 - 2) Winding-to-ground.
 - b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
 - c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
 - d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
 - e. Insulation resistance test results to compare within 1 percent of adjacent windings.
- E. Transformers - Liquid Filled:
1. Perform visual inspections and electrical tests per NETA ATS.
 - a. Bushing power factor.
 - b. Core insulation resistance.
 - c. Dissolved gas analysis.
 2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.
 - a. Perform the following optional tests per NETA ATS:
 - b. Excitation current.
 - c. Optional oil tests.
 3. Perform the following additional tests:
 - a. Record phase-to-phase, phase-to-neutral, and neutral-to-ground voltages at no load after energizing, and at operating load after start-up.
 4. Adjust tap changer setting as required to provide secondary voltage within 2-1/2 percent of nominal under normal load after approval of Engineer.
 4. Record as-left tap changer setting.
 5. Electrical Tests:
 - a. Insulation Resistance Test: Apply megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
 - 1) Winding-to-winding.
 - 2) Winding-to-ground.
 - b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
 - c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
 - d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
 - e. Insulation resistance test results to compare within 1 percent of adjacent windings.
 6. Sample insulating oil in accordance with ASTM D923 and have laboratory test for:
 - a. Dielectric breakdown voltage in accordance with ASTM D877 or ASTM D1816.

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- b. Acid neutralization number in accordance with ASTM D974.
- c. Interfacial tension in accordance with ASTM D971.
- d. Color in accordance with ASTM D1500.
- e. Visual condition in accordance with ASTM D1524.
- f. Specific gravity in accordance with ASTM D1298.
- g. Water content, in parts per million, in accordance with ASTM D1533.
- h. Dielectric fluid test results in accordance with NETA ATS, Table 100.4.
- i. Power factor at 25 degrees C and at 100 degrees, in accordance with ASTM D924.
- j. Maximum power factor, corrected to 20 degrees C, in accordance with manufacturer's specifications.

F. Transformer Cooling Fans/Temperature Controllers:

- 1. Verify each temperature sensor is of the correct type and rating and provides the correct output signal at ambient temperature.
- 2. Using a thermocouple or RTD simulator, verify correct temperature indication and alarm and fan control relay operation by signal injection.
- 3. Verify operation of controls in manual and automatic mode.
- 4. Verify operation of all cooling fans, record running current and compare to nameplate value.
- 5. Verify trip circuit operation where provided.

G. Cable - Low Voltage:

- 1. Perform visual inspections and electrical tests per NETA ATS.
- 2. Electrical Tests for Power Conductors:
 - a. Insulation Resistance Tests:
 - 1) Utilize 1,000-volt dc megohmmeter for 600-volt insulated conductors.
 - 2) Test each conductor with respect to ground and to adjacent conductors for 1 minute.
 - 3) Evaluate ohmic values by comparison with conductors of same length and type.
 - 4) Investigate values less than 50 megohms.
 - b. Continuity test by ohmmeter method to ensure proper cable connections.

H. Cable - Medium Voltage:

- 1. Perform visual inspections and electrical tests per NETA ATS.
- 2. Electrical Tests:
 - a. Insulation Resistance Tests:
 - 1) Utilize 5,000-volt megohmmeter for 15 kV conductors.
 - 2) Test each cable individually with remaining cables and shields grounded.
 - 3) Test each conductor with respect to ground and to adjacent conductors for 1 minute.
 - 4) Evaluate ohmic values by comparison with conductors of same length and type.
 - 5) Investigate values less than 50 megohms.
 - b. Shield Continuity Tests:
 - 1) By ohmmeter method on each section of conductor.
 - 2) Investigate values in excess of 10 ohms per 1,000 feet of conductors.
 - c. Acceptance Tests:

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- 1) In accordance with IEEE 400, ICEA S-93-639, NEMA WC 74, ICEA S-94-649, and ICEA S-97-682 for insulated conductors.
 - 2) Each conductor section tested with splices and terminations in place but disconnected from equipment, remaining conductors and shields grounded in accordance with IEEE 400.
 - 3) Apply maximum test voltage per NETA ATS, Table 100.6, based on method (DC, AC, PD or VLF) used.
 - 4) Measure only leakage current associated with conductor.
 - 5) Utilize guard ring or field reduction sphere to suppress corona at disconnected terminations.
 - 6) Maximum test voltage shall not exceed limits for terminators specified in IEEE 48, IEEE 386, or manufacturer's specifications.
 - 7) Apply test voltage in a minimum of five equal increments until maximum acceptable test voltage is reached.
 - 8) Increments not to exceed ac voltage rating of conductor.
 - 9) Record dc leakage current at each step after a constant stabilization time consistent with system charging current.
 - 10) Raise conductor to specified maximum test voltage and hold for 15 minutes or as specified by conductor manufacturer. Record leakage current at 30 seconds and 1 minute, and at 1-minute intervals, thereafter.
 - 11) Immediately following test, ground conductor for adequate time period to drain insulation stored charge.
 - 12) Test results evaluated on a pass/fail basis.
3. Non-destructive partial discharge test:
- a. After energization, perform a partial discharge test for baseline data for future partial discharge maintenance testing.
 - b. Perform the work while the medium voltage circuits and equipment are energized.
 - 1) The cables shall not be disconnected or de-energized and the testing shall not expose the cables to voltages that exceed normal operating voltage.
 - c. Use a frequency domain detection process incorporating a spectrum analyzer with radio frequency current transformer (RF CT) sensors.
 - 1) The detection system, including spectrum analyzer, RF CT's and interconnecting cable, shall have a partial discharge detection range that at least covers the frequency range of 10 kHz to 300 MHz.
 - 2) Testing shall be performed in a manner that complies with the requirements of IEEE 400 and IEEE 400.3.

D. Cable - Optical Fiber:

1. Perform inspections on tests per TIA/EIA/ANSI 455-78-B, including:
 - a. Optional time domain reflectometer test.
 - b. Power attenuation test.
 - c. Gain margin test.

E. Busway and Busduct (where applicable):

1. Perform inspections and tests per NETA ATS.
2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.

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F. Medium Voltage Source Transfer System:

1. Perform applicable inspections and test per:
 - a. NETA ATS for Air Interrupter Switches.
 - b. Manufacturer's instructions.

G. Medium voltage Metal Enclosed Air Switches:

1. Perform visual inspections and electrical tests per NETA ATS.
2. Electrical Tests:
 - a. Insulation Resistance Tests:
 - 1) Apply megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
 - 2) Phase-to-phase and phase-to-ground for 1 minute on each pole.
 - 3) Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
 - b. Contact Resistance Tests:
 - 1) Contact resistance in microhms across each switchblade and fuse holder.
 - 2) Investigate values exceeding 500 microhms or deviation of 50 percent or more from adjacent poles or similar switches.
 - c. Overpotential Tests:
 - 1) Apply voltage in accordance with NETA ATS, Table 100.19.
 - 2) Phase-to-phase and phase-to-ground for 1 minute.
 - 3) Test results evaluated on pass/fail basis.

H. Medium Voltage Circuit Breakers (where applicable):

1. Perform visual inspections and electrical tests per NETA ATS.
2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.
3. Perform the following optional tests per NETA ATS:
 - a. Control wiring insulation resistance.
 - b. Minimum trip and close voltage.
 - c. Overpotential.
4. Specifier: A timing test is only required for generator circuit breakers for large machines where breaker operating time is included in synchronism check relay setting calculations, or for breakers involved in fast motor bus transfer schemes.
5. Circuit breaker timing test: Power factor.
6. Perform the following additional tests:
 - a. High-potential vacuum integrity test per manufacturer's recommendations.

I. Low Voltage Power Circuit Breakers:

1. Perform visual inspections and electrical tests per NETA ATS.
 - a. Tests shall include primary current injection testing of all breakers at final settings.
 - b. Where short-time or instantaneous settings on large frame breakers are beyond the current capability of field testing, primary injection tests at reduced currents shall be permitted if combined with secondary injection calibration test of trip unit at final settings.
2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.
3. Perform the following optional tests per NETA ATS:
 - a. Control wiring insulation resistance.

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4. Perform the following additional tests:
 - a. Shunt trip devices minimum tripping voltage.
 - b. Insulation Resistance Tests:
 - 1) Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers.
 - 2) Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
 - 3) Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
 - 4) Test values to comply with NETA ATS, Table 100.1.
 - c. Contact Resistance Tests:
 - 1) Contact resistance in microhms across each pole.
 - 2) Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
 - d. Primary Current Injection Test to Verify:
 - 1) Long-time minimum pickup and delay.
 - 2) Short-time pickup and delay.
 - 3) Ground fault pickup and delay.
 - 4) Instantaneous pickup by run-up or pulse method.
 - 5) Trip characteristic when adjusted to setting sheet parameters shall be within manufacturer's published time-current tolerance band.
5. Record as-left settings.

J. Low Voltage Molded Case Circuit Breakers:

1. Perform visual inspections and electrical tests per NETA ATS.
2. Components:
 - a. Test all components per applicable paragraphs of this Specification Section and NETA ATS.
 - b. Thermal magnetic breakers: Visual and mechanical inspection per NETA ATS only.
 - c. Solid state trip type: Visual and mechanical inspection and electrical tests per NETA ATS.
3. Electrical tests:
 - a. Insulation Resistance Tests:
 - 1) Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers.
 - 2) Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
 - 3) Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
 - 4) Test values to comply with NETA ATS, Table 100.1.
 - b. Contact Resistance Tests:
 - 1) Contact resistance in microhms across each pole.
 - 2) Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
 - c. Primary Current Injection Test to Verify:
 - 1) Long-time minimum pickup and delay.
 - 2) Short-time pickup and delay.
 - 3) Ground fault pickup and delay.
 - 4) Instantaneous pickup by run-up or pulse method.

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- 5) Trip characteristics of adjustable trip breakers shall be within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
 - 6) Trip times shall be within limits established by NEMA AB 4, Table 5-3. Alternatively, use NETA ATS, Table 100.7.
 - 7) Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4. Alternatively, use NETA ATS, Table 100.8.
4. Record as-left settings.

K. Protective Relays:

1. Perform visual inspections and electrical tests per NETA ATS.
 - a. Tests to be performed using secondary injection of 3 Phase current and potential at final settings.
 - b. Test at manufacturer's recommended test points and critical timing points identified on relay setting sheet.
2. Perform all tests identified as optional per NETA ATS.
3. Perform the following additional tests:
 - a. Verification of direct trip of associated lockout relay or circuit breaker(s) by using relay test function or shorting trip contact at relay case.
 - b. Microprocessor-based relays:
 - 1) Complete commissioning procedure per manufacturer's instructions, followed by tests of each relay element at final settings.
 - 2) Verification of all internally-programmed logic.
 - c. Verification of all auxiliary input and output signals.
 - d. Verification of power supply/self-diagnostic alarm contact and remote annunciation.
 - e. Current Injection Tests:
 - 1) For entire current circuit in each section.
 - 2) Secondary injection for current flow of 1 ampere.
 - 3) Test current at each device.
4. Record as-left settings.

L. Instrument Transformers:

1. Perform visual inspections and electrical tests per NETA ATS.
2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.
3. Perform the following optional tests per NETA ATS:
 - a. Dielectric withstand test on potential transformers.
4. Current Transformer Tests:
 - a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts dc for 30 seconds.
 - b. Polarity test.
5. Potential Transformer Tests:
 - a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 100.9, for 1 minute on:
 - 1) Winding-to-winding.
 - 2) Winding-to-ground.
 - b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.

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6. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 100.5.

M. Metering:

1. Perform visual inspections and electrical tests per NETA ATS.
2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.

N. Grounding:

1. Perform visual inspections and electrical tests per NETA ATS.
2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.
3. Electrical Tests:
 - a. Fall-of-Potential Test:
 - 1) In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
 - 2) Main ground electrode system resistance to ground to be no greater than 5 ohm(s).
 - b. Two-Point Direct Method Test:
 - 1) In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
 - 2) Equipment ground resistance shall not exceed main ground system resistance by 0.50 ohm.

O. Ground Fault Protection (where applicable):

1. Perform inspections and tests per NETA ATS.
2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.
3. Perform the following optional tests per NETA ATS:
 - a. Control wiring insulation resistance.
4. Perform the following additional tests for four-wire systems:
 - a. Primary current injection into switchgear bus with test set configured to simulate transformer source and high current jumper used to simulate unbalanced load and ground fault conditions.
 - b. Verify no tripping for unbalanced load on each feeder and each main breaker.
 - c. Verify no tripping for unbalanced load across tie breaker for dual-source schemes.
 - d. Verify tripping for ground fault on load side of feeder each feeder and on each main bus.
 - e. Verify tripping for ground fault on a single feeder and on each main bus through tie breaker(s) for multiple-source schemes.

P. Motors (where applicable):

1. Perform inspections and tests per NETA ATS.

Q. Motor Controllers:

1. Perform visual inspections and electrical tests per NETA ATS.
2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.

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3. Check door and device interlocking system by:
 - a. Closure attempt of device when door is in OPEN position.
 - b. Opening attempt of door when device is in ON or CLOSED position.
4. Check nameplates for proper identification of:
 - a. Equipment title and tag number with latest one-line diagram.
 - b. Pushbuttons.
 - c. Control switches.
 - d. Pilot lights.
 - e. Control relays.
 - f. Circuit breakers.
 - g. Indicating meters.
 - h. Surge protective device counters.
5. Verify fuse and circuit breaker sizes and types conform to Contract Documents.
6. Verify current and potential transformer ratios conform to Contract Documents.
7. Check bus connections for high resistance by low-resistance ohmmeter, Ohmic value to be zero.
8. Check operation and sequencing of electrical and mechanical interlock systems by:
 - a. Closure attempt for locked open devices.
 - b. Opening attempt for locked closed devices.
 - c. Key exchange to operate devices in OFF-NORMAL positions.
9. Verify performance of each control device and feature furnished as part of motor control center.
10. Control Wiring:
 - a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
 - b. Check for proper conductor lacing and bundling.
 - c. Check for proper conductor identification.
 - d. Check for proper conductor lugs and connections.
11. Exercise active components.
12. Inspect contactors for:
 - a. Correct mechanical operations.
 - b. Correct contact gap, wipe, alignment, and pressure.
 - c. Correct torque of connections.
13. Compare overload heater rating with full-load current for proper size.
14. Compare motor protector and circuit breaker with motor characteristics for proper size.
15. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.
16. Perform the following optional tests per NETA ATS:
 - a. Motor running overcurrent protection.
17. Electrical Tests:
 - a. Insulation Resistance Tests:
 - 1) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
 - 2) Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
 - 3) Contactor phase-to-ground and across open contacts for 1 minute on each phase.

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- 4) Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
 - 5) Test values to comply with NETA ATS, Table 100.1.
 - b. Current Injection through Overload Unit at 300 Percent of Motor Full-Load Current and Monitor Trip Time:
 - 1) Trip time in accordance with manufacturer's published data.
 - 2) Investigate values in excess of 120 seconds.
 - c. Control Wiring Tests:
 - 1) Apply secondary voltage to control power and potential circuits.
 - 2) Check voltage levels at each point on terminal board and each device terminal.
 - 3) Insulation resistance test at 1,000 volts dc on control wiring, except that connected to solid state components; 1 megohm minimum insulation resistance.
 - d. Operational test by initiating control devices to affect proper operation.
- R. Generators:
- 1. Perform inspections and tests per NETA ATS.
 - 2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.
 - 3. Perform the following additional tests:
 - a. Load and cycle crank test per Specification Section 26 32 13.
 - b. Test engine protective shutdown features for:
 - 1) Low oil pressure.
 - 2) Overtemperature.
 - 3) Overspeed.
 - c. Phase rotation test.
- S. Surge Protective Devices:
- 1. Perform inspections and tests per NETA ATS.
 - 2. Check for ground connections to ground bus.
 - 3. Test grounding connection as specified herein. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.
- T. Control System Functional Test:
- 1. Perform test upon completion of equipment acceptance tests.
 - 2. The test is to prove the correct interaction of all sensing, processing and action devices.
 - 3. Develop a test plan and parameters for the purpose of evaluating the performance of the system.
 - 4. Perform the following tests:
 - a. Verify the correct operation of all interlock safety devices for fail-safe functions in addition to design function.
 - b. Verify the correct operation of all sensing devices, alarms and indicating devices.
 - 5. Systems to be tested:
 - a. Protective Relaying Systems.
 - b. Digital Metering System.
 - c. Medium Voltage Source Transfer System.
 - d. Paralleling Switchgear Schemes.
 - e. Standby Generator Systems.

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- f. PLC Automatic Throwover System.
- g. Load Shedding System.
- h. Automatic Transfer Switch Schemes.
- i. Low Voltage Lighting Control System.

END OF SECTION

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SECTION 26 09 13

ELECTRICAL POWER MONITORING

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PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Electrical Power Monitors.
 - 2. Serial to Ethernet Converter.
 - 3. Current Transformer (CT).
 - 4. Potential Transformer (PT) and Control Power Transformer (CPT).
- B. Related Sections:
 - 1. Division 26 Specifications.

1.02 SYSTEM DESCRIPTION

- A. Electrical Power Quality Meter shall provide continuous monitoring of a three phase system.
- B. Meter shall measure current, voltage, real and reactive power, energy use, cost of power, power factor and frequency.
- C. Programmable set points and 4 assignable output relays shall be provided for control functions for specific applications.
- D. Meter shall be capable of basic alarm on over/under current or over/under voltage, unbalance, demand based load shedding, and capacitor power factor correction control.
- E. More complex control shall be possible using the 4 switch inputs which also can be used for status such as breaker open/closed, flow information, etc.

1.03 SUBMITTALS

- A. Per Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings: Indicate dimensions drawings of electrical power monitoring system components and accessories.
 - 1. One-line diagram: Indicating system configuration indicating panels, number and type of devices.
 - 2. Include typical wiring diagrams for each component.
 - 3. Include elevation detail of system components within existing equipment.
- C. Product Data: Submit manufacturer’s standard product data for each system

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component.

- D. Installer qualifications.
- E. Manufacturer's Installation Instructions: Submit for each system component.
- F. Commissioning Plan and Forms.

1.04 CLOSEOUT SUBMITTALS

- A. Per Section 01 77 00 – Closeout Procedures.
- B. Spare Parts per Section 01 78 23 – Operation and Maintenance Data.
 - 1. Provide 2 spare fuses of each type and size for all power and control transformers associated with PQM equipment installations.

1.05 QUALITY ASSURANCE

- A. Per Section 01 45 00 – Quality Control.

1.06 QUALIFICATIONS

- A. Installer Qualifications: Installer having minimum 5 years documented experience in electrical power monitoring installations similar in design and extent to work indicated and having a successful service record. Licensed in the state in which work is to be performed.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 66 00 – Product Storage and Handling Requirements.

PART 2 PRODUCTS

2.01 ELECTRICAL POWER MONITORS

- A. Manufacturers:
 - 1. Electro Industries, Nexus 1500+ with Ethernet
 - 2. General Electric Company, PQM II- A.
 - 3. Electro Industries, Shark 200 V6 with Ethernet.
- B. Safety Certificate and Testing:
 - 1. Meter shall be manufactured under an ISO9001 registered program.
 - 2. The meter shall be UL listed and conform to CE EN 55011/CSPIR 11, EN50082-2, IEC 947-1 and IEC 1010-1 standards.
 - 3. Meter shall conform to environment standard IEC 68-2-38 for temperature and humidity cycle.
 - 4. Meter shall have a dielectric strength of 2.0 kV for 1 minute to relays, CTs, PTs and Power supply. Meter shall be able to withstand impulse rated at .5 Joules at 5kV.

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C. Metering and Monitoring:

1. Meter shall be panel mount design with integrated display. Display shall be a Liquid Crystal Display (LCD), minimum 40-character display capable of clearly displaying alphanumeric characters.
2. Meter shall provide separate LED indicators for Alarms, Relay Activation, Auxiliary and Communication (Rx,Tx) status.
3. Set-point keys shall be provided on the front panel of the meter to program the meter. Meter shall be able to display all measured value on demand using the keys on meters front panel.
4. For testing purposes meter shall be able to run in self test and simulation mode. The meter shall simulate values for current, voltage, analog input, switches and analog outputs.
5. Meter shall provide a true RMS monitoring of Ia, Ib, Ic, In, Van, Vbn, Vcn, Vab, Vbc, Vca, voltage/current unbalance, power factor, line frequency, watts, vars, VA, Wh, varh, VAh, and demand readings for A, W, vars, and VA. Maximum and minimum values of measured quantities shall also be recorded and date/time stamped.
6. Meter shall be able to provide demand metering for energy and power. Demand shall be programmable for Thermal or Rolling demand with the demand interval of 5-60 minutes in step of 1.
7. Meter shall be capable of calculating energy costs. User shall be able to program up to 3 different tariff rates for cost calculations.
8. Following minimum accuracy for the monitored parameters shall be provided:

Voltage: $\pm 0.2\%$ of full-scale

Current: $\pm 0.2\%$ of full-scale

Voltage unbalance: $\pm 1\%$ of full-scale

Current unbalance: $\pm 1\%$ of full-scale

kW: per curves ± 1 digit on display

kvar: per curves ± 1 digit on display

kVA: per curves ± 1 digit on display

kWh: per curves ± 1 digit on display kvarh: per curves ± 1 digit on display

kVAh: per curves ± 1 digit on display Power factor: $\pm 1\%$ of full-scale Frequency: ± 0.02 Hz

kW demand: $\pm 0.4\%$ of full-scale kvar demand: $\pm 0.4\%$ of full-scale

kVA demand: $\pm 0.4\%$ of full-scale

Current demand: $\pm 0.4\%$ of full-scale

Current THD: $\pm 2.0\%$ of full-scale Voltage THD: $\pm 2.0\%$ of full-scale

Crest factor: $\pm 0.4\%$ of full-scale

9. User shall be able to set Alarm conditions for all measured quantities. These include over-current, under-current, neutral current, current unbalance, voltage unbalance, phase reversal, over-frequency, under-frequency, power factor, switch inputs, etc. The alarm messages shall be displayed on the meter LCD display in a simple and easy to understand English format.

D. Power Quality:

1. Power analysis features shall include an event recorder, waveform capture, trace memory, harmonic spectrum display (through the 62nd harmonic with total harmonic distortion) and a data logger function. Meter shall be able to sample harmonic spectrum at 256 samples per cycle. All analysis data shall be non-

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volatile.

2. Meter shall have a Voltage Disturbance Recorder (VDR) function to monitor and record sag and swell disturbances. It shall record up to 500 sag/swell events for all voltages simultaneously and log them with a time stamp.
3. Meter shall simultaneously sample all channels at minimum 16 samples per cycle. Meter shall be able to automatically capture waveforms based on user-defined set-points.
4. Meter shall automatically generate log for alarms, triggers and input/output events. 150 events records with time stamp shall be stored in the meter.

E. Input/Outputs:

1. Meter shall have built in input and output modules for control and transducer functions:
 - a. Four switch inputs (digital inputs) shall be provided which can be programmed for relay activation, counters, logic, demand sync, reset and alarms.
 - b. Four output relays shall be provided which can be programmed to activate on alarms, setpoints, switch inputs, kWh pulse, trace memory triggers or KYZ communications control. These output relays shall also be able to use demand-metering values of A, VAR, W and VA to control load shedding.
 - c. Four isolated 4-20mA or 0-1mA analog outputs assignable to all measured and calculated parameters for output to PLC and other such external devices.

F. Communication:

1. Meter shall be able to communicate using Modbus and DNP 3.0 protocols over assignable RS 485 communication ports at minimum rate baud rate of 19200. Through the use of communication user shall be able to read/write set- points, read actual values, execute commands and read device status loop- back test.
 - a. Meter shall have a RS232 9-pin computer interface port accessible from the front of the meters for interface with local computer.
 - b. Two RS485 ports shall be provided for communication with SCADA and other systems. Each port shall be able to communicate independently to different systems using Modbus or DNP protocols
 - c. Through the use of external Ethernet module meter shall be able to communicate over Local Area Network (LAN) using TCP/IP. The module shall support both 10BaseT (copper) and 10BaseF (fiber optic) connections. The module shall allow up to thirty additional RS- 485/Modbus RTU devices to be connect to the Ethernet.

2.02 SERIAL TO ETHERNET CONVERTER

A. Manufacturers:

1. General Electric Company, Multinet.
2. No approved equal.

B. Safety Certificate and Testing:

1. Meter shall be manufactured under an ISO9001 registered program.
2. The meter shall be UL listed and conform to CE EN 55011/CSP1R 11, EN50082-2, IEC 947-1 and IEC 1010-1 standards.
3. Meter shall conform to environment standard IEC 60068-2-30 for temperature and humidity cycle.

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- C. Interfaces:
 1. Ethernet Version 2.0/ IEEE 802.3
 2. 10BaseT and 10BaseF Fiber connections
 3. RS485 2- wire, half duplex, isolated

2.03 CURRENT TRANSFORMERS (CT)

- A. Manufacturer:
 1. General Electric Company.
 2. Approved equal.

- B. Requirements:
 1. Outdoor rated suitable for operating meters and instruments.
 2. High Accuracy Applications:
 - a. 600V and Less: ANSI/IEEE Accuracy Class Burden of 0.15 at 60 HZ.
 - b. 601V and Greater ANSI/IEEE Accuracy Class Burden of 0.30 at 60 HZ.
 3. Current Ratio:
 - a. Primary Amperage per bus rating.
 - b. Secondary Amperage 5 Amps.
 4. High Accuracy Applications.
 5. BIL Rating:
 - a. 600V and Less: 10 kV.
 - b. 5000V and Less: 75 kV.
 - c. 5001V and Greater: 110 kV.

2.04 POTENTIAL TRANSFORMERS (PT) AND CONTROL POTENTIAL TRANSFORMERS (CPT)

- A. Manufacturer:
 1. General Electric Company.
 2. Approved equal.

- B. Requirements:
 1. Outdoor rated suitable for operating meters and instruments.
 2. ANSI/IEEE Accuracy Class Burden of 0.15 at 60 HZ.
 3. Voltage Ratio:
 - a. Primary Voltage per bus rating.
 - a. Secondary Voltage 120V.
 4. High Accuracy Applications.
 5. Dual Primary Fuses.
 6. BIL Rating:
 - a. 600V and Less: 10 kV.
 - b. 5000V and Less: 75 kV.
 - c. 5001V and Greater: 110 kV.

PART 3 EXECUTION

3.01 EXAMINATION

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- A. Verify equipment is ready for electrical connection, for wiring, and to be energized.

3.02 EXISTING WORK

- A. Remove exposed abandoned equipment wiring connections, including abandoned connections above accessible ceiling finishes.
- B. Disconnect abandoned utilization equipment and remove wiring connections. Remove abandoned components when connected raceway is abandoned and removed. Install blank cover for abandoned boxes and enclosures not removed.
- C. Extend existing equipment connections using materials and methods compatible with existing electrical installations, or as specified.

3.03 INSTALLATION

- A. Make electrical connections.
- B. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.
- C. Install suitable clamps and fittings for cable connections at outlet boxes and equipment connection boxes.
- D. Electrical Power Monitors:
 - 1. Install current transformers (CT), potential transformers (PT), control transformers (CPT), and control devices to complete equipment wiring requirements per manufacturer and Drawings.
 - 2. Install terminal block jumpers to complete equipment wiring requirements.
 - 3. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.
 - 4. Set time and date in all power quality meters set to match Greenwich Mean Time (GMT) with appropriate off-set for daylight savings time. Time and date may be set via Modbus.
- E. Serial Ethernet Converters:
 - 1. Install in Low Voltage Motor Control Centers and Low Voltage Switchgear as Shown.
 - 2. Mount on din rail and provide power via 120V circuit as Shown.
 - 3. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.
 - 4. Interface with existing network switch in Network cabinet/rack and Electrical Power Monitors.

3.04 COMMISSIONING ELECTRICAL EQUIPMENT AND SYSTEMS

- A. CONTRACTOR Commissioning Responsibilities:
 - 1. The CONTRACTOR is required to execute the commissioning responsibilities required by the OWNER, including, but not limited to, the following:
 - a. Furnishing cost for providing the services to commission electrical equipment

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- by the manufacturer.
- b. Provide a commissioning scoping meeting and other meetings necessary to facilitate the commissioning process for this Contract.
- c. Supporting the manufacturer through all phases of the commissioning process.
 - 1) The CONTRACTOR is responsible for working with the manufacturer according to the protocols established in the manufacturer commissioning requirements.
 - 2) The CONTRACTOR are responsible for providing sufficient notice to the manufacturer regarding the completion schedule for the pre- functional checklists and the startup of the electrical equipment and systems.
- d. Written Work Products:
 - 1) The CONTRACTOR are responsible for furnishing the written work products required by the manufacturer, including the procedures to be executed as part of initial checkout and other input for developing the Startup Plans, and executed (filled in and signed) initial checkout, startup, and pre-functional checklists.
 - 2) Using the manufacturer's startup procedures and pre-functional checklists, develop initial checkout and full Startup Plans for electrical equipment and systems to be commissioned in accordance with the requirements specified.
 - a. Submit the initial checkout and full Startup Plans to the ENGINEER for review and approval prior to startup of the equipment or system.
 - 3) Provide assistance to the manufacturer in preparing functional performance test procedures.
 - a) Review the test procedures to ensure their feasibility, safety, and protection of equipment; and furnish in writing the necessary alarm limits to be used during the tests.
- e. Furnish the electrical testing equipment required to perform the commissioning procedures.
- f. Executing the tasks listed on the approved pre-functional checklists and performing the startup tests.
 - 1) Provide skilled technicians to execute the starting of equipment.
 - a) Ensure that the technicians are available and present during agreed upon schedules, and for a sufficient time to complete the necessary tests, adjustments, and problem solving.
- g. Under the direction of the manufacturer, performing the functional performance tests (FPT), and executing seasonal or deferred functional performance testing, witnessed by the OWNER's representative, in accordance with the specifications.
 - 1) Provide skilled technicians to perform the functional performance testing under the direction of the manufacturer.
- h. Correcting deficiencies, meaning differences between the specified and observed performance as interpreted by the manufacturer, in the tested equipment and systems; and retesting the equipment and systems after corrections have been made.

B. Electrical Equipment Manufacturer Responsibilities:

- 1. The electrical equipment manufacturer are required to execute the commissioning responsibilities assigned to them by the Specifications and Drawings, including,

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but not limited to, the following:

- a. Furnishing requested Submittal data, including detailed startup procedures, and specifying specific responsibilities of the OWNER required for maintaining the equipment warranties in force.
- b. Furnishing assistance during equipment testing.
- c. Furnishing costs to include special tools and instruments only available from the equipment Suppliers or vendors, that are specific to a piece of equipment, as required by the Specifications, and required for testing the equipment according to the Drawings, except for stand-alone data logging equipment that may be used by the CONTRACTOR.
- d. Furnishing information requested by the CONTRACTOR regarding the sequences of operation and testing procedures for equipment.
- e. Reviewing and approving test procedures for equipment installed by factory representatives.

3.05 SYSTEM STARTUP

- A. Prior to system startup, complete the electrical systems and sub-systems so the systems and sub-systems are fully functional, and meet the performance and design requirements of the Drawings.
 - 1. Commissioning procedures and functional testing do not relieve or lessen this responsibility, or shift this responsibility in whole or in part to the OWNER.
 - 2. Address current punch list items before performing functional testing.
- B. Functional Testing:
 - 1. A complete list of systems to be commissioned, and a description of the process shall be provided by the CONTRACTOR.
 - 2. Begin functional testing of each electrical equipment item or system when the equipment item or system is completed.
 - a. At the discretion of the OWNER, functional testing may proceed prior to completion of the system or sub-systems.
 - b. Beginning testing of a system before it is completed does not relieve the CONTRACTOR from fully completing the system, or executing pre- functional checklists, as early as possible.

3.06 CLOSEOUT ACTIVITIES

- A. CONTRACTOR
 - 1. The CONTRACTOR are responsible for performing the following training- related functions after the functional testing is complete, unless otherwise approved by the OWNER in writing:
 - a. For each major piece of equipment, engage an appropriate expert and qualified trainer to furnish the instruction for the OWNER's operating staff and demonstrate the equipment as specified.
 - 1) The trainer may be the startup technician for the piece of equipment, the installing CONTRACTOR, or a trade or manufacturer's representative.
 - 2) The trainer must possess practical building operating expertise and in-depth knowledge of the specific piece of equipment's modes of operation.
 - 3) More than 1 trainer may be required to demonstrate or furnish training for a piece of equipment.

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- b. At least 3 weeks before the training and demonstration are scheduled to occur, submit an outline describing the training.
- c. For each electrical system, subsystem, or piece of equipment to be commissioned, provide the OWNER's designated personnel with a comprehensive orientation and a training session, or training sessions, designed to furnish an understanding of the systems and their operation and maintenance as specified in Section 01 75 05 – Testing, Training and Start-Up and Section 01 77 00 - Closeout Procedures.
 - 1) Begin the training with classroom sessions, followed by hands-on training on each piece of equipment or system designed to illustrate the equipment's or system's various modes of operation, including startup, shutdown, fire or smoke alarm, power failure, and similar modes.

B. Demonstration:

- 1. Engage the CONTRACTOR to fully explain and demonstrate the operation, function, and overrides of local packaged controls not controlled by the central control system to the OWNER's designated personnel.
 - a. During the demonstration, if the system fails to perform in accordance with the requirements of the Operation and Maintenance Manual or the sequence of operations, repair or adjust the system as necessary, and repeat the demonstration.

C. Training of OWNER Personnel:

- 1. Duration of Training:
 - a. Furnish training in accordance with Section 01 75 05 – Testing, Training, and Start-Up.
- 2. Classroom Sessions:
 - a. Design training sessions to follow the Table of Contents of the Operation and Maintenance Manuals for the subject equipment, and whenever possible illustrate the use of the Operation and Maintenance Manuals for reference.
 - 1) Use the format and training agenda included in ASHRAE Guideline 1.1-2008.
 - 2) Use overhead projections, slides, video/audio-taped material, as appropriate, in classroom sessions.
 - 3) Refer to the printed installation, operation, and maintenance instruction material included in the Operation and Maintenance Manual for the equipment or system.
 - 4) Review the written operation and maintenance instructions, emphasizing safe and proper operating requirements, preventative maintenance, special tools needed, and spare parts inventory suggestions.
 - 5) Teach students the startup, shutdown, seasonal changeover, and emergency procedures as applicable, and operation of the equipment or system in all possible modes.
 - 6) Discuss relevant health and safety issues and concerns.
 - 7) Discuss warranties and guarantees.
 - 8) Describe common troubleshooting problems and solutions.
 - 9) Discuss peculiarities of the equipment installation or operation.
 - 10) Discuss the explanatory information included in the Operation and Maintenance Manuals, and the location of plans and manuals in the facility.

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- 3. Hands-On Training:
 - a. Furnish hands-on training that includes startup and operation in all modes, including, but not limited to, manual operation, shut-down, and emergency operation procedures, if any.
 - b. Furnish hands-on maintenance training for each piece of equipment.

D. Record Documentation:

- 1. During construction, prepare and maintain as-built red-line drawings on Contract Drawings, and prepare final computer-generated as-built drawings to be used as coordination drawings.
- 2. Update the as-built drawings after completion of the commissioning activities, excluding the deferred functional testing.
- 3. Submit the final computer-generated as-built drawings showing the commissioned electrical equipment and systems to the OWNER.

3.07 MAINTENANCE

A. Operation and Maintenance Manuals:

- 1. Prepare Operation and Maintenance Manuals in accordance with the requirements specified in the Drawings.
 - a. The CONTRACTOR and equipment Suppliers are responsible for compiling and preparing documentation for the electrical equipment and systems provided under this Contract for inclusion in the Operation and Maintenance Manuals.
- 2. Submit a copy of the Operation and Maintenance Manuals and submittals for the electrical equipment and systems to be commissioned, as specified in the Drawings, to the Commissioning Authority for review.
- 3. The CONTRACTOR is responsible for clarifying and updating the original sequences of operation furnished to as-built conditions.

3.08 ADJUSTING

A. Section 01 75 05 – Testing, Training, and Start-Up.

- B. Cooperate with utilization equipment installers and field service personnel during checkout and starting of equipment to allow testing and balancing and other startup operations. Provide personnel to operate electrical system and checkout wiring connection components and configurations.

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SECTION 26 09 19

ENCLOSED CONTROLLER

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PART 1 GENERAL

1.01 RELATED COCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes ac, enclosed controllers rated 600 V and less, of the following types:
 - 1. Across-the-line, manual and magnetic controllers.

1.03 SUBMITTALS

- A. Product Data: For each type of enclosed controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each enclosed controller.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Each installed unit's type and details.
 - b. Nameplate legends.
 - c. Short-circuit current rating of integrated unit.
 - d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.
 - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.
- C. Wiring Diagrams: Power, signal, and control wiring.
- D. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around enclosed controllers where pipe and ducts are prohibited. Show enclosed controller layout and relationships between electrical components and adjacent structural and mechanical

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elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 include the following:
 1. Routine maintenance requirements for enclosed controllers and all installed components.
 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

1.04 QUALITY CONTROL

- A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles (160 km) of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction .
 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- C. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NFPA 70.
- F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed controllers, minimum clearances between enclosed controllers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose

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packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.06 COORDINATION

- A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

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SECTION 26 09 23

LIGHTING CONTROL DEVICES

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PART 1 GENERAL

1.01 RELATED COCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following lighting control devices:
 - 1. Time switches.
 - 2. Outdoor and indoor photoelectric switches.
 - 3. Indoor occupancy sensors.
 - 4. Outdoor motion sensors.
 - 5. Lighting contactors.
 - 6. Emergency shunt relays.
- B. Related Sections include the following:
 - 1. Division 16 Section "Lighting Controls" for low-voltage, manual and programmable lighting control systems.
 - 2. Division 16 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.03 DEFINITIONS

- A. LED: Light-emitting diode.
- B. PIR: Passive infrared.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show installation details for occupancy and light-level sensors.
 - 1. Interconnection diagrams showing field-installed wiring.
- C. Field quality-control test reports.

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D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.05 QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.06 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 PRODUCTS

2.01 TIME SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Grasslin Controls Corporation; a GE Industrial Systems Company.
 - 2. Intermatic, Inc.
 - 3. Leviton Mfg. Company Inc.
 - 4. Lightolier Controls; a Genlyte Company.
 - 5. Lithonia Lighting; Acuity Lighting Group, Inc.
 - 6. Paragon Electric Co.; Invensys Climate Controls.
 - 8. Square D; Schneider Electric.
 - 7. TORK.
 - 8. Touch-Plate, Inc.
 - 9. Watt Stopper (The).

- B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.
 - 1. Contact Configuration: As required by load.
 - 2. Contact Rating: 20-A ballast load, 120/240-V ac.
 - 3. Pulse signal for momentary-latching relay.
 - 4. Program: 8 on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
 - 5. Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.

END OF SECTION

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SECTION 26 11 16

SECONDARY UNIT SUBSTATIONS

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PART 1 GENERAL

1.01 REFERENCES

- A. Refer to the General Conditions and Division 1, General Requirements, requirements associated with Submittal Procedures, Material and Equipment, Product Options and Substitutions, Manufacturer’s Services, Checkout and Testing, Facility Start-up, Operations and Maintenance Data, Record Drawings, and Warranty. Comply with the requirements in this Section where they exceed the General Conditions or Requirements.

- B. The following is a list of standards which may be referenced in this section:
 - 1. ASTM International (ASTM): D3487, Specification for Mineral Insulating Oil Used in Electrical Apparatus.
 - 2. Institute of Electrical and Electronics Engineers (IEEE):
 - a. C37.20.1, Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.
 - b. C37.20.3, Metal-Enclosed Interrupter Switchgear.
 - c. C37.30, Standard Requirements for High-Voltage Switches.
 - d. C37.32, High-Voltage Switches, Bus Supports and Accessories Schedule of Preferred Ratings, Construction Guidelines and Specifications.
 - e. C37.34, Standard Test Code for High-Voltage Air Switches.
 - f. C37.100, Standard Definitions for Power Switchgear.
 - g. C57.12.00, Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
 - h. C57.12.90, Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers.
 - i. C57.106, Guide for Acceptance and Maintenance of Insulating Oil in equipment.
 - 3. National Electrical Manufacturers Association (NEMA):
 - a. TP 1, Guide for Determining Energy Efficiency for Distribution Transformers.
 - b. TP 2, Standard Test Method for Measuring the Energy Consumption of Distribution Transformers.
 - c. TP 3, Standard for the Labeling of Distribution Transformer Efficiency.
 - 4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

1.02 SUBMITTALS

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- A. Submittals shall be made in accordance with Division 1, General Requirements, and Section 26 00 00, Basic Electrical Requirements.
- B. Action Submittals:
1. Descriptive production information.
 2. Itemized Bill of Material.
 3. Dimensional drawings.
 4. Operational description.
 5. One-line, three-line, and control schematic drawings.
 6. Connection and interconnection drawings.
 7. Fuses and Circuit Breakers: Copies of time-current characteristics.
 8. Ground Fault Protection: Time-current characteristics.
 9. Bus data.
 10. Incoming line section equipment data.
 11. Transformer section equipment data.
 12. Outdoor walk-in secondary switchgear section equipment data. Provide Drawings and calculations sealed by a professional engineer registered in the State of Nevada.
 13. Conduit entrance locations.
 14. Seismic Bracing and Anchorage: Component seismic bracing and anchorage shop drawings and calculations utilizing an Importance Factor (I_p) of 1.5 and meeting the requirements of Section 01 81 02, Seismic Design Criteria, shall be submitted for Load Centers (outdoor equipment).
 15. Anchoring instructions and details.
 16. Outdoor equipment exterior finish and color.
- C. Informational Submittals:
1. Manufacturer's installation instructions.
 2. Certified Factory Test Reports.
 3. Operation and Maintenance Data: As specified in Section 01 33 00, Submittals Procedures.
 4. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 63 00, General Equipment Stipulations.
 5. Certificate of Compliance: A Certificate of Compliance for component seismic design utilizing an Importance Factor (I_p) of 1.5 and meeting the requirements of Section 01 45 00, Quality Control, shall be submitted by the manufacturer for Load Centers (outdoor equipment).

1.03 QUALITY CONTROL

- A. Authority Having Jurisdiction (AHJ):
1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
 2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark.
 3. Manufacturer shall be experienced in the manufacture, operation, and servicing of equipment equal to the type, size, quality, performance, and reliability

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specified. Manufacturers of equipment finished under this Section shall have a minimum of 10 years' experience in the manufacturer of such equipment.

4. Transformers rated 600 volts and below and 1,000 kVA and below shall have energy efficiencies that meet or exceed the latest requirements of NEMA TP 1, TP 2, and TP 3, and local codes and ordinances. Transformers shall be Energy Star labeled.

1.04 EXTRA MATERIALS

- A. Furnish, tag, and box for shipment and storage, and deliver prior to 80 percent project completion the following spare parts and special tools, and materials:

Item	Quantity
Load Break Switch:	
Spare Fuses of each current rating	3
Fuse Mounting Clips	1 set of two for each unit
Fuse Removal Sticks (hook sticks) Hook-sticks shall have fiberglass handles and be new and unused, and the "shotgun" type.	2
Other Components:	
Fuses	1 complete set of spare fuses of each current rating, both power and control for each unit
Lights	1 complete set of spare indicating lights (LEDs) for each unit
Paint	1 pint, to match enclosure exterior finish in color and quality
Indicating Lamp LED Pullers	2 each
Indicating Lamp LED Sockets	2 each

1.05 PACKING AND SHIPPING

- A. Shipping Splits: Established by CONTRACTOR to facilitate transportation of equipment to final installation location.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Eaton/Cutler-Hammer (Westinghouse).
- B. Or OWNER approved EQUAL.

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2.02 GENERAL

- A. Double-ended secondary unit substitution.
- B. Equipment suitable for 12,470 volts, three-phase, three-wire solid grounded-wye electrical system having an available short-circuit current at line terminals as shown on the Drawings.
- C. Designed, tested, and assembled in accordance with standards of ASTM, IEEE, and NEMA, applicable to its three major sections.
- D. Unit substation and all its major components to be manufactured and assembled by a single manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts and replacement, and manufacturer's services.
- E. Lifting lugs on equipment and devices weighing over 50 pounds.
- F. Rail mounted lifting devices for all drawout circuit breakers with adequate clearance above the switchgear to operate the lifter.
- G. Anchor Bolts: Galvanized, sized seismically by a licensed structural Engineer registered in the state of Nevada, in accordance with Section 01 63 00, General Equipment Stipulations.
- H. Operating Conditions:
 - 1. As specified in Section 26 05 00, Common Work Results for Electrical.
 - 2. Equipment to be fully rated without any derating for operating conditions.
- I. Infra-red Scan Windows (Large installed on the front of gear, as shown on Drawings):
 - 1. Windows shall enable inspection, IR scans, and digital photos while the equipment is in operation. Provide factory-installed at locations as shown on Drawings.
 - 2. Dual-View type combining a 15 inch by 3.254 inch IR window with a 15 inch by 2.25 inch visual inspection window.
 - 3. Material:
 - a. Viewing window: Impact resistant polycarbonate with peel away scratch protection.
 - b. IR optic window: Transmissive polymer.
 - c. Stainless steel panel, cover, and reinforcing plate, with stainless steel hardware.
 - d. Silicone and neoprene gaskets between cover and body for a NEMA 250, type 4X enclosure.
 - 4. UL listed.
 - 5. Manufacturer and product: Exiscan, XDP-SA-15KF, no substitutes.
- J. Infra-red Scan Windows (Small installed at the back of gear, as shown on Drawings):
 - 1. Windows shall enable IR scans while the equipment is in operation. Provide factory-installed at locations as shown on Drawings.
 - 2. 4 inch by 4 inch IR window aperture with a 6 inch by 6 inch body and cover.
 - 3. Material:
 - a. IR optic window: Transmissive polymer.

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- b. Stainless steel panel, cover, and reinforcing plate, with stainless steel hardware.
 - c. Silicone and neoprene gaskets between cover and body for a NEMA 250, type 4X enclosure.
 - 4. UL listed.
 - 5. Manufacturer and product: Exiscan, XIR-A4-H, no substitutes.
- K. Equipment Finish:
- 1. Electrocoating process applied over a rust-inhibiting phosphated base coating.
 - 2. Color:
 - a. Exterior: Manufacturer's standard ANSI 61 Gray.
 - b. Interior: Manufacturer's standard.

2.03 INCOMING LINE SECTION

- A. Provide for each secondary unit substation.
- B. Enclosure: IEEE C37.100 outdoor, rain tight, gasketed, nonwalk-in air insulated, steel, separated from transformer by steel barrier.
- C. Connection to Transformer: Tin-plated copper throughout entire length for rigid bus.
- D. Feeder Conductors: Incoming to enter enclosure from bottom.
- E. Surge Arrestors: Distribution type for grounded system, connected to incoming cable terminals.
- F. Air Terminal Section:
 - 1. Suitable for single radial or primary selective distribution system.
 - 2. Sufficient space and terminals for stress cones.
 - 3. Double through-feed lugs.
 - 4. Bolt-on end panel for compartment access.
 - 5. Rear access not permitted.
 - 6. Attached junction box with flange for close coupling to transformer.
- G. Two-Position Air Interrupter Switch:
 - 1. Switch shall be the open/close, three-pole, quick-make, quick-break, single-throw, stored energy, gang operated type, in accordance with ANSI/IEEE Standards for High-Voltage Switches and Switchgear Assemblies C37.20.3, C37.30, C37.32, and C37.34.
 - 2. Switch shall be the load break fused type, rated 15 kV, 600 amperes, 95 kV BIL.
 - 3. Switch shall have a momentary and fault close rating of 40,000 amperes rms asymmetrical.
 - 4. Switch speed shall be independent of the speed with which the operating handle is moved. "Teasing" of the switch poles is not permitted.
 - 5. Switch main and arcing contacts shall be designed for load interrupting and fault closing. The arcing contacts shall be spring loaded on-break and shall be last-in and last out. They shall operate in an arc chute designed to assist in interruption, and liberate no appreciable gases on interruption.
 - 6. Main blades shall be made of electrolytically pure cold-rolled copper. All contact points shall be silver plated on blades as well as hinge and jaw castings. These

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contacts each shall be one-piece castings to provide maximum heat dissipation and continuous current transfer.

7. Wet process porcelain insulators shall be used to insulate the hinge and jaw castings from the frame.
8. Interphase and barriers shall be NEMA Grade GPO-3 polyester glass.
9. Operating Handle: Externally mounted, non-removable, self-latching, operable from the front or side of the cubicle, and padlockable with multiple padlocks in either the CLOSE or OPEN position. "Telltale" indicators shall show switch position.
10. All components, except the operating handle system, shall be mounted in a jig-welded frames to form a rugged unitized assembly to ensure all parts function as required.
11. Protective, hinged screen barriers, retained with captive thumbscrews, shall be provided as stipulated in the applicable codes and standards.
12. Ventilation shall be provided to prevent condensation and equipment overheating.
13. Switch compartment door shall be mechanically interlocked with air interrupter switch to prevent closing the switch with the door open and opening the door with the switch closed.
14. Provide a separate fuse compartment within enclosure accessible through the hinged door and mechanically interlocked with the switch.
15. Provide a normally-OPEN and a normally-CLOSED auxiliary contact for remote monitoring of the switch position and wired to terminal blocks in the fuse compartment.
16. Ground Bus: Tin-plate copper, 1/4-inch by 2-inch (minimum).
17. Switch enclosure shall be the full height, freestanding type, with visual inspection window and flanges for close coupling to the transformer.
18. Manufacturer:
 - a. Eaton/Cutler-Hammer.
 - b. Or OWNER approved EQUAL.

H. Power Fuses:

1. Hook-stick operated, current limiting, single-pole, fused links; three-phase unit.
2. Manufacturer:
 - a. Eaton/Cutler-Hammer; Type CLE.
 - b. No like, equivalent, or "or equal" item is permitted.

2.04 TRANSFORMER SECTION

A. General:

1. Primary Windings: 12,470 volts, three-phase, three-wire, delta-connected.
2. Efficiency: Meet or exceed efficiency values stated in applicable NEMA TP 1 Table 4.1 for liquid filled transformers.
3. Guaranteed Minimum Efficiency: Manufacturer's standard.
4. Oil air transformers shall be rated for 15 percent continuous overload.
5. Primary Winding Taps:
 - a. Fully rated no-load taps.
 - b. Two 2-1/2 percent taps above rated voltage.
 - c. Two 2-1/2 percent taps below rated voltage.

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- d. Taps wired to externally operated no-load tap changer with provisions for locking handle in any position.
 - 6. Secondary Windings: 480Y/277 volts, three-phase, four-wire, wye-connected, solidly grounded with full capacity insulated neutral bushing.
 - 7. Impedance: 5.75 percent.
 - 8. Close-Coupling between Incoming and Outgoing Sections:
 - a. Full-height, high-voltage flange.
 - b. Full-height, low-voltage flange.
 - c. Primary Connections: Copper, rigid bus.
 - 9. Tank Grounding Pads: One primary and one secondary.
 - 10. Base: Suitable for jacking, rolling, or sliding transformer in any direction.
 - 11. Coolant: Normally formulated, hydro-refined oil, free from PCB chemicals.
 - 12. Liquid-Filled Transformer Instrumentation:
 - a. Alarm Contacts: 5 amperes, 120 volt, inductive, open to alarm.
 - b. Pressure relief device with alarm contacts.
 - c. Fault pressure relay.
 - d. Dial type liquid level gauge with adjustable alarm contact.
 - e. Dial type pressure/vacuum gauge.
 - f. Factory installed, calibrated, and preset top liquid three-phase winding temperature detector and dual type indicator with adjustable alarm contacts wired to cooling fan control panel.
 - 13. Cooling Fans (Transformers Larger than 500 kVA):
 - a. Voltage 120, single-phase from unit mounted control transformer.
 - b. Control system to include thermostat, AUTO/MANUAL switch, temperature indicator junction boxes, terminal blocks, current-limiting fuses or circuit breakers, factory-wired requiring no external connections.
 - c. Fans sized to increase nominal oil air (OA) transformer kVA rating by 15 to 25 percent on forced air (FA).
 - d. Fans located on top of radiators.
 - e. Control panel located in a control cabinet mounted on front exterior of transformer.
 - f. Indicating Lights: Green for POWER ON; amber for HIGH TEMPERATURE; amber for FAN ON.
 - g. Auxiliary alarm contact for remote control and temperature monitoring.
- B. Liquid Filled Transformer:
- 1. Dielectric Coolant: Normally formulated, hydro-refined inhibited mineral oil, meeting minimum requirements in Table 1 of ASTM D3487 and IEEE C57.106.
 - 2. Outdoor tank, with barrier between high and low voltage sections in accordance with IEEE C57.12.00.
 - 3. Self-Cooled:
 - a. KVA capacity 2,500/3,500 kVA OA/FA,, three-phase, 60-Hz.
 - b. Temperature rise by resistance not exceeding 55/65 degrees C, based on 30 degrees C average ambient over 24-hour period with 50 degrees C maximum.
 - 4. Designed to carry short-time emergency overloads in accordance with IEEE C57.12.90, as applicable.
 - 5. Primary Insulation Level: 95 kV BIL at 14.4 kV.
 - 6. Sound Rating (guaranteed):
 - a. 500 kVA OA: 56 db.

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- b. 2,000 kVA OA: 61 db.
- c. 2,000 kVA FA: 67 db.
- d. 2500 kVA OA: 62 db.
- e. 2500 kVA FA: 67 db.
- 7. Continuous barrel copper coil windings. Winding conductors impregnated with thermosetting varnish or epoxy insulation.
- 8. Three-legged core formed from non-aging laminated silicon steel.
- 9. Tubular radiator coolers, welded to tank wall.
- 10. Welded plate steel tank designated to withstand minimum of 8 psi pressure with drain valve and sampling device.

2.05 SECONDARY SWITCHGEAR SECTION

- A. Electrical Service: 480 volts, three-phase, three-wire, having an available short-circuit current at line terminals as shown on the Drawings.
- B. Comply with Section 26 23 00, Low Voltage Switchgear.
- C. Full height, flanged transition section with bus connection to transformer.

2.06 SECONDARY TERMINAL COMPARTMENT

- A. Terminal compartment incorporated into transformer section, but barriered from transformer.
- B. Silver- or tin-plated copper bus of sufficient size to limit temperature rise to 65 degrees F at rated load.
- C. Provide ground terminal in terminal compartment.
- D. Provide NEMA drilling for two-hole cable lugs where cable connection is shown.

2.07 FACTORY TESTING

- A. Incoming Line Section: Perform production tests on air interrupter switches in accordance with IEEE C37.20.3.
- B. Transformer Section: Perform production tests on liquid-filled in accordance with IEEE C57.12.00.
- C. Secondary Section: Perform production tests on switchgear in accordance with IEEE C37.20.1.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install equipment in accordance with manufacturer’s instructions and recommendations.
- B. Secure equipment to mounting pads with anchor bolts.

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- C. Install equipment plumb and in longitudinal alignment with pad or wall.
- D. Coordinate terminal connections with installation of secondary feeders.

3.02 FIELD QUALITY CONTROL

- A. In accordance with Section 26 08 00, Acceptance Testing.

3.03 MANUFACTURER’S SERVICES

- A. Furnish manufacturer’s representative in accordance with Section 01 63 00, General Equipment Stipulations, for the following services at Job Site or classroom as designated by OWNER, for minimum person-days listed below at all unit substations, travel time excluded:
 1. 5 person-days for installation assistance and inspection.
 2. 5 person-days for functional and performance testing.
 3. 1 person-day for pre-startup classroom or Job Site training.
 4. 3 person-days for plant startup.
 5. 1 person-day for post-startup training.
- B. Furnish startup services and training of OWNER’s personnel at such times as requested by OWNER.

END OF SECTION

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SECTION 26 12 00

MEDIUM VOLTAGE TRANSFORMERS

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PART 1 GENERAL

1.01 RELATED COCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following types of transformers with medium-voltage primaries:
 1. Dry-type distribution and power transformers.
 2. Pad-mounted, liquid-filled transformers.

1.03 DEFINITIONS

- A. NETA ATS: Acceptance Testing Specification.

1.04 SUBMITTALS

- A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.
- B. Shop Drawings: Diagram power signal and control wiring.
- C. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 1. Underground primary and secondary conduit stub-up location.
 2. Dimensioned concrete base, outline of transformer, and required clearances.
 3. Ground rod and grounding cable locations.
- D. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 16 Section "Electrical Supports and Seismic Restraints." Include the following:

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1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E. Qualification Data: For testing agency.
- F. Source quality-control test reports.
- G. Field quality-control test reports.
- H. Follow-up service reports.
- I. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

1.05 QUALITY CONTROL

- A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor : Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of transformers and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with IEEE C2.
- E. Comply with ANSI C57.12.10, ANSI C57 .12.28, IEEE C57.12.70, and IEEE C57.12.80.
- F. Comply with NFPA 70.

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1.06 DELIVERY, STORAGE, AND HANDLING

- A. Store transformers protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

1.07 PROJECT CONDITIONS

- A. Service Conditions: IEEE C37.121, usual service conditions except for the following:
 - 1. Exposure to significant solar radiation.
 - 2. Altitudes above 3300 feet (1000 m).
 - 3. Exposure to fumes, vapors, or dust.
 - 4. Exposure to explosive environments.
 - 5. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
 - 6. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
 - 7. Exposure to excessively high or low temperatures.
 - 8. Unusual transportation or storage conditions.
 - 9. Unusual grounding-resistance conditions.
 - 10. Unusual space limitations.

1.08 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
- B. Coordinate installation of louvers, doors, spill retention areas, and sumps. Coordinate installation so no piping or conduits are installed in space allocated for medium-voltage transformers except those directly associated with transformers.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Acme Electric Corporation; Power Distribution Products Division
 - 2. Cooper Industries; Cooper Power Systems Division
 - 3. Cutler-Hammer
 - 4. Federal Pacific Transformer Company; Division of Electro-Mechanical Corp.
 - 5. GE Electrical Distribution & Control
 - 6. Hammond Manufacturing; Transformer Group.
 - 7. Kuhlman Electric Corporation
 - 8. Pauwels Transformers
 - 9. Pioneer Transformers
 - 10. Siemens Energy & Automation, Inc.
 - 11. Square D; Schneider Electric
 - 12. Uptegraft, R. E. Mfg. Co.
 - 13. Virginia Transformer Corp.

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2.02 DRY-TYPE DISTRIBUTION AND POWER TRANSFORMERS

- A. Description: NEMA ST 20, IEEE C57.12.01, dry-type, 2-winding transformers.
 - 1. Indoor, ventilated, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 220 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.
- B. Primary Connection: Air terminal compartment with hinged door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.
- C. Primary Connection: Transition terminal compartment with connection pattern to match switchgear.
- D. Secondary Connection: Air terminal compartment with removable door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.
- E. Secondary Connection: Transition terminal compartment with connection pattern to match equipment indicated on the drawings.
- F. Insulation Materials: IEEE C57.12.01, rated at 220 deg C.
- G. Insulation Temperature Rise: 80 deg C, maximum rise above 40 deg C.
- H. Basic Impulse Level: 95 kV.
- I. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage.
- J. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps below rated primary voltage.
- K. Cooling System: Class AA/FA, self-cooled, and with forced-air-cooled rating complying with IEEE C57.12.01.
 - 1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.
 - 2. Include mounting provision for fans.
- L. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.
- M. Impedance: 5 - 75 percent.
- N. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

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2.03 PAD- MOUNTED, LIQUID-FILLED TRANSFORMERS

- A. Description: ANSI C57.12.13, IEEE C57.12.00, pad-mounted, 2-winding transformers. Stainless-steel tank base.
- B. Insulating Liquid: Mineral oil, complying with ASTM D 3487, Type II, and tested according to ASTM D 117.
- C. Insulating Liquid: Less flammable, edible-seed-oil based, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.
- D. Insulating Liquid: Less flammable, dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.
- E. Insulating Liquid: less flammable, silicone-based dielectric and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall have low toxicity and be nonhazardous.
- F. Insulation Temperature Rise: 55 deg C when operated at rated kVA output in a 40 deg C ambient temperature. Transformer shall be rated to operate at rated kilovolt ampere in an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C without loss of service life expectancy.
- G. Basic Impulse Level: 95 kV.
- H. Full-Capacity Voltage Taps: Four 2.5 percent taps, 2 above and 2 below rated high voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
- I. High-Voltage Switch: 200 A , make-and-latch rating of 10-kA RMS, symmetrical, arranged for radial feed with 3-phase, 2-position, gang-operated, load-break switch that is oil immersed in transformer tank with hook-stick operating handle in primary compartment.
- J. High-Voltage Switch: 200A, make-and-latch rating of 10-kA RMS, symmetrical, arranged for loop feed with 3-phase, 4-position, gang-operated, load-break switch that is oil immersed in transformer tank with hook-stick operating handle in primary compartment.
- K. Primary Fuses: 150-kV fuse assembly with fuses complying with IEEE C37.47. Rating of current-limiting fuses shall be 50-kA RMS at specified system voltage.
 - 1. Current-limiting type in dry-fuse holder wells, mechanically interlocked with liquid-immersed switch in transformer tank to prevent disconnect under load.
 - 2. Internal liquid-immersed cartridge fuses.
 - 3. Bay-0-Net liquid-immersed fuses that are externally replaceable without opening transformer tank.

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4. Bay-0-Net liquid-immersed fuses in series with liquid-immersed current-limiting fuses. Bay-0-Net fuses shall be externally replaceable without opening transformer tank.
 5. Bay-0-Net liquid-immersed current-limiting fuses that are externally replaceable without opening transformer tank.
- L. Surge Arresters: Distribution class, one for each primary phase; complying with IEEE C62.11 and NEMA LA 1; support from tank wall within high-voltage compartment. Transformers shall have three arresters for radial-feed or three arresters for loop-feed circuits.
- M. High-Voltage Terminations and Equipment: Live front with externally clamped porcelain bushings and cable connectors suitable for terminating primary cable.
- N. High-Voltage Terminations and Equipment: Dead front with universal-type bushing wells for dead-front bushing-well inserts, complying with IEEE 386 and including the following:
1. Bushing-Well Inserts: One for each high-voltage bushing well.
 2. Surge Arresters: Dead-front, elbow-type, metal-oxide-varistor units.
 3. Parking Stands: One for each high-voltage bushing well.
 4. Portable Insulated Bushings: Arranged for parking insulated, high-voltage, load-break cable terminators; one for each primary feeder conductor terminating at transformer.
- O. Accessories:
1. Drain Valve: 1 inch (25 mm), with sampling device.
 2. Dial-type thermometer.
 3. Liquid-level gage.
 4. Pressure-vacuum gage.
 5. Pressure Relief Device: Self-sealing with an indicator.
 6. Mounting provisions for low-voltage current transformers.
 7. Mounting provisions for low-voltage potential transformers.
 8. Busway terminal connection at low-voltage compartment.
 9. Alarm contacts for gages and thermometer listed above.

2.04 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 16 Section "Electrical Identification."

2.05 SOURCE QUALITY CONTROL

- A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to ANSI and IEEE.
- B. Factory Tests: Perform the following factory-certified tests on each transformer :
1. Resistance measurements of all windings on rated-voltage connection and on tap extreme connections.
 2. Ratios on rated-voltage connection and on tap extreme connections.

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3. Polarity and phase relation on rated-voltage connection.
4. No-load loss at rated voltage on rated-voltage connection.
5. Excitation current at rated voltage on rated-voltage connection.
6. Impedance and load loss at rated current on rated-voltage connection and on tap extreme connections.
7. Applied potential.
8. Induced potential.
9. Temperature Test: If transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class OA/FA or Class AA/FA rating.
 - a. Temperature test is not required if record of temperature test on an essentially duplicate unit is available.
10. Owner will witness all required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for medium-voltage transformers.
- B. Examine roughing-in of conduits and grounding systems to verify the following:
 1. Wiring entries comply with layout requirements.
 2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and that requirements in Division 16 Section "Grounding and Bonding" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install transformers on concrete bases.
 1. Anchor transformers to concrete bases according to manufacturer's written instructions and seismic codes at Project.
 2. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit and 4 inches (100 mm) high.
 3. Use 3000-psi (20.7-MPa) 28-day compressive-strength concrete and reinforcement as specified in Division 3 Section "Cast-in-Place Concrete".
 4. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.

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5. Install epoxy-coated anchor bolts, for supported equipment, that extend through concrete base and anchor into structural concrete floor.
 6. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 7. Tack-weld or bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.
- B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.03 IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs as specified in 26 05 53 "Electrical Identification."

3.04 CONNECTIONS

- A. Ground equipment according to 26 05 26 "Grounding and Bonding."
 B. Connect wiring according to 26 05 19 "Conductors and Cables."

3.05 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- C. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- D. Perform the following field tests and inspections and prepare test reports:
1. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.
 2. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.
 3. Perform visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Remove and replace malfunctioning units and retest as specified above.
- F. Test Reports: Prepare written reports to record the following:
1. Test procedures used.
 2. Test results that comply with requirements.

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3. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.

3.06 FOLLOW-UP SERVICE

- A. Voltage Monitoring and Adjusting: If requested by Owner, perform the following voltage monitoring after Substantial Completion but not more than six months after Final Acceptance:
 1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at secondary terminals of each transformer. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
 2. Corrective Actions: If test results are unacceptable, perform the following corrective actions, as appropriate:
 - a. Adjust transformer taps.
 - b. Prepare written request for voltage adjustment by electric utility.
 3. Retests: After corrective actions have been performed, repeat monitoring until satisfactory results are obtained.
 4. Report: Prepare written report covering monitoring and corrective actions performed.

- B. Infrared Scanning: Perform as specified in 26 13 00 "Medium-Voltage Switchgear."

END OF SECTION

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SECTION 26 13 00

MEDIUM VOLTAGE SWITCHGEAR

[CLICK HERE TO ENTER PROJECT NAME](#)

CCWRD PROJECT NO. [CLICK HERE TO ENTER CCWRD PROJECT NO.](#)

PART 1 GENERAL

1.01 RELATED COCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section

1.02 SUMMARY

- A. This Section includes metal-enclosed interrupter switchgear and metal-clad, circuit-breaker switchgear with the following optional components, features, and accessories:
 - 1. Copper, tin-plated main bus.
 - 2. Communication modules.
 - 3. Surge arresters.
 - 4. Provisions for future devices.
 - 5. Control battery system.
- B. Section is applicable to large pump stations only.

1.03 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
- B. GFCI: Ground-Fault Circuit Interrupter.

1.04 SUBMITTALS

- A. Product Data: For each type of switchgear and related equipment, include the following:
 - 1. Rated capacities, operating characteristics, furnished specialties, and accessories for individual interrupter switches and circuit breakers.
 - 2. Time-current characteristic curves for overcurrent protective devices, including circuit-breaker relay trip devices and fusible devices.

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- B. Shop Drawings: For each type of switchgear and related equipment, include the following:
 - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show method of field assembly and location and size of each field connection. Include the following:
 - a. Tabulation of installed devices with features and ratings.
 - b. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
 - c. Drawing of cable termination compartments showing preferred locations for conduits and indicating space available for cable terminations.
 - d. Floor plan drawing showing locations for anchor bolts.
 - e. Current ratings of buses.
 - f. Short-time and short-circuit ratings of switchgear assembly.
 - g. Nameplate legends.
 - h. Utility company's metering provisions with indication of approval by utility company.
 - 2. Wiring Diagrams: For each type of switchgear and related equipment, include the following:
 - a. Power, signal, and control wiring.
 - b. Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.
 - c. Schematic control diagrams.

- C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where piping and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Identify field measurements.

- D. Qualification Data: For testing agency.

- E. Field quality-control test reports.

- F. Operation and Maintenance Data: For switchgear and switchgear components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 include the following:
 - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - 2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.05 QUALITY CONTROL

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction .

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1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Source Limitations: Obtain each type of switchgear and associated components through one source from a single manufacturer.
- C. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with IEEE C2.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver in sections of lengths that can be moved past obstructions in delivery path as indicated.
- B. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- C. If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

1.07 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:
 1. Ambient temperature not exceeding 140 deg F (60 deg C).
 2. Altitude of 2500 feet above sea level.
- B. Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.08 COORDINATION

- A. Coordinate layout and installation of switchgear and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.

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- B. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.09 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: Six of each type and rating used. Include spares for future transformers, control power circuits, and fusible devices.
 - 2. Indicating Lights: Six of each type installed.
- B. Maintenance Tools: Furnish tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include the following:
 - 1. Fuse-handling tool.
 - 2. Extension rails, lifting device, transport or dockable dolly or mobile lift, and all other items necessary to remove circuit breaker from housing and transport to remote location.
 - 3. Racking handle to move circuit breaker manually between connected and disconnected positions, and a secondary test coupler to permit testing of circuit breaker without removal from switchgear.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 MANUFACTURED UNITS

- A. Description: Factory assembled and tested, and complying with IEEE C37.20.1.
- B. Ratings: Suitable for application in 3-phase, 60-Hz, solidly grounded-neutral system.
- C. System Voltage: 12.47 kV nominal; 15 kV maximum

2.03 METAL-ENCLOSED INTERRUPTER SWITCHGEAR

- A. Manufacturers:
 - 1. Eaton Corporation; Cutler-Hammer Products
 - 2. S&C Electric Company
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D/Groupe Schneider NA
- B. Comply with IEEE C37.20.3.

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- C. Comply with IEEE C37.20 .7. Provide arc-resistant switchgear.
- D. Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with value of fault current indicated.
- E. Ratings: Comply with standard ratings designated in IEEE C37.20.3 for maximum-rated voltage specified.
 - 1. Main-Bus Rating: Continuous rating as indicated on the drawings.
- F. Interrupter Switches: Stationary, gang operated and suitable for application at maximum short-circuit rating of integrated switchgear assembly.
 - 1. Rating: A continuous duty and load break rating as indicated on the drawings.
 - 2. Duty-Cycle, Fault Closing: 40,000 asymmetrical A.
 - 3. Switch Action: No external arc and no significant quantities of ionized gas released into the enclosure.
 - 4. Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.
 - 5. Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.
 - 6. Protective Shields: Cover live components and terminals.
 - 7. Fuses: De-energized if switch is open.
- G. Mechanical Interlock: Prevent opening switch compartment door unless switchblades are open, and prevent closing switch if door is open.
- H. Window: Permit viewing switchblade positions if door is closed.
- I. Power Fuses: Comply with the following and with applicable requirements in NEMA SG 2.
 - 1. Indicator: Integral with each fuse to indicate when it has blown.
 - 2. Mounting: Positively held in position with provision for easy removal and replacement from front without special tools.
 - 3. Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.
 - 4. Expulsion Fuses: Furnished in disconnect-type mountings and renewable with replacement fuse units. Gases emitted on interruption are controlled and silenced by chambers designed for that purpose.

2.04 FABRICATION

- A. Indoor Enclosure: Steel.
- B. Outdoor Enclosure: Galvanized steel, weatherproof construction; integral structural-steel base frame with factory-applied asphaltic undercoating.
 - 1. Each compartment shall have the following features:
 - a. Structural design and anchorage adequate to resist loads imposed by 125-mph (200-km/h wind).

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- b. Louvers equipped with insect and rodent screen and filter, and arranged to permit air circulation while excluding rodents and exterior dust.
 - c. Hinged front door with locking provisions.
 - d. Interior light with switch.
 - e. Weatherproof GFCI duplex receptacle.
 - f. Power for lights, and receptacles to be provided by control power transformer.
- C. Finish: Manufacturer's standard gray finish over rust-inhibiting primer on phosphatizing- treated metal surfaces.
- D. Bus Transition Unit: Arranged to suit bus and adjacent units.
- E. Incoming-Line Unit: Arranged to suit incoming line.
- F. Outgoing Feeder Units: Arranged to suit distribution feeders.
- G. Auxiliary Compartments: Arranged to suit house meters, relays, controls, and auxiliary equipment; isolated from medium-voltage components.
- H. Key Interlocks: Arranged to effect interlocking schemes indicated.
- I. Provisions for Future Key Interlocks: Mountings and hardware required for future installation of locks, where indicated.

2.05 COMPONENTS

- A. Main Bus: Copper, silver plated at connection points; full length of switchgear.
- B. Ground Bus: Copper, silver plated or copper, tin plated; minimum size 1/4 by 2 inches (6 by 50 mm); full length of switchgear.
- C. Bus Insulation: Covered with flame-retardant insulation.
- D. Instrument Transformers: Comply with IEEE C57.13.
- 1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
 - 2. Current Transformers Burden and accuracy class suitable for connected relays, meters, and instruments.
- E. Multifunction Digital-Metering Monitor: Provide per 26 09 13 and with the following features:
- 1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
 - 2. Switch-selectable digital display with the following features :
 - a. Phase Currents, Each Phase: Plus or minus 1 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d. Three-Phase Real Power: Plus or minus 2 percent.
 - e. Three-Phase Reactive Power: Plus or minus 2 percent.

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- f. Power Factor: Plus or minus 2 percent.
 - g. Frequency: Plus or minus 0.5 percent.
 - h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
 - i. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
3. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements according to Division 16 Section "Electrical Power Monitoring and Control."
 4. Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.
- F. Surge Arresters: Distribution class. Comply with NEMA LA 1. Provide per Section 16289.
1. Install in cable termination compartments in each phase of circuit.
 2. Coordinate rating with circuit voltage.
- G. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.
- H. Control Power Supply: Control power transformer supplies 120-V control circuits through secondary disconnect devices. Include the following features:
1. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
 2. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.
 - a. Secondary windings connected through relay(s) to control bus to affect an automatic transfer scheme.
 - b. Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.
 3. Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.
- I. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:
1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.
 2. Conductors sized according to NFPA 70 for duty required.
- J. Infra-red Scan Windows (Large installed on the front of gear, as shown on Drawings):
1. Windows shall enable inspection, IR scans, and digital photos while the equipment is in operation. Provide factory-installed at locations as shown on Drawings.

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2. Dual-View type combining a 15 inch by 3.254 inch IR window with a 15 inch by 2.25 inch visual inspection window.
3. Material:
 - a. Viewing window: Impact resistant polycarbonate with peel away scratch protection.
 - b. IR optic window: Transmissive polymer.
 - c. Stainless steel panel, cover, and reinforcing plate, with stainless steel hardware.
 - d. Silicone and neoprene gaskets between cover and body for a NEMA 250, type 4X enclosure.
4. UL listed.
5. Manufacturer and product: Exiscan, XDP-SA-15KF, no substitutes.

K. Infra-red Scan Windows (Small installed at the back of gear, as shown on Drawings):

1. Windows shall enable IR scans while the equipment is in operation. Provide factory-installed at locations as shown on Drawings.
2. 4 inch by 4 inch IR window aperture with a 6 inch by 6 inch body and cover.
3. Material:
 - a. IR optic window: Transmissive polymer.
 - b. Stainless steel panel, cover, and reinforcing plate, with stainless steel hardware.
 - c. Silicone and neoprene gaskets between cover and body for a NEMA 250, type 4X enclosure.
4. UL listed.
5. Manufacturer and product: Exiscan, XIR-A4-H, no substitutes.

2.06 IDENTIFICATION

- A. Materials: Refer to 26 05 53 "Electrical Identification." Identify units, devices, controls, and wiring.

2.07 SOURCE QUALITY CONTROL

- A. Before shipment of equipment, perform the following tests and prepare test reports:
1. Production tests on circuit breakers according to ANSI C37.09.
 2. Production tests on completed switchgear assembly according to IEEE C37.20.2.
- B. Assemble switchgear and equipment in manufacturer's plant and perform the following :
1. Functional tests of all relays, instruments, meters, and control devices by application of secondary three-phase voltage to voltage circuits and injection of current in current transformer secondary circuits.
- K. Prepare equipment for shipment.
1. Provide suitable crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.

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2. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.

2.08 FACTORY FINISHES

- A. Finish: Manufacturer's standard color finish applied to equipment before shipping.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine elements and surfaces to receive switchgear for compliance with requirements for installation tolerances, required clearances, and other conditions affecting performance.
 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Anchor switchgear assembly to 4-inch (100-mm), channel-iron sill embedded in concrete base and attach by bolting.
 1. Sills: Select to suit switchgear; level and grout flush into concrete base.
 2. Design each fastener and support to carry load.
 3. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no less than 3 inches (75 mm) in all directions beyond the maximum dimensions of switchgear, unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Division 3.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchgear units and components.

3.03 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification."
- B. Diagram and Instructions:
 1. Frame under clear acrylic plastic on front of switchgear.
 - a. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
 - b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.
- C. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

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3.04 CONNECTIONS

- A. Cable terminations at switchgear are specified in Division 16 Section "Medium-Voltage Cables."
- B. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values.
- C. Ground equipment according to 26 05 26 "Grounding and Bonding."
- D. Connect wiring according to 26 05 19 "Conductors and Cables" and 26 05 13 "Medium-Voltage Cables."

3.05 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform the following field tests and inspections and prepare test reports.
 - 1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:
 - 2. Switchgear.
 - 3. Circuit breakers.
 - 4. Protective relays.
 - 5. Instrument transformers.
 - 6. Metering and instrumentation.
 - 7. Ground-fault systems.
 - 8. Battery systems.
 - 9. Surge arresters.
 - 10. Capacitors.
- B. Remove and replace malfunctioning units and retest as specified above.
- C. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
 - 2. Instrument: Use an infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes infrared-scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action. A copy of the report shall be delivered directly to facility division.
 - 4. Schedule testing with Owner with at least seven days advance notice.

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3.06 ADJUSTING

- A. Set field-adjustable, protective-relay trip characteristics according to results in the coordination study.

3.07 CLEANING

- A. On completion of installation, inspect interior and exterior of switchgear. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair damaged finishes.

3.08 PROTECTION

- A. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

3.09 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear.
- B. Train Owner's maintenance personnel on procedures and schedules for energizing and de-energize, troubleshooting, servicing, and maintaining equipment and schedules.
- C. Review data in maintenance manuals.
- D. Schedule training with Owner with at least seven days advance notice.

END OF SECTION

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SECTION 26 21 16

SERVICE ENTRANCE

[CLICK HERE TO ENTER PROJECT NAME](#)

CCWRD PROJECT NO. [CLICK HERE TO ENTER CCWRD PROJECT NO.](#)

PART 1 GENERAL

1.01 RELATED COCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 WORK INCLUDED

- A. Coordinate with Utility Company to arrange for permanent electric service.
- B. Underground service entrance.

1.03 SYSTEM DESCRIPTION

- A. System Voltage: See contract documents.

1.04 QUALITY CONTROL

- A. Utility Company: Nevada Power Company, Colorado River Commission, or as required per location.
- B. Install service entrance in accordance with Utility Company's rules, regulations, and standards.

1.05 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 01 30 00.

PART 2 PRODUCTS

2.01 EQUIPMENT

- A. Pull section for Metering Equipment: As required by Utility Service Guide.
- B. Concrete Pad for Utility Equipment: As required by Utility Service Guide.

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PART 3 EXECUTION

3.01 INSTALLATION

- A. Make arrangements with Utility Company to obtain permanent electric service to the Project.
- B. Underground: Install conduits in accordance with the Utility Service Guide.

END OF SECTION

SECTION 26 22 00

LOW VOLTAGE TRANSFORMER

[CLICK HERE TO ENTER PROJECT NAME](#)

CCWRD PROJECT NO. [CLICK HERE TO ENTER CCWRD PROJECT NO.](#)

PART 1 GENERAL

1.01 RELATED COCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
 - B. Distribution transformers.

1.03 SUBMITTALS

- A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- C. Wiring Diagrams: Power, signal, and control wiring.
- D. Source quality-control test reports.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.04 QUALITY CONTROL

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing

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laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

- B. Testing Agency's Field Supervisor : Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- C. Source Limitations: Obtain each transformer type through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with IEEE C57.12 .91, "Test Code for Dry-Type Distribution and Power Transformers."

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.06 COORDINATION

- A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
- B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.
- C. Coordinate mounting location with transfer switches as required.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Products
 2. General Electric Company
 3. Hammond Co.; Matra Electric, Inc.
 4. Siemens Energy & Automation, Inc.
 5. Square D; Schneider Electric

2.02 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

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- B. Cores: Grain-oriented, non-aging silicon steel.
- C. Coils: Continuous windings without splices except for taps.
 - 1. Internal Coil Connections: Brazed or pressure type.
 - 2. Coil Material: Copper.

END OF SECTION

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SECTION 26 23 00

LOW-VOLTAGE SWITCHGEAR

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PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American National Standards Institute (ANSI): C37.50, Switchgear—Low-Voltage AC Power Circuit Breakers Used in Enclosures—Test Procedures.
 2. Institute of Electrical and Electronics Engineers (IEEE):
 - a. C37.13, Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.
 - b. C37.16, Standard for Preferred Ratings, Related Requirements, and Application Recommendation for Low-Voltage AC (635V and below) and DC (3200V and below) Power Circuit Breakers.
 - c. C37.20.1, Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.
 - d. C37.20.3, Standard for Metal Enclosed Interrupter Switchgear.
 - e. C37.100, Standard Definitions for Power Switchgear.
 3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 5. Underwriters Laboratories, Inc. (UL):
 - a. 489, Standard for Safety for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
 - b. 1558, Standard for Safety for Metal-Enclosed, Low-Voltage Power Circuit Breaker Switchgear.

1.02 SUBMITTALS

- A. Action Submittals:
1. Descriptive product information.
 2. Itemized Bill of Material.
 3. Dimensional drawings.
 4. Operational description.
 5. Anchoring instructions and details.
 6. One-line, three-line, and control schematic drawings.
 7. Connection and interconnection drawings.
 8. Circuit Breakers: Copies of time-current characteristics.
 9. Ground Fault Protection: time-current characteristics.
 10. Bus data.

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11. Incoming line section equipment data.
12. Transformer section equipment data.
13. Conduit entrance locations.
14. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 81 02, Seismic Design Criteria.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 81 02, Seismic Design Criteria.
2. Manufacturer's installation instructions.
3. Certified Factory Test Report.
4. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
5. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 75 05, Testing, Training, and Startup.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

1.04 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts:

1. Power and Control Fuses: One complete set.
2. Indicating Lights: One complete set.
3. Paint: One pint, to match enclosure exterior finish in color and quality.
4. Indicating Lamp Pullers: Two each.
5. Indicating Lamp Resistors and Sockets: Two each.
6. Drawout breaker test kit.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Eaton Cutler Hammer.
2. Or OWNER approved EQUAL.

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2.02 GENERAL REQUIREMENTS

- A. Service: 480 volts, three-phase, three-wire solid, grounded wye, having an available short circuit current at line terminals as shown on Drawings.
- B. Designed and assembled in accordance with IEEE C37.20.3, IEEE C37.100, ANSI C37.50, and UL 1558.
- C. Switchgear and its major components shall be end products of one manufacturer in order to achieve standardization for appearance, operation and maintenance, spare parts replacement, and manufacturer's services.
- D. Operating Conditions:
 - 1. Ambient Temperature: As per Section 26 05 00, Common Work Results for Electrical.
 - 2. Equipment shall be fully rated without derating for operating conditions.
- E. Lifting lugs on equipment and devices weighing over 100 pounds.
- F. Anchor Bolts: Galvanized, seismically by a licensed structural ENGINEER registered in the State where equipment is to reside, and in accordance with Section 01 63 00, General Equipment Stipulations.

2.03 STATIONARY STRUCTURE

- A. Type: ANSI C37.50 switchgear construction, consisting of metering, breaker, transition, and auxiliary sections assembled to form a rigid, self-supporting, metal enclosed structure.
- B. Material: 11-gauge minimum cold-rolled steel, formed with reinforced steel members.
- C. Grounded metal barriers between each breaker, main bus, branch cabling, and instrumentation/control.
- D. Modular-designed steel frame with removable plates and individual, bolted, steel-framed vertical sections.
- E. Individual, hinged doors over each breaker, metering, and auxiliary compartments.
- F. Cable Installation and Termination Compartments:
 - 1. Rear hinged doors, capable of being bolted closed.
 - 2. Cable bending space in accordance with NFPA 70.
 - 3. **Cable supports in each vertical section.**
- G. Breaker Compartments:
 - 1. Individual, grounded compartments, with:
 - a. Sheet steel, top, bottom, sides, and nonventilated compartment door with padlocking features.

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- b. Flame-retardant, arc track-resistant nonmetallic rear barrier.
 - c. Drawout rails, stationary breaker contacts, interlocks, and necessary control and indicating devices.
 - d. Shutters over stationary contacts when breaker is in TEST or DISCONNECT position.
 - e. Padlocking provision on rackout rails for locking breaker in TEST or DISCONNECT position.
2. Drawout Mechanism:
 - a. Shall retain removable element in connected position.
 - b. Mechanical interlocks to ensure breaker is open before moved from a position, or when between positions.
 - c. Four Distinct Breaker Positions: CONNECTED, TEST, DISCONNECTED, and WITHDRAW.
 - d. Indicators to display breaker position.
 - e. Capable of being operated without opening breaker door.
 3. Breaker frame grounded to steel frame throughout travel of drawout mechanism.
 4. Each compartment designed for specific breaker frame size.
 5. Future breaker compartments fully equipped with electrical connections, bolted metal barrier across compartment face, and compartment door.
- H. Slide-Out Instrument Tray:
1. Mount above associated breaker.
 2. Accessible from front of switchgear.
 3. For control circuitry, breaker close and trip fuses, indicating lights.
- I. Auxiliary sections equipped with devices shown on Drawings, with hinged door over each compartment.

2.04 ENCLOSURE

- A. Finish: Baked enamel applied over rust-inhibiting phosphated base coating.
1. Color:
 - a. Exterior: Provide ANSI 61 Gray finish.
 - b. Interior: White.
 - c. Unpainted Parts: Plated for corrosion resistance.
- B. Indoor Enclosure:
1. NEMA 250, Type 1, with formed edges on hinged and nonhinged panels.
 2. Rear, full-height, bolt-on panels for each enclosure section.
 3. Cable Termination Access: Padlock provision.
- C. Walk-in Outdoor Enclosure:
1. NEMA 250, Type 3R, enclosing NEMA 250, Type 1 enclosed switchgear.
 2. Hinged, full-height doors with three-point latch operated by vault type handle with multiple padlocking provisions for each rear switchgear section.
 3. Minimum 42-inch-wide aisle in front of switchgear.
 4. Access Door: With panic hardware at each end of aisle.
 5. Latch Mechanism: Inside quick-release, to allow opening of door from inside even when locked on outside.

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6. Gasketed doors, rear panels, end panels, and sloped roof having 4-inch minimum overhang on all sides.
7. Support assembly on 4-inch modular base.
8. Steel bottom enclosure and support assembly undercoated with coal tar emulsion.
9. Ventilating louvers with filters in rear panels and at end of each aisle.
10. Lighting: LED, 30-foot-candle minimum aisle lights, three-way light switches and minimum of two convenience receptacles in aisle.
11. Receptacles: Grounding type, 120 volts, 20 amperes, at each end of aisle.
12. Space Heaters: Thermostatically controlled, in each switchgear vertical section.
13. Adjustable thermostat for temperature range of 50 degrees F to 70 degrees F.

D. Enclosure Transformer and Panelboard:

1. Transformer, primary and secondary main circuit breakers, and secondary panelboard section enclosed in a NEMA 250, Type 1 enclosure.
2. Transformer and Panel Location: In auxiliary section.
3. Self-Cooled, Encapsulated, Dry Type Transformer:
 - a. Manufacturer's standard insulation and temperature rise, in accordance with UL 1561.
 - b. Full-capacity, 2-1/2 percent voltage taps, two above and two below normal voltage.
 - c. Primary Voltage: 480 single-phase with current limiting fuses in primary circuit.
 - d. Secondary Voltage: 240/120-volt, single-phase, three-wire.
 - e. kVA Rating: As required.
 - f. Primary circuit extended from breaker installed in switchgear.
4. Panelboard:
 - a. Full, short-circuit current rated, in accordance with UL 489.
 - b. Thermal magnetic, quick-make, quick-break, indicating type, non-interchangeable, molded case circuit breaker.
 - c. Number and breaker ampere ratings as required.

2.05 BUSWORK

- A. Material: Phase isolated and insulated silver-plated copper throughout entire length of sufficient cross section to limit temperature rise at rated current to 65 degrees C at 50 degrees C ambient.
- B. Bus Arrangement: A-B-C, left-to-right, top-to-bottom, and front-to-rear, as viewed from front.
- C. Brace for short circuit currents 100,000 amperes rms symmetrical.
- D. Main Horizontal Bus: Nontapered, continuous current rating as shown.
- E. Ground Bus:
 1. Material: Copper.
 2. Rating: 1,600 amperes.

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3. Bolted to each vertical section.
 4. Ground lug for 4/0 copper conductor on each end of bus.
 5. Bus Connections and Joints: Bolted.
- F. Extend each bus entire length of switchgear.

2.06 PROTECTIVE DEVICES

- A. Power Air Circuit Breakers:
1. Main, Tie, and feeder breakers in accordance with IEEE C37.13 and IEEE C37.16.
 2. Arrangement: Fully rated main and branch feeder circuit breakers as shown.
 3. Three-pole electrically and mechanically trip-free with:
 - a. Self-aligning primary and secondary contacts.
 - b. Integral, solid state, over-current trip programmer.
 - c. Arc quenchers.
 - d. Closing Mechanism: Electric for main and tie breakers, manual for feeder breakers.
 - e. Stored energy mechanism with maximum five-cycle closing.
 - f. Solid state trip device.
 4. Individually mounted, drawout breaker listed for 100 percent continuous ampere rating.
 5. Frame Size: As shown on Drawings.
 6. Interrupting Rating: 65,000 amperes rms symmetrical at 480 volts.
- B. Mechanical Operation (feeder breakers):
1. Front mounted, spring charging handle.
 2. Mechanical closing **breaker handle, with breaker control switch.**
 3. Mechanical trip, escutcheon mounted, trip pushbutton handle.
- C. Electrical Operation (main and tie breakers):
1. Motor or solenoid automatic charging, plus manual charging.
 2. Electrically closing, escutcheon mounted pushbutton with mechanical closing upon loss of control power.
 3. Electrical trip, escutcheon mounted, trip pushbutton.
 4. Control Power Voltage: Manufacturer's standard.
- D. Incorporate the following automatic operation of main and tie breakers:
1. Interlocking:
 - a. In Manual and Automatic modes:
 - 1) Main and tie breakers shall include electrical and logical circuit breaker interlocking to prevent all three breakers from being closed or remaining closed simultaneously. Paralleling is not permitted.
 - 2) If two of the three Main-Tie-Main circuit breakers are closed, the third circuit breaker shall be prevented from being closed.
 - 3) If all three of the Main-Tie-Main circuit breakers are closed, the tie circuit breaker shall be opened automatically via the PLC.

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- b. Manual operation of main and tie breakers is performed using operator interface.
 - 2. Lock-Out:
 - a. Overcurrent trip switch on main and tie breakers are incorporated such that there shall be no closure of a breaker on a fault. This scheme shall not be defeatable. Trip unit and the trip switch must be reset to resume automatic operation.
 - 3. Initial Start-up:
 - a. Place the breaker in Manual operation mode.
 - b. Verify all transfer related breakers are in the fully connected positions.
 - c. Close main breakers.
 - d. Open tie breaker.
 - e. Then place breakers in Automatic operation mode.
 - 4. Automatic operational sequence shall be as follows:
 - a. Upon loss of utility power at any one main breaker, loss of normal voltage is detected, and after an adjustable time delay (0-60 seconds), main breaker opens. Tie breaker closes.
 - b. Upon loss of utility power at both main breakers, no action is taken.
 - c. Upon return of utility power to any one main breaker opened in 'a' above, normal voltage is detected, and tie breaker opened after an adjustable time delay (0-60 seconds). The main breaker is then closed after an adjustable time delay (0-10 seconds).
 - d. This mode shall be disabled when less than two circuit breakers are in the closed position simultaneously for more than 12 seconds.
- E. Color-Coded Visual Indicators: Contacts OPEN and CLOSED, plus mechanism CHARGED and DISCHARGED.
- F. Accessories:
 - 1. Slow breaker closing handle for contact adjustments.
 - 2. Breaker lifting hoist and travel rail on top of switchgear.
 - 3. Auxiliary a/b contacts on main and tiebreakers.
- G. Test Facilities:
 - 1. Breakers with integral external test points for portable test kit.
 - 2. Handheld test kit for functional testing of trip circuitry of each breaker.
- H. Solid State Trip Units: Flux-shift trip and current sensors.
 - 1. Protective Programmers:
 - a. Self-powered, automatic rms sensing micro-electronic processor.
 - b. No external relays or accessories.
 - c. Printed circuit cards with gold-plated contacts.
 - d. Programmable Controls:
 - 1) Fixed-point, with repetitive accuracy and precise unit settings.
 - 2) Trip adjustments made by nonremovable, discrete step switching.
 - e. Field-Installable Rating Plugs:
 - 1) Long-time pickup LED indicator and test receptacle.
 - 2) Matching load and cable requirements.

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- 3) Interlocked with tripping mechanism.
- 4) Breaker to remain trip-free with plug removed.
- 5) Keyed rating plugs to prevent incorrect application.
- f. Long-time pickup light.
- g. Selective coordination time/current curve shaping adjustable functions:
 - 1) Current setting.
 - 2) Long-time pickup.
 - 3) Long-time delay.
 - 4) Instantaneous pickup.
 - 5) Short-time pickup.
 - 6) Short-time delay.
 - 7) Ground fault pickup.
 - 8) Ground fault delay with I2T function.
- h. Fault Trip Indicators: Mechanical push-to-reset type for overload and short circuit overload plus ground fault trip.
- i. Rejection Pins: For each programmer frame size.
- 2. Phase Current Sensors:
 - a. Single-ratio type.
 - b. Fixed, mounted on breaker frame.
 - c. Molded epoxy construction.
 - d. One toroidal type for each phase.
- 3. Ground Fault Sensor:
 - a. Neutral bar single-ratio CT mounted in cable compartment.
 - b. Molded epoxy construction.
 - c. Shorting bar.

2.07 CONTROL WIRING

- A. NFPA 70, Type SIS, single-conductor, Class B, stranded copper, rated 600 volts for control, instrumentation, and power/current circuits.
- B. Shielded cable rated 600 volts for transducer output and analog circuits.
- C. Enclosed in top and vertical steel wiring troughs, and front-to-rear in nonmetallic wiring troughs.
- D. Conductor Lugs: Preinsulated, self-locking, spade type, with reinforced sleeves.
- E. Identification: Individually, with permanent wire markers at each end.
- F. Splices: Not permitted in switchgear wiring.

2.08 ACCESSORIES

- A. Uninterruptible Power Supply: Size as needed for 30 minutes of uninterrupted switchgear control component operation.
- B. Programmable Logic Controller (PLC) with Operator Interface Terminal (OIT) for fail-safe Main-Tie-Main anti-parallel interlocking and automatic transfer of line

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source(s) via Main-Tie-Main breaker operation as described in Paragraph 2.6 Protective Devices, above. PLC shall be Eaton Logic Controller (ELC) modular PLC, or equal; OIT shall be Eaton XV Operator Interface, or equal.

- C. Ethernet Switch: 6 port switch for connection of PLC and Serial to Ethernet Converter to OWNER's radio as shown on Drawings. Switch shall be CISCO Model IE-3000-8TC, or equal.
- D. Infra-red Scan Windows:
 - 1. Windows shall enable IR scans while the equipment is in operation. Provide factory-installed at locations as shown on Drawings.
 - 2. As per Section 26 11 16, Secondary Unit Substations.

2.09 TERMINAL BLOCKS

- A. Enclosed in steel wiring troughs.
- B. Rated 600 volts, 30 amperes minimum, one-piece barrier type with strap screws.
- C. Shorting type for current transformer leads.
- D. Provide terminal blocks for:
 - 1. Conductors connecting to circuits external to switchgear.
 - 2. Internal circuits crossing shipping splits.
 - 3. Equipment parts requiring replacement and maintenance.
- E. Spare Terminals: Not less than 20 percent.
- F. Group terminal blocks for external circuit wiring leads.
- G. Maintain 6-inch minimum space between columns of terminal blocks.
- H. Identification: Permanent, for each terminal and columns of terminals blocks.
- I. Manufacturer and Product: Manufacturer's standard.

2.10 TEST FACILITIES

- A. Breakers with integral external test points for portable test kit.
- B. Handheld test kit for functional testing of trip circuitry of each breaker.

2.11 ELECTRICAL POWER MONITORING

- A. Electrical Power Monitors (EPM): In accordance with Section 26 09 13, Electrical Power Monitoring.
- B. Serial to Ethernet Converter: In accordance with Section 26 09 13 – Electrical Power Monitoring.

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- C. Control Power Transformers (CPT): In accordance with Section 26 09 13 – Electrical Power Monitoring.
- D. Potential Transformers (PT): In accordance with Section 26 09 13 – Electrical Power Monitoring.
- E. Current Transformers (CT): In accordance with Section 26 09 13 – Electrical Power Monitoring.
- F. Power Supply: Provide 24 VDC power supplies and redundancy modules for radio as Shown.

2.12 EQUIPMENT IDENTIFICATION

- A. Master Nameplate:
 - 1. Deep-etched aluminum with manufacturer’s name and model number.
 - 2. Riveted to main vertical section.
- B. Section Identification:
 - 1. Photo etched metallic, riveted to each vertical section.
 - 2. Serial number, bus rating, and section reference number.
 - 3. Size: Manufacturer’s standard.
- C. Nameplate:
 - 1. Engraved, acrylic for each circuit breaker cubicle and door-mounted device.
 - 2. White with black block type characters.
 - 3. Character Height: 3/16-inch.
 - 4. Size: Manufacturer’s standard.
 - 5. Inscriptions: As shown on one-line diagram.
 - 6. Blank plates for future spaces.
 - 7. Attachment Screws: Stainless steel panhead.
- D. Cubicle Labels:
 - 1. Nonmetallic, applied inside each cubicle compartment.
 - 2. Device serial number, rating, and description.
 - 3. Size: As required.
- E. Metering Instruments: Meter type identified on meter face below pointer or dial.
- F. Control Switches: Deep-etched, aluminum escutcheon plate.
- G. Relays and Devices:
 - 1. Stamped metallic, riveted to instrument case.
 - 2. Manufacturer’s name, model number, relay type, and rating data.
- H. Switchgear Signs:
 - 1. Two signs each on front and back of switchgear.
 - 2. Size: Manufacturer’s standard.
 - 3. Engraved, acrylic.

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- 4. Color: Red with white.
- 5. Inscription: DANGER/HIGH VOLTAGE/KEEP OUT.
- 6. Characters: Gothic type 1 inch high.
- 7. Attachment: Four rivets each sign.

I. None – PLC controlled electronic transfer of power.

2.13 FACTORY TESTING

A. In accordance with IEEE C37.20.1.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install equipment in accordance with manufacturer’s instructions and recommendations.
- B. Secure equipment to mounting pads with anchor bolts.
- C. Install equipment plumb and in longitudinal alignment with pad or wall.
- D. Coordinate terminal connections with installation of secondary feeders.

3.02 MANUFACTURER’S SERVICES

- A. Furnish manufacturer’s representative in accordance with Section 01 75 05, Training, Testing, and Startup for the following services at Site or classroom as designated by OWNER, for minimum person-days as listed in Section 26 11 16, Secondary Unit Substation.
- B. Furnish startup services and training of OWNER’s personnel at such times as requested by OWNER.
- C. Provide Manufacturer’s Certificate of Proper Installation in accordance with Section 01 75 05, Training, Testing, and Startup.

END OF SECTION

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SECTION 26 24 13

SWITCHBOARDS

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PART 1 GENERAL

1.01 RELATED COCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes service and distribution switchboards rated 600 V and less.

1.03 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. RFI: Radio-frequency interference.
- D. RMS: Root mean square.
- E. SPOT: Single pole, double throw.

1.04 SUBMITTALS

- A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.
 - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details for types other than NEMA 250, Type 1.
 - b. Bus configuration, current, and voltage ratings.

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- c. Short-circuit current rating of switchboards and overcurrent protective devices.
 - d. Descriptive documentation of optional barriers specified for electrical insulation and isolation.
 - e. Utility company's metering provisions with indication of approval by utility company.
 - f. Mimic-bus diagram.
 - g. UL listing for series rating of installed devices.
 - h. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
2. Wiring Diagrams: Power, signal, and control wiring.
- C. Field quality-control test reports including the following:
- 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- D. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 include the following :
- 1. Routine maintenance requirements for switchboards and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - 3. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.05 QUALITY CONTROL

- A. Testing Agency Qualifications : An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- 1. Testing Agency's Field Supervisor : Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Source Limitations: Obtain switchboards through one source from a single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

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- E. Comply with NEMA PB 2, "Deadfront Distribution Switchboards."
- F. Comply with NFPA 70.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver in sections or lengths that can be moved past obstructions in delivery path.
- B. Store indoors in clean dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- C. If stored in areas subjected to weather, cover switchboards to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchboards.
- D. Handle switchboards according to NEMA PB 2.1 and NECA 400.

1.07 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Ambient Temperature: Not exceeding 140 deg F (60 deg C).
 - 2. Altitude: Not exceeding 2500 feet (above sea level).

1.08 COORDINATION

- A. Coordinate layout and installation of switchboards and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.09 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Potential Transformer Fuses: Equal to 10 percent of amount installed for each size and type, but no fewer than 2 of each size and type.
 - 2. Control-Power Fuses: Equal to 10 percent of amount installed for each size and type, but no fewer than 2 of each size and type.
 - 3. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of amount installed for each size and type, but no fewer than 3 of each size and type.
 - 4. Indicating Lights: Equal to 10 percent of amount installed for each size and type, but no fewer than 1 of each size and type.

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PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 MANUFACTURED UNITS

- A. Manufacturers:
 - 1. Eaton Corporation ; Cutler-Hammer Products
 - 2. General Electric Co.; Electrical Distribution & Protection Div.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D
- B. Front-Connected, Front-Accessible Switchboard: Fixed, individually mounted main device, panel-mounted branches, and sections rear aligned.
- C. Nominal System Voltage: As indicated on the drawings.
- D. Main-Bus Continuous: As indicated on the drawings.
- E. Enclosure: Steel.
- F. Enclosure Finish for Outdoor Units: Factory-applied finish in manufacturer's standard color, undersurfaces treated with corrosion-resistant undercoating.
- G. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- H. Barriers: Between adjacent switchboard sections.
- I. Utility Metering Compartment: Fabricated compartment and section complying with utility company's requirements. If separate vertical section is required for utility metering, match and align with basic switchboard.
- J. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- K. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- L. Buses and Connections: Three phase, four wire, unless otherwise indicated.
 - 1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity with feeder circuit-breaker line connections.

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2. Load Terminals: Insulated, rigidly braced, silver-plated, copper runback bus extensions equipped with pressure connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full ampere rating of circuit-breaker position.
3. Ground Bus: 1/4-by-2-inch- (6-by-50-mm-) minimum-size, hard-drawn copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
4. Contact Surfaces of Buses: Silver plated.
5. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
6. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
7. Neutral Buses: 100 percent of the ampacity of phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus are braced.

M. Future devices: equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.03 SURGE PROTECTIVE DEVICES

A. Refer to Section 26 43 13 device requirements.

2.04 OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker: NEMA AB 3, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Electronic trip-unit circuit breakers shall have RMS sensing, field-replaceable rating plug, and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I²t response.
 3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 4. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
1. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.

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2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
4. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.

2.05 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:
 1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
 2. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
 3. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondaries to ground overcurrent relays to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker ground-fault protection.
- B. Multifunction Digital-Metering Monitor: Provide per Section 26 09 13.
 1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: Plus or minus 1 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d. Megawatts: Plus or minus 2 percent.
 - e. Megavars: Plus or minus 2 percent.
 - f. Power Factor: Plus or minus 2 percent.
 - g. Frequency: Plus or minus 0.5 percent.
 - h. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from 5 to 60 minutes.
 - i. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent. Accumulated values unaffected by power outages up to 72 hours.

2.06 CONTROL POWER

- A. Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer.
- B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

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PART 3 EXECUTION

3.01 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.02 EXAMINATION

- A. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1 and NECA 40.
- B. Install and anchor switchboards level on concrete bases, 4-inch (100-mm) nominal thickness. Concrete materials and installation requirements are specified in Division 3.
- C. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
- D. For switchboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
- E. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
- F. Install anchor bolts to elevations required for proper attachment to switchboards.
- G. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- H. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- I. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
- J. Set field-adjustable switches and circuit-breaker trip ranges.

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3.04 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in 26 05 53 "Electrical Identification."
- B. Switchboard nameplates: label each switchboard compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.05 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
 - 1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
 - c. Instruments, Equipment, and Reports:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 2) Prepare a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 CLEANING

- A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.07 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

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- B. Train Owner's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing, and maintaining equipment and schedules.
- C. Review data in maintenance manuals.
- D. Schedule training with Owner with at least seven days advance notice.

END OF SECTION

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SECTION 26 24 16

PANELBOARDS

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PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.
 - 3. Load centers (panelboard type).
 - 4. Electronic-grade panelboards.

1.03 DEFINITIONS

- A. SVR: Suppressed voltage rating.
- B. SPD: Surge Protection Devices.
- C. EMI: Electromagnetic interference.
- D. GFCI: Ground-fault circuit interrupter.
- E. NRTL: Nationally recognized testing laboratory.
- F. RFI: Radio-frequency interference.
- G. RMS: Root mean square.
- H. SPDT: Single pole, double throw.

1.04 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of

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any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. In accordance with Section 01 81 02 Seismic Design Criteria, 26 05 48 Vibration and Seismic Control for Electrical Systems.

1.05 SUBMITTALS

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 3. Detail bus configuration, current, and voltage ratings.
 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 5. Include evidence of NRTL listing for series rating of installed devices.
 6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 7. Include wiring diagrams for power, signal, and control wiring.
 8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
- C. Qualification Data: For qualified testing agency per Section 01 61 03.
- D. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 26 05 48 Vibration and Seismic Control for Electrical Systems. Include the following:
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E. Field Quality-Control Reports:
 1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- F. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.
- G. Operation and Maintenance Data: In addition to items specified in Section 01 78 23, Operation and Maintenance Data, include the following:

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1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.06 QUALITY CONTROL

- A. Testing Agency Qualifications: Member company of NETA or a NRTL.
 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise onsite testing.
- B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NEMA PB 1.
- F. Comply with NFPA 70.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to Section 01 66 00, Product Storage and Handling Requirements and NEMA PB 1.

1.08 PROJECT CONDITIONS

- A. Environmental Limitations:
 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 2. Rate equipment for continuous operation under the conditions specified under Section 26 05 00, Common Work Results for Electrical.

1.09 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

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- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 (where applicable).

1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Two years from date of Substantial Completion, per Section 00 61 15 Warranty Bond.

1.11 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Keys: Two spares for each type of panelboard cabinet lock.
 - 2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.
 - 3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 26 05 48.
- B. Enclosures: Surface mounted cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations and Indoor Wet Locations: NEMA 250, Type 4X.
 - 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 - 4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
 - 5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 - 6. Finishes:
 - a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Galvanized steel.
 - c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

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- 7. Directory Card: Inside panelboard door, mounted in transparent card holder.
- C. Incoming Mains Location: Top and bottom.
 - D. Phase, Neutral, and Ground Buses:
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 - 3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
 - 4. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
 - 5. Split Bus: Vertical buses divided into individual vertical sections.
 - E. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Main and Neutral Lugs: Mechanical type.
 - 3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
 - 4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - 5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 - 6. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 - 7. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
 - F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.
 - G. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.
 - H. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
 - I. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include size and type of allowable upstream and branch devices, listed and labeled for series-connected short-circuit rating by an NRTL.
 - J. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.
 - K. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution

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3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- L. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front mounted, field-adjustable trip setting.
 3. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground fault protection (6-mA trip).
 4. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high intensity discharge (HID) lighting circuits.

2.02 DISTRIBUTION PANELBOARDS

- A. Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, power and feeder distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 36 inches high, provide two latches, keyed alike.
- D. Main Overcurrent Protective Devices: Circuit breaker.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive locking device requires mechanical release for removal.

2.03 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.

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- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Main Overcurrent Protective Devices: Circuit breaker or lugs only.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- F. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.04 PANELBOARD SUPPRESSORS

- A. Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Current Technology; a subsidiary of Danahar Corporation.
 - 2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 4. Liebert Corporation.
 - 5. Siemens Energy & Automation, Inc.
 - 6. Square D; a brand of Schneider Electric.
- B. Provide Type 2 surge suppressor with overcurrent protection in accordance with Section 26 43 13, Surge Protective Devices.

2.05 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1 and Section 01 66 00, Product Storage and Handling Requirements.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- A. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

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- E. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated in Section 01 14 00, Work Restrictions:
 1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service, unless otherwise noted.
 2. Do not proceed with interruption of electric service without Owner's written permission.
 3. Comply with NFPA 70E.

3.02 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

3.03 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Equipment Mounting: Install panelboards on wall or concrete bases, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 Section Miscellaneous Cast-in-Place Concrete, if applicable.
 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
 2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 4. Install anchor bolts to elevations required for proper attachment to panelboards.
 5. Attach panelboard to the vertical finished or structural surface behind the panelboard.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- D. Comply with mounting and anchoring requirements in accordance with Section 26 05 48, Vibration and Seismic Controls for Electrical Equipment.
- E. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- G. Install overcurrent protective devices and controllers not already factory installed.

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- 1. Set field-adjustable, circuit-breaker trip ranges.
- H. Install filler plates in unused spaces.
- I. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- J. Arrange conductors in gutters into groups and bundle after completing load balancing.
- K. Comply with NECA 1.

3.04 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 26 05 53, Electrical Identification.
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 05 53, Electrical Identification.
- D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Section 26 05 53, Electrical Identification.

3.05 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting Supply, feeder, and control circuit.
- 2. Test continuity of each circuit.
 - A. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification, and as specified in Section 26 08 00, Acceptance Testing. Certify compliance with test parameters.

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2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- B. Panelboards will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73 Overcurrent Protective Device Coordination and Electrical System Studies where included, or as provided by ENGINEER.
- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
 1. Measure as directed during period of normal system loading.
 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.07 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.08 CLEANING

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- A. On completion of installation, inspect interior and exterior of panel boards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION

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SECTION 26 24 19

LOW VOLTAGE MOTOR CONTROL CENTERS

[CLICK HERE TO ENTER PROJECT NAME](#)

CCWRD PROJECT NO. [CLICK HERE TO ENTER CCWRD PROJECT NO.](#)

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes requirements for:
 - 1. Motor Control Centers for use on ac circuits rated 600 V and less.

1.02 REFERENCES

- A. Refer to Sections 01 11 05 Project Requirements, 26 05 00 Common Work Results for Electrical, and 26 09 13 Electrical Power Monitoring, 26 36 23 Automatic Transfer Switch.
- B. National Electrical Manufacturer's Association (NEMA):
 - 1. ICS 18-2001 Motor Control Centers.
- C. Underwriters Laboratories (UL):
 - 1. UL 845 - Motor Control Centers.

1.03 DEFINITIONS

- A. Refer to Section 26 05 00, Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. General: Factory assembled, factory wired and factory tested motor control centers:
 - 1. Motor Control Centers and major components to be products of a single manufacturer including, but not limited:
 - a. Starters.
 - b. Circuit breakers.
 - c. Related equipment specified or indicated on the Drawings.

1.05 SUBMITTALS

- A. Furnish submittals in accordance with Sections 01 33 00 Submittal Procedures, and 26 05 00 Common Work Results for Electrical.
- B. Product Data:
 - 1. Manufacturer of motor control center.
 - 2. Manufacturer of motor control center parts.

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3. Weight of motor control center.
4. Dimensions:
 - a. Height.
 - b. Length.
 - c. Depth.
5. Nameplate schedule.
6. Bill of material.
7. Enclosure NEMA rating and color.
8. Ratings:
 - a. Voltage.
 - b. Phase.
 - c. Current:
 - 1) Horizontal bus ampacity.
 - 2) Vertical bus ampacity.
 - 3) Ground bus ampacity.
 - d. Short circuit withstand rating.
 - e. Protective device interrupting rating.
9. List of recommended spare parts.
10. Manufacturer's time current curves for protective devices printed on 11-inch by 17 -inch log-log paper.
11. Bud data.
12. Catalog cut sheets:
 - a. Submit complete manufacturer's catalog information:
 - 1) Clearly indicate the features of the equipment including any options necessary to meet the required functionality.
 - 2) Descriptive information.

C. Shop Drawings:

1. Layout Drawings:
 - a. Provide fully dimensioned and to scale layout Drawings which include:
 - 1) Dimensions:
 - a) Overall length.
 - b) Overall width.
 - c) Overall height.
 - d) Overall weight and weight of individual shipping splits.
 - 2) Elevations confirming widths and sizes.
2. Interfaces to other equipment.
3. Shipping splits.
4. Allowable top and bottom conduit windows.
5. Complete component and unit layout Drawings.
6. Indicate lug sizes, type, and Manufacturer based on the cable size specified and as indicated on the Drawings.
7. Elementary schematics:
 - a. Provide one custom schematic diagram for each compartment
 - 1) Include all remote devices.
 - 2) Show wire numbers on the schematics:
 - a) Provide wire numbering in accordance with Section 26 05 53, Electrical Identification.
 - b) Refer to Section 26 05 00, Common Work Results for detailed requirements.
8. External connection diagram showing the wiring to the external controls and

- devices associated with the motor control center.
9. Single-line Diagrams:
 - a. Provide single-line diagrams for each motor control center, including but not limited to:
 - 1) Circuit breakers.
 - 2) Motor circuit protectors.
 - 3) Motor starters.
 - 4) Instrument transformers.
 - 5) Relays.
 - 6) Control devices.
 - 7) Surge protective devices.
 10. Indicate electrical ratings of the equipment shown on the single-line diagrams.
 11. Typed Tabulation:
 - a. Motor name; tag (equipment) numbers as shown on Drawings.
 - b. Motor horsepower.
 - c. Nameplate full load current.
 - d. Measured load current and voltage.
 - e. Overload model number and setting.
 - f. Protective device trip settings.
 - g. Manufacturer's solid state starter switch or dip switch or program settings.
 - h. Attach above typed, tabulated data to a copy of starter manufacturer's overload heater or setting selection tables for starters provided.
- D. Installation Instructions:
1. Detail the complete installation of the motor control center including rigging, moving, and setting into place.
 2. Provide anchorage instructions and requirements for the motor control center based on the seismic requirements at the project site as indicated in Section 26 05 00 Common Work Results for Electrical, and Section 01 81 02, Seismic Design Criteria:
 - a. Stamped by a Nevada Professional Engineer.
- E. Operation and Maintenance Manuals:
1. Provide complete operating and maintenance instructions presenting full details for care and maintenance of all types of equipment furnished and/or installed under this section. Include the following:
 - a. Electrical ratings:
 - 1) Phase.
 - 2) Wire.
 - 3) Voltage.
 - 4) Ampacity.
 - b. Manufacturer's operating and maintenance instructions for the motor control center and all component parts, including:
 - 1) Starters.
 - 2) Overload relays and heater elements.
 - 3) Protective devices including, but not limited to, fuses, circuit breakers, and protective relays.
 - 4) Pilot devices.
 - c. Complete renewal parts list.
 - d. Certified factory test reports.

- e. Completed manufacturer's certificate of installation, per Section 01 75 05, Testing Training and Startup.
- F. Record Documents:
 - 1. Elementary Schematics:
 - a. Provide a single-line diagram for every unit installed.
 - b. Provide one custom schematic diagram for each compartment:
 - 1) Include all remote devices.
 - 2) Show wire numbers on the schematics.
 - 2. Layout Drawings:
 - a. Provide complete dimensioned component and unit layout drawings.
 - 3. The record documents shall reflect all modifications made during the submittal review process and during construction.
- G. Calculations:
 - 1. Detailed calculations or details of the actual physical testing performed on the motor control center to prove the motor control center is suitable for the seismic requirements at the project site.

1.06 QUALITY CONTROL

- A. Refer to Sections 01 45 00, Quality Control, and 26 05 00, Common Work Results for Electrical.
- B. Source Limitations: Obtain motor-control centers and controllers of a single type through one source from a single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with NFPA 70.
- E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for motor control centers, including clearances between motor-control centers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.
- F. All portions of the motor control center, vertical bays, and components shall be UL listed and labeled.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Refer to Sections 01 66 00, Product Storage and Handling Requirements, and 26 05 00 Common Work Results for Electrical.
- B. Deliver motor-control centers in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.
- C. Ship the motor control center and associated equipment to the job site on a dedicated air ride vehicle that will allow onsite off-loading equipment.

1.08 PROJECT OR SITE CONDITIONS

- A. Refer to Section 26 05 00, Common Work Results for Electrical.

1.09 SEQUENCING

- A. Where included, conduct the initial fault current study in accordance with Section 26 05 73 and submit results for ENGINEER's review, otherwise request data from ENGINEER.
- B. If applicable, after successful review of the initial fault current study, as required by Section 26 05 73, submit complete equipment submittal in accordance with Paragraph 1.05 of this specification for ENGINEER's review.
- C. Complete submittal requirements as specified in this section and obtain ENGINEER's approval on submittals.
- D. Conduct internal factory test to ensure that systems and equipment are functional and submit Certified Test Results for ENGINEER's review.
- E. Coordinate with ENGINEER for cutover requirements as specified in Section 01 14 00, Work Restrictions.
- F. Ship equipment to the project site after successful completion of Factory Acceptance Test.
- F. Assemble equipment in the field.
- G. Coordinate features of motor-control centers, installed units, and accessory devices with pilot devices and control circuits to which they connect.
- H. Coordinate features, accessories, and functions of each motor-control center, each controller, and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.
- I. Conduct field acceptance test and submit results for ENGINEER's review.
- J. Submit manufacturer's certification that the equipment has been properly installed and is fully functional for ENGINEER's review.
- K. Conduct OWNER's training sessions.
- L. Formally energize, start-up, and commission equipment, coordinate with ENGINEER as per Section 01 14 00, Work Restrictions.

1.10 SCHEDULING

- A. Refer to Sections 01 32 15 Scheduling Requirements, 01 14 00 Work Restrictions, and 26 05 00 Common Work Results for Electrical.

1.11 WARRANTY

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- A. Refer to Document 00 61 15 Warranty Bond and Section 26 05 00 Common Work Results for Electrical.

1.12 SYSTEM START UP

- A. Refer to Sections 01 75 05 Testing Training and Startup, and 26 05 00 Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Eaton Cutler Hammer: Freedom 2100.
 - 2. Allen Bradley: CENTERLINE 2100.
 - 3. Or OWNER approved EQUAL.

2.02 SEPARATELY MOUNTED STARTERS

- A. Combination Full-Voltage, Magnetic Starter:
 - 1. Rating: Horsepower rated at 600 volts, UL labeled for 65,000 amperes at 480 volts short circuit capacity with overload protection.
 - 2. Three-phase, nonreversing, full voltage, NEMA rating as shown.
 - 3. Control: HAND/OFF/AUTO selector switch.
 - 4. Disconnect Type: Motor circuit protector.
 - 5. Enclosure: NEMA 250, Type 12.
 - 6. Pilot Lights: Red–OFF and Green–ON.
 - 7. Padlockable operating handle, capable of up to three locks.
 - 8. Manufacturers and Products:
 - a. Eaton Cutler Hammer.
 - b. Allen Bradley.
 - c. Or OWNER approved EQUAL.

2.03 MOTOR CONTROL CENTER EQUIPMENT

- A. General:
 - 1. Furnish motor control centers as specified and indicated on the Drawings.
 - 2. Arrange the equipped sections side by side to form continuous motor control center lineups as indicated on the Drawings:
 - a. Identify any deviations from the Drawings in writing and submit for approval.
 - 3. Provide complete and functional motor control centers, assembled and tested by one manufacturer.
 - 4. Provide devices or accessories not described herein but necessary for the proper installation and operation of the equipment.
 - 5. Provide new components of the latest construction series available from the manufacturer.
- B. Design and construct motor control center to operate on a 480 volt, 3-phase, 3-wire 60 hertz solidly grounded system.

- C. Short Circuit Rating: In amperes rms symmetrical at 480 volts for entire motor control center as a complete assembly, as shown on Drawings.
- D. Main and branch circuit breakers, controllers, wire connections, and other devices to be front mounted and accessible, unless otherwise noted.
- E. Bus System:
 - 1. Material:
 - a. Tin-plated hard-drawn copper, 98 percent conductivity.
 - b. Short-Circuit rating: 65,000 RMS symmetrical amps or as indicated on the Drawings, whichever is greater.
 - c. Bus Bar Supports: High impact strength, non-tracking glass-polyester material that is impervious to moisture and gases.
 - 2. Horizontal Power Bus:
 - a. Current-carrying capacity of not less than 600 amps or as indicated on the Drawings.
 - b. Mounting:
 - 1) Mount horizontal bus bars edgewise, one above the other, and fully isolated from all wireways and units.
 - c. Temperature Rise:
 - 1) Rated at 50 degrees Celsius temperature rise over a 40 degree Celsius ambient temperature.
 - 2) De-rate the temperature rating of the bus for the specified conditions of ambient temperature and altitude as specified in Section 26 05 00, Common Work Results for Electrical.
 - 3. Vertical Power Bus:
 - a. Current-carrying capacity of not less than 300 amps.
 - b. Current-carrying capacity of not less than 600 amps, where required for large ampacity feeder breakers.
 - c. Mounting:
 - 1) Enclose the vertical bus in a polyester-glass cover with small openings to permit unit stabs to mate with the bus:
 - a) Provide a shutter mechanism to cover the stab openings when plug-units are removed.
 - 2) Provide top and bottom bus covers for insulation and isolation of the ends of the bus.
 - d. Isolated from the unit compartments by a full height barrier.
 - 4. Ground Bus:
 - a. Horizontal Ground Bus:
 - 1) Current-carrying capacity of not less than 300 amps.
 - 2) Mounting:
 - a) Full-width, firmly secured to each vertical section structure:
 - (1) Located in the top or bottom wireway.
 - b) Pre-drilled and furnished with lugs for connection to equipment ground wires: Furnish a minimum of 10 lugs per vertical section of MCC.
 - b. Vertical Ground Bus.
 - 1) Mounting:
 - a) Furnish in each vertical section.
 - b) Bolted to the horizontal ground bus.
 - c) Install parallel to the vertical power bus.

- d) Mount vertical ground bus such that plug-in units engage the ground bus before any connection to the power bus is made. Upon removal of plug-in units, ground stabs are disconnected from the ground bus after the power stabs have been disconnected.
5. Bus Splice Bars:
- a. Provided to join the bus at the splits.
 - b. Connected to each horizontal bus bar with a minimum of two bolts.
 - c. Employ conical or spring washers at connections, designed to maintain constant pressure against the splice joint.
 - d. Same ampacity rating as the horizontal bus.
- F. Enclosures:
- 1. Each motor control center shall consist of 1 or more vertical sections bolted together:
 - a. Freestanding, NEMA 250, type 12 industrial use enclosure, unless otherwise indicated on Drawings.
 - b. Totally enclosed.
 - c. Dead-front assembly.
 - d. Designed for modification and/or addition of future vertical sections.
 - e. Form each vertical section of heavy gauge steel.
 - 2. Standard Section Dimensions:
 - a. Nominal height: 90 inches.
 - b. Nominal depth: 21 inches.
 - c. Vertical section width as indicated on the Drawings, do not exceed space shown.
 - 3. Wireways:
 - a. Provide each vertical section with a horizontal wireway at the top and bottom of the section:
 - 1) Arranged to provide a full-width metal enclosed wiring trough across the entire motor control center assembly.
 - b. Provide each vertical section with a full-height vertical wireway.
 - c. Completely isolated from the vertical and horizontal bus bars.
 - d. Provide a removable, hinged door.
 - 4. Shipping Splits:
 - a. No more than 3 vertical sections and not more than 60 inches in width.
 - b. Solid bussing between vertical sections in a shipping split is not acceptable.
 - 5. Lifting Angles:
 - a. Furnish each vertical section and/or shipping split with a removable lifting angle mounted to the top of the enclosure:
 - 1) Extending the entire width of the shipping split.
- G. Units:
- 1. A plug-in unit consists of:
 - a. Unit assembly.
 - b. Unit support pan.
 - c. Unit door assembly.
 - 2. Completely enclosed and isolated from adjacent units, buses, and wireways, except for conductor entries into the unit, by a metal enclosure.
 - 3. Constructed so that any fault will be contained in the unit compartment.
 - 4. Supported and guided by a removable unit support pan:

- a. Re-arrangement of units and the removal of a unit so that a new and possibly larger unit can be added without the removal of an in-service unit to gain access to the unit support pan.
5. Held in place by screws or other positive locking means after insertion.
6. Provide a test position with the unit supported in the structure but disengaged from the bus.
7. Integral plug-in ground stab.
8. Stabs:
 - a. Free floating.
 - b. Self-aligning.
 - c. Backed by spring steel clips to ensure high pressure contacts:
 - d. Electrolytically tin-plated copper.
9. Separate hinged doors for each starter, feeder, or other unit.
10. Door Interlocking: Mechanically interlock starter and feeder doors so doors cannot be opened with unit energized. Provide defeater mechanism to allow intentional access and energizing at any time by qualified individual.
11. Handle:
 - a. Provide a flange mounted handle mechanism to operate each disconnect switch or circuit breaker.
 - b. Door mounted operators or operator handles are not acceptable.
 - c. Engaged with the disconnect device at all times as an integral part of the unit independent of the door position.
 - d. Lockable in the "OFF" position with up to 3 padlocks.
 - e. Mechanically interlocked so that the door cannot be opened with the handle in the "ON" position.
 - 1) Provide a means for qualified personnel to defeat this interlock.
 - f. Interlocked so the unit cannot be inserted or withdrawn with the handle in the "ON" position.
 - g. Lockable in the "ON" position:
 - 1) This shall not prevent the circuit breaker from operating and opening the contacts in the event of a fault condition.
 - h. Color-coded to indicate position.
 - i. Located so the center of the grip when it is in its highest position is not more than 6 feet 7 inches above the finished floor, including the height of the housekeeping pad.
12. Where indicated on the Drawings, provide units for spaces and future equipment:
13. Equip these units to accept a future plug-in unit without modification to the vertical sections.

H. Starters:

1. General:
 - a. NEMA ICS 18, standard rating, except none smaller than NEMA ICS, Size 1.
 - b. Rating: Horsepower rated at 600 volt, UL labeled for 65,000 amperes at 480 volts short circuit capacity with overload protection.
 - c. Three-phase, non-reversing, unless specified otherwise.
 - d. Disconnect Type: Motor circuit protector or thermal magnetic molded case circuit breaker as shown on Drawings.
2. Combination Full Voltage, Magnetic Starter:
 - a. Control: As shown on Drawings.
 - b. Pilot Lights: As shown on Drawings.

3. Combination Reduced Voltage, Solid State Starter:
 - a. Ampere rating: To supply connected motor hp as Shown, with a 1.15 service factor.
 - b. Duty Rating: Standard, unless otherwise noted.
 - c. Control: As shown on Drawings.
 - d. Bypass contactor.
 - e. Class 10/20/30 electronic overload relay, switch, or dip switch selectable.
 - f. Kick start, with adjustable torque and time settings.
 - g. Ramp start, selectable current or torque, and adjustable time.
 - h. Smooth stop ramp, adjustable time.
 - i. Phase loss unbalance and phase reversal protection.
 - j. LED display or LCD of fault, N.O. contact to communicate fault condition.

2.04 COMPONENTS

- A. Provide components contained within the motor control center as indicated on Drawings in accordance with the following sections (as applicable):
 1. Section 26 05 19.
 2. Section 26 05 53.
 3. Section 26 09 13.
 4. Section 26 28 13.
 5. Section 26 36 23.
 6. Section 26 43 13.
- B. Circuit Breaker, thermal magnetic:
 1. Meet requirements of UL 489.
 2. Molded case with manufacturer's recommended trip setting for maximum motor protection.
 3. Thermal-magnetic trip, or magnetic only as shown on Drawings.
 4. Tripping indicated by operating-handle position.
 5. Interrupting capacity required for connection to system with short-circuit capacity indicated.
- C. Solid State Trip Circuit Breaker:
 1. In accordance with UL 489.
 2. Main and feeder protective device, where shown on Drawings, for frame size 400 Amperes and above.
 3. Insulated or molded case breakers with ambient insensitive solid-state trips and having current sensors and logic circuits integral in breaker frame.
 4. Solid-state current control with adjustable ampere setting, adjustable long-time delay, adjustable short-time trip and delay band, fixed or adjustable instantaneous trip, and adjustable ground fault trip and delay band.
 5. Setting adjustments to be covered by a sealable, tamper-proof, transparent cover (insulated case breakers only) or by compartment door for other breakers).
 6. Locate trip button on front cover of breaker to permit mechanical simulation overcurrent tripping for test purposes and to trip breaker quickly in emergency situation.
- D. Thermal Motor Overload Protection:
 1. Inverse-time-limit characteristic.

2. Heater: Bimetallic overload, adjustable trip, or directly heated melting alloy, ratchet principle type element.
3. Relay Trip: Standard, Class 20.
4. Manual reset.
5. Provide in each ungrounded phase.
6. Mount within starter unit.

E. Solid State Motor Protection Relay:

1. General:
 - a. Multifunction, microprocessor based, programmable digital device.
 - b. Single, self-contained, door-mounted unit with data input pushbuttons on face of relay.
 - c. Motor protection against overload, overtemperature, phase reversal, phase unbalance, single-phase, ground fault, jam, underload, and bearing overtemperature, plus starts per hour, over and undervoltage protection, phase loss trip, and phase sequence trip.
 - d. Standard thermal curves self-generated within module based on motor data.
 - e. Motor current integrated with winding temperatures to establish trip times.
 - f. Separate trip points for each function.
 - g. Visual display to indicate relay status and operation.
 - h. Read out to include real-time motor data using pushbuttons.
 - i. System data and trip limit points accessible from same display.
 - j. Nonchangeable trip limit points, except with program jumper.
 - k. Separate alarm, auxiliary, and trip output contacts rated 8 amperes, 230 volts.
 - l. Alarm contacts wired to remote alarm indicator.
 - m. Interconnecting wires terminated on terminal boards.
2. Protective Features:
 - a. Time overcurrent and instantaneous trip functions.
 - b. Winding temperature, motor bearing, and driven equipment bearing RTD software set and adjustable trip and alarm levels.
 - c. Ground fault alarm and trip.
 - d. Load jam overcurrent and load loss undercurrent.
 - e. Unbalanced current trip and alarm.
 - f. Current trip for phase reversal and phase loss
 - g. Starts per hour limit.
 - h. Overvoltage and undervoltage protection.
 - i. Voltage trip for phase loss and phase sequence.
 - j. Trip and alarm independently adjustable.
 - k. Loss of protection.
 - l. Measurement and display.
 - m. Three-phase line and percent full load currents.
 - n. Three-phase line voltage.
 - o. kVA and kW.
 - p. Ground current.
 - q. Current unbalance at trip condition only.
 - r. RTD temperatures and hottest RTD.
 - s. Normal operating conditions and trip annunciators.
3. Module Features:
 - a. Programmable trip, alarm, and auxiliary relays
 - b. Relay status.

- c. Settable CT ratio.
- d. Hold system values at trip.
- e. Communications output.
- 4. Manufacturers and Products:
 - 1) General Electric; Multilin 469.
 - 2) No substitutes.
- F. Push Button, Indicating Light, and Selector Switch:
 - 1. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.
 - 2. Selector Switch Operating Lever: Standard, lockable in OFF position if shown.
 - 3. Indicating Light: Push-to-test, transformer-type.
 - 4. Pushbutton Color:
 - a. ON or START: Black.
 - b. OFF or STOP: Red.

2.05 ELECTRICAL POWER MONITORS

- A. Provide the following electrical power monitoring components in accordance with Section 26 09 13 – Electrical Power Monitors:
 - 1. Electrical Power Monitors (EPM).
 - 2. Current Transformer (CT).
 - 3. Potential Transformer (PT).
 - 4. Serial to Ethernet Converters.

2.06 ACCESSORIES

- A. Control Power Transformers:
 - 1. Two winding, 120-volt secondary, primary voltage to suit.
 - 2. Two current-limiting fuses for primary circuit.
 - 3. One fuse in secondary circuit with blown fuse indicator.
 - 4. Mount within starter unit.
- B. Wiring:
 - 1. Wire the motor control center in accordance with the following NEMA Class and Type as defined by NEMA ICS 18-2001:
 - a. NEMA Class I-S, unless wiring interface is shown between starter cubicles where wiring shall be NEMA Class II-S:
 - 1) Furnish wiring diagrams for individual units consisting of drawings that identify electrical devices, electrical connections, and indicate terminal numbering designations.
 - 2) Furnish individual unit diagrams with each unit and include interwiring between units, i.e. electrical interlocking, etc., as specifically indicated in the Contract Documents.
 - 3) Supply a chart indicating factory interconnections with the motor control center.
 - 4) Provide custom drawings with unique terminal numbering designations in lieu of standard manufacturer Drawings.
 - b. NEMA Type B Wiring:
 - 1) Control wiring: Type B-T pull-apart terminal blocks.
 - 2) Power wiring:

- a) Type B-T for Size 1 starters.
- b) Type B-T or B-D for Size 2 and 3 starters.
- c) Type B for Size 4 and larger starters and feeder units.

C. Lugs and Terminals:

1. For all external connections of NO.6 AWG wire or larger:
 - a. UL listed for copper or aluminum conductors.
2. Compression type, requiring a hydraulic press and die for installation.
3. Suitable for 75 degrees C wire at full NFPA 70, 75 degree C ampacity.

D. Nameplates:

1. Provide nameplates in accordance with Section 26 05 53, Electrical Identification:
 - a. Identifying the motor control center designation as indicated on the Drawings.
2. Identifying the vertical section:
 - a. Mounted and centered on the top horizontal wireway for each vertical section.
3. Furnish individual nameplates for each unit identified on the Contract Drawings:
 - a. 1 nameplate to identify the unit designation.
 - b. 1 nameplate to identify the load served.
 - c. Furnish space units with blank nameplates.
4. Manufacturer's Labels:
 - a. Furnish each vertical section with a label identifying:
 - 1) Serial number.
 - 2) Bus rating.
 - 3) Vertical section reference number.
 - 4) Date of manufacture.
 - 5) Catalog number of section.

E. Industrial Capacitors:

1. UL 810, NEMA CP 1, IEEE 18, and NFPA 70, Article 460.
2. Enclosed, indoor, dustproof, three-phase capacitor units containing internally mounted, indicating type, high interrupting-capacity, current-limiting fuses, and discharge resistors.
3. Units containing PCB dielectric fluid are unacceptable.
4. Kilovar Ratings: As shown on Drawings.
5. Reduce capacitor rating, if required, to not exceed motor manufacturer's recommended maximum size, and to not exceed value required to raise motor no-load power factor to 0.95.
6. Manufacturers:
 - a. General Electric Co.
 - b. Square D Co.
 - c. Or Equal.

F. Magnetic Control Relay:

1. Industrial control with field convertible contacts rated 10 amps continuous, 7,200VA make, 720VA break.
2. NEMA ICS 2, Designation: A600 (600 volts).
3. Time Delay Relay Attachment:

- a. Pneumatic type, timer adjustable from 5 seconds to 200 seconds (minimum)
 - b. Field convertible from ON delay to OFF delay and vice versa.
 - 4. Latching Attachment: Mechanical latch, having unlatching coil and coil clearing contacts.
 - 5. Manufacturers and Products:
 - a. Eaton/Cutler-Hammer; Type D26 Type M.
 - b. Or Equal.
- G. Time Delay Relay:
 - 1. Industrial relay with contacts rated 5 amps continuous, 3,600VA make, 360VA break.
 - 2. NEMA ICS 2 Designation: B150 (150 volts).
 - 3. Solid-state electronic, field convertible ON/OFF delay.
 - 4. One normally open and one normally closed contact (minimum).
 - 5. Repeat accuracy plus or minus 2 percent.
 - 6. Timer adjustment from 1 second to 60 seconds, unless otherwise indicated on Drawings.
 - 7. Manufacturers and Products:
 - 1) Eaton/Cutler-Hammer; Type D26MR
 - 2) Or Equal.

2.07 FINISHES

- A. Finish metal surfaces and structural parts with phosphatizing, or equal, treatment before painting.
- B. Finish interior surfaces including bus support angles, control unit back plates, and top and bottom barrier plates with baked white enamel.
- C. Finish exterior of enclosure with ANSI 61 gray.

2.08 FACTORY TESTING

- A. Applicable Standards: NEMA ICS 18, UL 845, and NEC Article 430, Part VIII.
- B. Perform standard factory inspection and tests in accordance with NEMA requirements to verify components have been designed to Specification, assembled in accordance with applicable standards, and each unit functions in accordance with electrical diagrams.
- C. Actual operation shall be performed wherever possible. Otherwise, inspect and perform continuity checks.
- D. Verify component devices operated correctly in circuits as shown on diagrams or as called for in Specification.
- E. Control Circuits and Devices:
 - 1. Energize circuit at rated voltage.
 - 2. Operate control devices.
 - 3. Perform continuity check.

- F. Instruments, Meters, Protective Relays, and Equipment:
 - 1. Verify devices functioned by energizing potential to rated values with connection to devices made at outgoing terminal blocks.
 - 2. Verify protective relays operated for functional checks and trips manually initiated to verify functioning of operation for indicator and associated circuits.
- G. Perform dielectric tests on primary circuits and equipment, except potential transformers. Tests shall be made phase-to-phase and phase-to-around with 60-cycle test voltages applied for 1 second at 2,640 volts.
- H. Verify equipment passed tests and inspection.
- I. Provide standard factory inspection and test checklists, and final certified and signed test report.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Refer to Section 26 05 00, Common Work Results for Electrical. Carefully study Drawings for motor control equipment to be installed in existing spaces, evaluate conflicts if any and immediately inform ENGINEER.
- B. Install the motor control center per the manufacturer's guidelines and submitted installation instructions to meet the seismic requirements at the project site.
- C. Anchor each motor-control center assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with motor-control center mounting surface.
- D. General:
 - 1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories necessary to completely install the motor control center for the line, load, and control connections.
 - 2. Assemble and install the motor control center in the locations and with the layouts as indicated on the Drawings.
 - 3. Make bus splice connections.
 - 4. Perform work in accordance with manufacturer's instruction and shop drawings.
 - 5. Furnish all components, and equipment necessary to complete the installation.
 - 6. Replace hardware, lost or damaged during installation or handling, in order to provide a complete installation.
 - 7. Install the MCC on a 3-1/2 inch raised concrete housekeeping pad or existing pad.
- E. Provide openings in the top or bottom of the motor control center for conduit only. No additional openings will be accepted:
 - 1. Mis-cut holes will require that the entire vertical section or removable panel be replaced. No hole closers or patches will be accepted.
- F. Bundle circuits together and terminate in each unit:

1. Tie in accordance with Section 26 05 19, Conductors and Cables.
 2. Label all wires at each end with wire numbers as shown on the approved elementary schematics.
- G. Connect hand-off-automatic switch and other automatic-control devices where applicable.
1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
 2. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.02 FIELD QUALITY CONTROL

- A. Refer to Section 26 05 00 Common Work Results for Electrical, 26 08 00 Acceptance Testing.
- B. Provide the services of a manufacturer's representative to:
1. Inspect, verify, and certify that the motor control center installation meets the manufacturer's requirements.

3.03 ADJUSTING

- A. Make all adjustments as necessary and recommended by the manufacturer, ENGINEER, or testing firm.
- B. Set field-adjustable switches and circuit-breaker trip ranges.

3.04 CLEANING

- A. Refer to Section 26 05 00, Common Work Results for Electrical.

3.05 DEMONSTRATION AND TRAINING

- A. Refer to Section 26 05 00 Common Work Results for Electrical, 01 75 05 Testing Training and Startup.
- B. Demonstrate the operation of the motor control center to ENGINEER's satisfaction.
- C. Training:
1. Provide training for motor control center components in accordance with the individual component specifications.

3.06 PROTECTION

- A. Refer to Section 26 05 00, Common Work Results for Electrical.

END OF SECTION

SECTION 26 25 00

ENCLOSED BUS ASSEMBLIES

[CLICK HERE TO ENTER PROJECT NAME](#)

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PART 1 GENERAL

1.01 RELATED COCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Feeder-bus assemblies
 - 2. Plug-in bus assemblies
 - 3. Bus plug-in devices

1.03 DEFINITIONS

- A. TVSS: Transient voltage surge suppressor.

1.04 SUBMITTALS

- A. Shop Drawings: For each type of bus assembly and plug-in device.
 - 1. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.
 - 2. Show fittings, materials, fabrication, and installation methods for listed fire-stop barriers and weather barriers.
 - 3. Indicate required clearances, method of field assembly, and location and size of each field connection.
 - 4. Detail connections to switchgear, switchboards, transformers, and panelboards.
 - 5. Wiring Diagrams: Power wiring.

- B. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled bus- assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Show the following:
 - 1. Vertical and horizontal enclosed bus-assembly runs, offsets, and transitions.
 - 2. Clearances for access above and to the side of enclosed bus assemblies.

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- 3. Vertical elevation of enclosed bus assemblies above the floor or bottom of structure.
 - 4. Support locations, type of support, and weight on each support.
- C. Location of adjacent construction elements including light fixtures, HVAC and plumbing equipment, fire sprinklers and piping, signal and control devices, and other equipment.
 - D. Product Certificates: For each type of enclosed bus assembly, signed by product manufacturer.
 - E. Field quality-control test reports.
 - F. Operation and Maintenance Data: For enclosed bus assemblies to include in emergency, operation, and maintenance manuals.

1.05 QUALITY CONTROL

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor : Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Source Limitations: Obtain enclosed bus assemblies and plug-in devices through one source from a single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with NEMA BU 1, "Busways."
- E. Comply with NFPA 70.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle enclosed bus assemblies according to NEMA BU 1.1, "General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 Volts or Less."

1.07 PROJECT CONDITIONS

- A. Derate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding 140 deg F (60 deg C).

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1.08 COORDINATION

- A. Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
 - 1. Coordinate size and location of concrete curbs around openings for vertical bus. Concrete, reinforcement, and formwork requirements are specified in Division 3.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Eaton Electrical Inc.; Cutler-Hammer Products
- C. General Electric Company; Electrical Distribution & Control Division
- D. Siemens Energy & Automation, Inc.
- E. Square D; Schneider Electric

2.02 ENCLOSED BUS ASSEMBLIES

- A. Feeder-Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in nonventilated housing; single-bolt joints; ratings as indicated.
 - 1. Voltage: As indicated on the drawings.
 - 2. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
 - 3. Bus Materials: Current-carrying copper conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.
 - 4. Ground:
 - a. 50 percent capacity integral with housing.
 - b. 50 percent capacity internal bus bars of material matching bus material.
 - c. 50 percent capacity isolated, internal bus bar of material matching bus material.
 - 5. Enclosure: Steel with manufacturer's standard finish
 - 6. Fittings and Accessories: Manufacturer's standard.
 - 7. Mounting: Arranged flat, edgewise, or vertically without derating.
- B. Plug-in Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in nonventilated housing; single-bolt joints; ratings as indicated.
 - 1. Voltage: As indicated on the drawings; 3 phase;.
 - 2. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
 - 3. Bus Materials: Current-carrying copper conductors, fully insulated with Class 130C insulation except at stabs and joints; plated surface at stabs and joints.

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4. Ground:
 - a. 50 percent capacity integral with housing.
 - b. 50 percent capacity internal bus bar of material matching bus material.
 - c. 50 percent capacity isolated, internal bus bar of material matching bus material.
5. Enclosure: Steel, with manufacturer's standard finish, plug-in openings 24 inches (610 mm) o.c., and hinged covers over unused openings
6. Fittings and Accessories: Manufacturer's standard.
7. Mounting: Arranged flat, edgewise, or vertically without derating.

2.03 PLUG-IN DEVICES

- A. Fusible Switches: NEMA KS 1, heavy duty; with fuse clips to accommodate specified fuses; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. See Division 16 Section "Fuses" for fuses and fuse installation requirements.
- B. Molded-Case Circuit Breakers: NEMA AB 1; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.
 1. Design each fastener and support to carry 200 lb (90 kg) or 4 times the weight of bus assembly, whichever is greater.
 2. Support bus assembly to prevent twisting from eccentric loading.
 3. Support bus assembly with not less than 3/8-inch (10-mm) steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
 4. Fasten supports securely to building structure according to Division 16 Section "Hangers and Supports for Electrical Equipment".
- B. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.
- C. Construct rated fire-stop assemblies where bus assemblies penetrate fire-rated elements such as walls, floors, and ceilings. Seal around penetrations according to Division 7.
- D. Install weatherseal fittings and flanges where bus assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight. See Division 7.

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- E. Install a concrete curb at least 3 inches (75 mm) high around bus-assembly floor penetrations.
- F. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.
- G. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.
- H. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

3.02 CONNECTIONS

- A. Ground equipment according to 26 05 26 "Grounding and Bonding."
- B. Connect wiring according to 26 05 19 "Conductors and Cables."

3.03 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. Remove and replace units that do not pass tests and inspections and retest as specified above.
- D. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of bus assembly including joints and plug-in units.
 - 1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
 - 2. Perform 2 follow-up infrared scans of bus assembly, one at 4 months and the other at 11 months after Substantial Completion.
 - 3. Prepare a certified report identifying bus assembly checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

3.04 ADJUSTING

- A. Set field-adjustable, circuit-breaker trip ranges as indicated in the coordination study.

3.05 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

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3.06 PROTECTION

A. Provide final protection to ensure that moisture does not enter bus assembly.

END OF SECTION

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SECTION 26 28 13

FUSES

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PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches and enclosed controllers.
 - 2. Plug fuses rated 125-V ac and less for use in plug-fuse-type enclosed switches.
 - 3. Plug-fuse adapters for use in Edison-base, plug-fuse sockets.
 - 4. Spare-fuse cabinets.

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
 - 1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
 - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
 - 2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
 - 3. Current-limitation curves for fuses with current-limiting characteristics.
 - 4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
 - 5. Coordination charts and tables and related data.
- B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section Operation and Maintenance Data, include the following:
 - 1. Ambient temperature adjustment information.

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2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.

1.04 QUALITY CONTROL

- A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA FU 1 for cartridge fuses.
- D. Comply with NFPA 70.
- E. Comply with UL 248-11 for plug fuses.

1.05 PROJECT CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 degrees F or more than 100 degrees F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.06 COORDINATION

- A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

1.07 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Cooper Bussmann, Inc.
 2. Edison Fuse, Inc.
 3. Ferraz Shawmut, Inc.
 4. Littelfuse, Inc.

2.02 CARTRIDGE FUSES

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- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.03 PLUG FUSES

- A. Characteristics: UL 248-11, nonrenewable plug fuses; 125-V ac.

2.04 PLUG-FUSE ADAPTERS

- A. Characteristics: Adapters for using Type S, rejection-base plug fuses in fuse holders or sockets; ampere ratings matching fuse ratings; irremovable once installed.

2.05 SPARE-FUSE CABINET

- A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
 1. Size: Adequate for storage of spare fuses specified with 20 percent spare capacity minimum.
 2. Finish: Gray, baked enamel.
 3. Identification: "SPARE FUSES" in 1-1/2-inch- high letters on exterior of door.
 4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 FUSE APPLICATIONS

- A. Cartridge Fuses:
 1. Service Entrance: Class L, time delay.
 2. Feeders: Class L, time delay.
 3. Motor Branch Circuits: Class RK1, time delay.
 4. Other Branch Circuits: Class RK1, time delay.

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5. Control Circuits: Class CC, fast acting.

3.03 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- B. Install plug-fuse adapters in fuse holders and sockets. Ensure that adapters are irremovable once installed.
- C. Install spare-fuse cabinet(s).

3.04 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Division 26 Section Identification for Electrical Systems and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

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SECTION 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

[CLICK HERE TO ENTER PROJECT NAME](#)

CCWRD PROJECT NO. [CLICK HERE TO ENTER CCWRD PROJECT NO.](#)

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following individually mounted, enclosed switches and circuit breakers:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Bolted-pressure contact switches.
 - 4. Molded-case circuit breakers.
 - 5. Molded-case switches.
 - 6. Enclosures.

1.03 DEFINITIONS

- A. GD: General duty.
- B. GFCI: Ground-fault circuit interrupter.
- C. HD: Heavy duty.
- D. RMS: Root mean square.
- E. SPOT: Single pole, double throw.

1.04 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.

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2. Current and voltage ratings.
 3. Short-circuit current rating.
 4. UL listing for series rating of installed devices.
 5. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Field quality-control test reports including the following:
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- D. Manufacturer's field service report.
- E. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1, include the following:
1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 2. Time-current curves, including selectable ranges for each type of circuit breaker.

1.05 QUALITY CONTROL

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.
- D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.06 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

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1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 140 deg F (60 deg C).
2. Altitude: Not exceeding 2500 feet (above sea level).

1.07 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 FUSIBLE AND NONFUSIBLE SWITCHES

- A. Manufacturers:
1. Eaton Corporation; Cutler-Hammer Products
 2. General Electric Co.; Electrical Distribution & Control Division
 3. Siemens Energy & Automation, Inc.
 4. Square D/Group Schneider
- B. Fusible Switch, 600 A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- C. Nonfusible Switch, 600 A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to
- D. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.
 3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

2.03 FUSED POWER CIRCUIT DEVICES

- A. Bolted-Pressure Contact Switch: 800A and larger UL 977; operating mechanism shall use a rotary-mechanical-bolting action to produce and maintain high-clamping pressure on the
1. Manufacturers:

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- a. Boltswitch, Inc.
- b. Eaton Corporation; Cutler-Hammer Products.
- c. Pringle Electrical Mfg. Co.
- d. Siemens Energy & Automation, Inc.
- e. Square D/Group Schneider.

2.04 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

- A. Manufacturers:
 - 1. Eaton Corporation; Cutler-Hammer Products
 - 2. General Electric Co.; Electrical Distribution & Control Division
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D/Group Schneider

- B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - 3. Electronic Trip-Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and 12t response.
 - 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller and let-through ratings less than NEMA FU 1, RK-5.
 - 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
 - 6. GFCI Circuit Breakers: Single- and two-pole configurations with 5 -mA trip sensitivity.

- C. Molded-Case Circuit-Breaker Features and Accessories:
 - 1. Standard frame sizes, trip ratings, and number of poles.
 - 2. Lugs: Mechanical style suitable for number, size, trip ratings, and conductor material.
 - 3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
 - 4. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - 5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
 - 6. Auxiliary Switch: One SPOT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

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- 7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 - 8. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
- D. Molded-Case Switches: Molded-case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
- E. Molded-Case Switch Accessories:
- 1. Lugs: Mechanical style suitable for number, size, trip ratings, and material of conductors.
 - 2. Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment.
 - 3. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage. Provide "dummy" trip unit where required for proper operation.
 - 4. Auxiliary Switch: One SPOT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - 5. Key Interlock Kit: Externally mounted to prohibit operation; key shall be removable only when switch is in off position.

2.05 ENCLOSURES

- A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
- 1. Outdoor Locations: NEMA 250, Type 3R.
 - 2. Corrosive Areas: NEMA 250, Type 4X, stainless steel.
 - 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - 4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.
- B. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.

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- C. Comply with mounting and anchoring requirements specified in Division 16 Section "Electrical Supports and Seismic Restraints."
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.03 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in 26 05 53 "Electrical Identification."
- B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate as specified in 26 05 53 "Electrical Identification."

3.04 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Prepare for acceptance testing as follows:
 - 1. Inspect mechanical and electrical connections.
 - 2. Verify switch and relay type and labeling verification.
 - 3. Verify rating of installed fuses.
 - 4. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.
- C. Testing Agency : Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
 - 1. Test mounting and anchorage devices according to requirements in Division 16 Section "Electrical Supports and Seismic Restraints."
 - 2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
 - 3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 4. Infrared Scanning:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors or panels so connections are accessible to portable scanner.
 - b. Follow-Up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 11 months after date of Substantial Completion.
 - c. Instruments, Equipment and Reports:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 2) Prepare a certified report that identifies enclosed switches and circuit breakers included and describes scanning results. Include notation of

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deficiencies detected, remedial action taken and observations after remedial action.

3.05 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

3.06 CLEANING

- A. On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.
- B. Inspect exposed surfaces and repair damaged finishes.

END OF SECTION

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SECTION 26 32 13.1

MOBILE DIESEL ENGINE GENERATOR SET

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PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM): A335/A335M, Specification for Seamless Ferritic Alloy-Steel Pipe for High-Temperature Service.
 2. Code of Federal Regulations (CRF): Title 40 Volume 18, Control of Emissions from New and In-Use Non-road Compression-Ignition Engines.
 3. National Electric Manufacturer's Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. MG 1, Motors and Generators.
 4. SAE International (SAE): J1074, Engine Sound Level Measurement.
 5. Underwriters Laboratories, Inc. (UL):
 - a. 142, Steel Aboveground Tanks for Flammable and Combustible Liquids.
 - b. 508, Industrial Control Equipment.
 - c. 1236, Battery Chargers for Charging Engine-Starter Batteries.
 - d. 2085, Protected Aboveground Tanks for Flammable and Combustible Liquids.
 - e. 2200, Stationary Engine Generator.
- B. This Specification is representative of a diesel generator. Loads listed are an example and will be adjusted depending on the application of the generator.

1.02 SUBMITTALS

- A. Action Submittals:
1. Dimensioned outline drawing showing plan and elevations of engine generator set and drive system.
 2. Paragraph by paragraph specification compliance statement, describing differences between specified and proposed equipment.
 3. Engine, generator and trailer total weight.
 4. Catalog information and technical description; include materials for block, heads, valves, rings, cylinders, pistons, crankshaft, and major bearings and wear surfaces.
 5. Complete list of accessories provided.
 6. Performance curves showing engine efficiency (fuel consumed per kWh output), gross fuel consumption rate, and kW output at design rated output, one-half load, and one-quarter load. Account for design altitude, temperature corrections, and engine parasitic loads.

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7. Transient and subtransient reactances per unit.
 8. Output waveform and telephone interference factor (TIF).
 9. Circuit breaker data, including make model, catalog number, settings, and time current curves.
 10. Control panel instrument identification inscriptions.
 11. Sample guarantee.
 12. Electrical schematic and wiring diagrams for the following:
 - a. Generator control panel.
 - b. Main generator.
 - c. Voltage regulator.
 - d. Battery charging system.
 - e. Governing system.
 - f. Enclosed electrical components.
 13. Engine generator set motor starting capability and percent voltage dip curve.
 14. Block heater size and voltage.
 15. Fuel transfer pump size and voltage.
 16. Subbase tank size and dimensions.
 17. Noise data for enclosed engine generator at 50 percent, 75 percent, and full load.
- B. Informational Submittals:
1. Manufacturer's Certificate of compliance with specified EPA emissions requirements.
 2. Certification, copies of analyses, or test reports demonstrating appropriate vibration analysis and design in all modes.
 3. Factory Test Report.
 4. Generator set UL 2200 certification documentation.
 5. Operation and Maintenance Data.
 6. Description of parts and service availability.
 7. Special guarantee.

1.03 QUALITY ASSURANCE

- A. Authority Having Jurisdiction (AHJ):
1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
 2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.
- B. Manufacturer Special Requirements:
1. Generator set shall be listed to UL 2200 or submitted to an independent third party certification process to verify compliance as installed.
 2. Manufacturer of generator set shall be certified to ISO 9001 and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

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1.04 AIR QUALITY PERMIT

A. Provided by OWNER.

1.05 SPECIAL GUARANTEE

A. Provide manufacturer's guarantee or warranty with no deductibles and including travel time, service hours, repair parts and expendables (oil, filters, antifreeze and other items required for the complete repair) with OWNER named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction of the Work specified in this Specification section found defective during a period of 2 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

<u>Item</u>	<u>Quantity</u>
Diesel fuel line filter elements	3 complete sets
Lubricating oil filter elements with gasket	3 complete sets
Air cleaner filter element	1 complete set
Cooling fan drive belt (if applicable)	2 complete sets
Hydrometer	1 each
Two-pronged battery voltmeter	1 each
Spare fuses, if used in control panel	1 complete set
Spare indicating lamps (if applicable)	4 each type used
Touch up paint	1 quart each color used
Special tools required to maintain or dismantle engine generator set	1 complete set

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and equipment specified in this section shall be products of:
1. Caterpillar
2. Cummins

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2.02 SERVICE CONDITIONS

- A. Ambient Temperature at Air Intake: 122 degrees F maximum.
- B. Ambient Temperature at Engine Generator Set: 122 degrees F maximum.

2.03 GENERAL

- A. Ratings:
 - 1. Operate at 1,800 rpm.
 - 2. Standby Rated 500kW-750kW
 - 3. Voltage: 480Y/277 volts, three-phase, 4-wire, 60-Hz.
- B. Emissions:
 - 1. Engines shall meet emission requirements specified in 40 CFR Chapter I Part 89 for off-highway Internal Combustion (IC) engines.

2.04 ENGINE

- A. General:
 - 1. Manufacturer's standard design, unless otherwise specified.
 - 2. Engine parts designed with adequate strength for specified duty.
- B. Type:
 - 1. Diesel Cycle, 4-stroke type with unit mounted radiator and fan cooling.
 - 2. Minimum displacement shall be as recommended by generator manufacturer.
 - 3. Minimum number of cylinders shall be as recommended by generator manufacturer.
- C. Starting System:
 - 1. Type: Automatic, using 12-volt or 24-volt battery-driven starter acting in response to control panel.
 - 2. Starter shall be capable of three complete cranking cycles without overheating.
 - 3. Batteries:
 - a. Sized as recommended by engine manufacturer.
 - b. Lead-acid type.
 - c. Capable of providing 15 seconds minimum of cranking current at 0 degree C and three complete 15-second cranking cycles at 50 degrees C.
 - d. Housed in acid-resistant frame isolated from engine generator main frame.
 - e. Located such that maintenance and inspection of engine is not hindered.
 - f. Complete with battery cables and connectors.
 - 4. Battery Charger:
 - a. UL 1236 listed and labeled.

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- b. 10-amp automatic float, taper and equalize charge type, with plus or minus 1 percent voltage regulation over a plus or minus 10 percent input voltage variation.
- c. Temperature compensated to operate over an ambient range of minus 30 degrees C to 50 degrees C.
- d. Locate charger in generator control panel, or wall mounted in generator enclosure.
- e. Include:
 - 1) Ammeter and voltmeter.
 - 2) Fused ac input and dc output.
 - 3) Power ON pilot light.
 - 4) AC failure relay and light.
 - 5) Low and high dc voltage alarm relay and light.
- f. Alarm relay dry contacts rated 4 amps at 120V ac.

D. Fuel System:

- 1. Engine driven, mechanical, positive displacement fuel pump.
- 2. Fuel filter with replaceable spin-on canister element.
- 3. Fuel Connections to Engine: Flexible hose, suitable for application.

E. Governing System:

- 1. Electro-mechanical or electro-hydraulic type.
- 2. Regulates speed as required to hold generating frequency within tolerable limits and within 5 percent of nominal design speed.
- 3. Accessories:
 - a. Manual speed control device.
 - b. Positive overspeed trip switch.

F. Jacket Water Cooling System:

- 1. Radiator: As recommended by manufacturer to provide cooling.
- 2. Engine Thermostat: As recommended by manufacturer to regulate engine water temperature.
- 3. Jacket Water Heater:
 - a. Suitable for operation on 120-volt, single-phase, 60-Hz current.
 - b. Maintain engine water temperature at 120 degrees F with an ambient temperature of 50 degrees F.
 - c. Thermostatically controlled.
- 4. Engine Cooling Liquid: Fill cooling system with a 50/50-ethylene glycol/water mixture prior to shipping.

G. Lubrication System:

- 1. Type: Full-pressure.
- 2. Accessories:
 - a. Pressure switch to initiate shutdown on low oil pressure.
 - b. Oil filter with replaceable element.
 - c. Bayonet type oil level stick.
 - d. Valved oil drain extension.
- 3. Oil Cooling System: Water-cooled heat exchanger utilizing jacket water.

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- H. Exhaust System:
 - 1. Muffler: Rated for as recommended by generator manufacturer to meet noise requirements specified under Article Sound Attenuation.
 - 2. Exhaust Pipe: ASTM A53, standard wall, with fittings selected to match piping materials.
 - 3. Pipe Connections: Welded.
 - 4. Engine Connection:
 - a. Flanged, flexible, corrugated, Type 321 stainless steel expansion fitting, specifically suited for diesel exhaust service.
 - b. Length as required for flexibility.
- I. Air Intake System: Equip with dry type air cleaner with filter service (restriction) indicator.

2.05 GENERATOR

- A. General:
 - 1. Meet requirements of NEMA MG 1.
 - 2. Overspeed Capability: 125 percent.
 - 3. Waveform Deviation from Sine Wave: 5 percent maximum.
 - 4. Telephone Interference Factor: 50 maximum.
 - 5. Total Harmonic Current and Voltage Distortion: 5 percent maximum, measured at generator main circuit breaker.
- B. Voltage Regulation:
 - 1. Solid state, three-phase sensing type.
 - 2. Adjustable output voltage level to plus or minus 5 percent.
 - 3. Provisions for proper voltage regulation for existing or future adjustable frequency drives as part of generator load.
- C. Voltage and Frequency Regulation Performance:
 - 1. Steady State Voltage Regulation: Less than plus or minus 1 percent from no load to continuous rating point.
 - 2. NEMA MG 1 Defined Transient Voltage Dip:
 - a. Less than 20 percent at rapid application of rated load.
 - b. Recovery to rated voltage and frequency within 2 seconds following initial load application.
 - 3. Steady State Frequency Regulation: Plus or minus 1.5-Hz overload range.

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- D. Short Circuit Capabilities: Sustain 300 percent of rated current for 10 seconds for external three-phase bolted fault without exceeding rated temperatures.
- E. Main Circuit Breaker:
 - 1. Type: Molded case.
 - 2. Current Rating: As recommended by generator manufacturer.
 - 3. Interrupt Rating: 100,000 amps RMS symmetrical at 480 volts.
 - 4. Short Time Rating: As required.
 - 5. Trips:
 - a. Solid state, RMS sensing.
 - b. Adjustable Functions:
 - 1) Long-time current pickup.
 - 2) Long-time delay.
 - 3) Normal range instantaneous short-time pickup short-time delay.
 - 4) Short-time delay with I2t function.
 - 5) Ground fault pickup.
 - 6) Ground fault delay.

2.06 INTEGRAL SUBBASE FUEL TANK

- A. General:
 - 1. Full load operation of generator set for 24 hours.
 - 2. UL 142 listed and labeled.
 - 3. Installation shall be in compliance to NFPA 37.
 - 4. Double-walled, steel construction and shall include the following features:
 - a. Emergency tank and basin vents.
 - b. Mechanical level gauge.
 - c. Fuel supply and return lines, connected to generator set with flexible fuel lines as recommended by engine manufacturer and in compliance to UL 2200 and NFPA 37 requirements.

2.07 AUTOMATIC LOAD TRANSFER CONTROL

- A. Automatic run controls shall be suitable for remote interface and control by automatic transfer switch. Engine generator set shall start and run upon closure of a remote dry contact provided at existing automatic transfer switch.

2.08 CONTROL SYSTEM

- A. Control Panel:
 - 1. UL 508 listed.
 - 2. Tested to meet or exceed IEEE 587 requirements for voltage surge resistance.
 - 3. Controls shall be solid-state, microprocessor based. Control panel shall be designed and built by generator manufacturer and shall provide operating, monitoring, and control functions for generator set.
- B. Instrumentation:
 - 1. Type: Suitable for engine-mounted vibration environment.

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2. Mounting: Nonshock mounted.
 3. Alarm and Signal Contacts: Rated 5 amps at 120V ac, dry.
 4. Fault Indication Lamps: Push-to-test type.
 5. Meters: Digital, plus or minus 2 percent accuracy.
- C. Operator Controls and Indicators:
1. HANDCRANK/STOP/AUTO/ENGINE TEST selector switch.
 2. Generator voltage adjustment.
 3. Voltmeter PHASE SELECTOR switch.
 4. Ammeter PHASE SELECTOR switch.
 5. Voltmeter.
 6. Ammeter.
 7. Kilo-Watts (kW).
 8. Power Factor.
 9. FREQUENCY meter.
 10. Engine OIL PRESSURE indicator.
 11. Engine jacket WATER TEMPERATURE indicator.
 12. Engine SPEED indicator (RPM).
 13. Engine OIL TEMPERATURE indicator.
 14. RUNNING TIME indicator.
 15. DC battery voltage.
 16. Emergency Stop button.
- D. Alarm Indicators with Manual Pushbutton RESET:
1. Low oil pressure.
 2. High jacket water temperature.
 3. Engine overspeed.
 4. Engine overcrank.
 5. Low/high dc voltage.
- E. External Interfaces:
1. Furnish a single, common DPDT relay output upon occurrence of alarm condition.
 2. Output: Dry contact rated 5 amps at 120V ac.
 3. Accept remote dry start contact closure from automatic transfer switch, rated 10 amps at 32V dc.
- F. Functional Requirements:
1. LCD text display of alarm/event descriptions.
 2. Recracking Lockout: When engine fires, starting control shall automatically disconnect cranking control to prevent recracking for a preset period of time after engine stop.
 3. Overcranking Lockout: Initiate after four cranking cycles of 10 seconds on and 10 seconds off or provide continuous cranking cycle with crank time limiter.
 4. Cooldown timer, adjustable from 5 minutes to 60 minutes.
 5. Alarms:
 - a. Low coolant level.
 - b. Low fuel level.
 - c. Low battery voltage

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- d. High battery voltage.
- e. Battery charger failure.
- 6. Engine shutdown upon any of the following conditions:
 - a. Engine overspeed.
 - b. Emergency stop button depressed.
 - c. High jacket water temperature
 - d. Low oil pressure alarm setpoint and shutdown setpoint.
- 7. Air Inlet Damper Opening:
 - a. Upon engine start sequence initiation, a normally closed, dry contact, rated 5 amps at 120V ac, from engine start circuit shall open to provide a signal to open air inlet dampers.
 - b. Air inlet dampers shall fail open.

G. Power Requirements: Manufacturers standard internally connected.

2.09 OUTDOOR WEATHER-PROTECTIVE ENCLOSURE

- A. General:
- 1. Provide generator set with outdoor enclosure, with entire package listed under UL 2200.
 - 2. Two-axle chassis.
 - 3. Package shall comply with requirements of NEC for wiring materials and component spacing.
 - 4. Design total assembly of generator set, enclosure, and subbase fuel tank (when used) to be lifted into place using spreader bars.
 - 5. Housing:
 - a. Provide ample airflow for generator set operation at rated load in ambient temperature of 100 degrees F.
 - b. Doors:
 - 1) Hinged access doors as required to maintain easy access for operating and service functions.
 - 2) Lockable and include retainers to hold door open during service.
 - 6. Roof: Cambered to prevent rainwater accumulation.
 - 7. Openings: Screened to limit access of rodents into enclosure.
 - 8. Electrical power and control interconnections shall be made within perimeter of enclosure.
 - 9. Finishes:
 - a. Prime sheet metal for corrosion protection and finish painted with manufacturer's standard color using a two-step electrocoating paint process, or equal.
 - b. Prime and paint surfaces of metal parts.
 - 10. Hardware and hinges shall be austenitic stainless steel.
 - 11. Exhaust Silencer:
 - a. Install factory-mounted exhaust silencer inside enclosure.
 - b. Exhaust shall exit enclosure through a rain collar and terminate with a rain cap.
 - c. Exhaust connections to generator set shall be through seamless flexible connections.
 - 12. Inlet ducts shall include rain hoods.

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13. Provide external emergency stop switch that is protected from accidental actuation.
14. Provide factory mounted and wired electrical provisions including:
 - a. Two duplex GFI receptacles, one inside enclosure, and one weatherproof receptacle on outside of enclosure.
 - b. Two three-way switches controlling three ac lamps mounted in vapor tight and gasketed fixtures.
 - c. Normal ac service from existing panelboard to engine coolant, alternator heaters, and battery charger.
 - d. 120V single phase branch circuits will be provided from existing panelboards, coordinate size of circuit breakers and wiring required with OWNER.
15. Sound Attenuation:
 - a. Provide with sound-attenuated housing which allows generator set to operate at full rated load in an ambient temperature of up to 100 degrees F.
 - b. Enclosure shall reduce sound level of generator set while operating at full rated load to a maximum of 72 dBA at any location 7 meters from generator set in a free field environment when tested in accordance with SAE J1074.
 - c. Insulate enclosure with nonhydroscopic materials.

2.10 FACTORY FINISHING

- A. Engine Generator Set and Instrument Panel: Factory-applied primer and two finish coats of manufacturer's standard heat-resistant engine paint.

2.11 FACTORY TESTS

- A. General: Conform to NFPA 110.
- B. Steady Load Test: Test engine generator set at steady load run of 60 minutes minimum duration at 100 percent full-rated load.
- C. Transient Load Test: Conduct transient load test to demonstrate ability to meet load pickup and load release requirements specified.
- D. Harmonic Test: Conduct at full load conditions on actual unit or one of same size and model.
- E. Record and Report:
 1. Strip chart recording and full harmonic analysis measuring up to 50th harmonic for both voltage and current and three phases simultaneously.
 2. Transient response.
 3. Load/speed stability.
 4. Engine fuel consumption.
 5. Power output.
 6. Harmonic analysis.

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PART 3 EXECUTION

3.01 INSTALLATION

- A. Level and securely mount engine generator set on a trailer in accordance with manufacturer's recommendations.
- B. Where applicable, mount engine generator set on vibration isolators in accordance with isolator manufacturer's recommendations.

3.02 FIELD FINISHING

- A. Touch up damaged coating with paint system compatible to existing.

3.03 FIELD TESTS

- A. General:
 - 1. Conform to NFPA 110.
 - 2. Fuel provided by CONTRACTOR.
 - 3. Top off fuel after testing.
- B. Performance Test:
 - 1. Perform upon completion of installation.
 - 2. Operate 2 hours minimum.
 - 3. Manufacturer's representative shall make necessary adjustments.
 - 4. Demonstrate ability of engine generator set to carry specified loads (provide load bank for testing).
 - 5. Demonstrate engine generator set safety shutdowns.
- C. Test Report: Record and report the following:
 - 1. Electric load on generator.
 - 2. Fuel consumption.
 - 3. Exhaust temperature.
 - 4. Ambient air temperature.
 - 5. Safety shutdown performance results.
 - 6. Noise levels at 7 meters.
- D. Post-test Requirements:
 - 1. Make final adjustments.
 - 2. Replace fuel and oil filters.
 - 3. Check belt drive tensions.
 - 4. Demonstrate proper operation of equipment, including automatic operation with control from automatic transfer switch, to ENGINEER and OWNER.

END OF SECTION

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SECTION 26 32 13.13

DIESEL ENGINE GENERATOR SET

[CLICK HERE TO ENTER PROJECT NAME](#)
CCWRD PROJECT NO. [CLICK HERE TO ENTER CCWRD PROJECT NO.](#)

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM): A335/A335M, Specification for Seamless Ferritic Alloy-Steel Pipe for High-Temperature Service.
 2. California Air Resources Board (CARB).
 3. Code of Federal Regulations (CRF): Title 40 Volume 18, Control of Emissions from New and In-Use Non-road Compression-Ignition Engines.
 4. International Organization for Standardization (DIN/ISO): 9001, Quality Management Systems—Fundamentals and Vocabulary.
 5. National Electric Manufacturer’s Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. MG 1, Motors and Generators.
 6. National Electrical Contractors Association (NECA): 404, Recommended Practice for Installing Generator Sets.
 7. National Fire Protection Association (NFPA):
 - a. 37, Installation and Use of Stationary Combustion Engines and Gas Turbines.
 - b. 70, National Electric Code.
 - c. 110, Emergency and Standby Power Systems.
 8. SAE International (SAE): J1074, Engine Sound Level Measurement.
 9. Underwriters Laboratories, Inc. (UL):
 - a. 142, Steel Aboveground Tanks for Flammable and Combustible Liquids.
 - b. 508, Industrial Control Equipment.
 - c. 1236, Battery Chargers for Charging Engine-Starter Batteries.
 - d. 2085, Protected Aboveground Tanks for Flammable and Combustible Liquids.
 - e. 2200, Stationary Engine Generator.
- B. This Specification is representative of a diesel generator. Adjustments will be made for a natural gas generator of the same size. Loads listed are an example and will be adjusted depending on the application of the generator.

1.02 SUBMITTALS

- A. Action Submittals:
1. Dimensioned outline drawing showing plan and elevations of engine generator set and drive system.

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2. Paragraph by paragraph specification compliance statement, describing differences between specified and proposed equipment.
3. Engine and generator weight, and anchoring requirements.
4. Catalog information and technical description; include materials for block, heads, valves, rings, cylinders, pistons, crankshaft, and major bearings and wear surfaces.
5. Complete list of accessories provided.
6. Performance curves showing engine efficiency (fuel consumed per kWh output), gross fuel consumption rate, and kW output at design rated output, one-half load, and one-quarter load. Account for design altitude, temperature corrections, and engine parasitic loads.
7. Transient and subtransient reactances per unit.
8. Output waveform and telephone interference factor (TIF).
9. Circuit breaker data, including make model, catalog number, settings, and time current curves.
10. Control panel instrument identification inscriptions.
11. Sample guarantee.
12. Electrical schematic and wiring diagrams for the following:
 - a. Generator control panel.
 - b. Main generator.
 - c. Voltage regulator.
 - d. Battery charging system.
 - e. Governing system.
 - f. Interconnection wiring diagram for automatic transfer switch.
 - g. Enclosed electrical components.
13. Engine generator set motor starting capability and percent voltage dip curve.
14. Block heater size and voltage.
15. Heated fuel strainer system size and voltage.
16. Jacket water heater size and voltage.
17. Fuel transfer pump size and voltage.
18. Subbase tank size and dimensions.
19. Noise data for enclosed engine generator at 50 percent, 75 percent, and full load.
20. Anchorage and bracing drawings and cut sheets, as required by Section 01 81 02, Seismic Design Criteria.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 81 02, Seismic Design Criteria.
2. Manufacturer's Certificate of compliance with specified EPA emissions requirements.
3. Certification, copies of analyses, or test reports demonstrating appropriate vibration analysis and design in all modes.
4. Factory Test Report.
5. Generator set UL 2200 certification documentation.
6. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
7. Description of parts and service availability.

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8. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 75 05, Testing, Training, and Startup.
9. Special guarantee.

1.03 QUALITY ASSURANCE

- A. Authority Having Jurisdiction (AHJ):
1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
 2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.
- B. Manufacturer Special Requirements:
1. Generator set shall be listed to UL 2200 or submitted to an independent third party certification process to verify compliance as installed.
 2. Manufacturer of generator set shall be certified to ISO 9001 and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

1.04 AIR QUALITY PERMIT

- A. **Provided by OWNER.**

1.05 SPECIAL GUARANTEE

- A. Provide manufacturer's guarantee or warranty with no deductibles and including travel time, service hours, repair parts and expendables (oil, filters, antifreeze and other items required for the complete repair) with OWNER named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction of the Work specified in this Specification section found defective during a period of 2 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

1.06 EXTRA MATERIALS

- A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

Item	Quantity
Diesel fuel line filter elements	3 complete sets
Lubricating oil filter elements with gasket	3 complete sets
Air cleaner filter element	1 complete set

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Item	Quantity
Cooling fan drive belt (if applicable)	2 complete sets
Hydrometer	1 each
Two-pronged battery voltmeter	1 each
Spare fuses, if used in control panel	1 complete set
Spare indicating lamps (if applicable)	4 each type used
Touch up paint	1 quart each color used
Special tools required to maintain or dismantle engine generator set	1 complete set

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Materials and equipment specified in this section shall be products of:
1. Caterpillar; Model C7.1.
 2. Cummins; Equivalent Model.

2.02 SERVICE CONDITIONS

- A. Ambient Temperature at Air Intake: 122 degrees F maximum.
- B. Ambient Temperature at Engine Generator Set: 122 degrees F maximum.

2.03 GENERAL

- A. Ratings:
1. Operate at 1,800 rpm.
 2. Rated at 200kW at 0.8 PF, based on specified service conditions.
 3. Voltage: 480Y/277 volts, three-phase, 4-wire, 60-Hz.
 4. Rated based on standby service.
- B. Emissions:
1. Engines shall meet emission requirements specified in 40 CFR Chapter I Part 89 for off-highway Internal Combustion (IC) engines.
- C. Vibration Design:
1. Use vibration analytical techniques to determine shaft critical speeds, and to develop bearing design and shaft balancing to mitigate vibration.
 2. Apply torsional analysis and design to mitigate torsional vibration.
 3. Engine and generator, individually, shall not exhibit vibration in any plane exceeding 10 mils at continuous rating point, when measured at attachment points to common steel subbase.

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2.04 ENGINE

- A. General:
1. Manufacturer's standard design, unless otherwise specified.
 2. Engine parts designed with adequate strength for specified duty.
- B. Type:
1. Diesel Cycle, 4-stroke type with unit mounted radiator and fan cooling.
 2. Minimum displacement shall be as recommended by generator manufacturer.
 3. Minimum number of cylinders shall be as recommended by generator manufacturer.
- C. Starting System:
1. Type: Automatic, using 12-volt or 24-volt battery-driven starter acting in response to control panel.
 2. Starter shall be capable of three complete cranking cycles without overheating.
 3. Batteries:
 - a. Sized as recommended by engine manufacturer.
 - b. Lead-acid type.
 - c. Capable of providing 15 seconds minimum of cranking current at 0 degree C and three complete 15-second cranking cycles at 50 degrees C.
 - d. Housed in acid-resistant frame isolated from engine generator main frame.
 - e. Located such that maintenance and inspection of engine is not hindered.
 - f. Complete with battery cables and connectors.
 4. Battery Charger:
 - a. UL 1236 listed and labeled.
 - b. 10-amp automatic float, taper and equalize charge type, with plus or minus 1 percent voltage regulation over a plus or minus 10 percent input voltage variation.
 - c. Temperature compensated to operate over an ambient range of minus 30 degrees C to 50 degrees C.
 - d. Locate charger in generator control panel, or wall mounted in generator enclosure.
 - e. Include:
 - 1) Ammeter and voltmeter.
 - 2) Fused ac input and dc output.
 - 3) Power ON pilot light.
 - 4) AC failure relay and light.
 - 5) Low and high dc voltage alarm relay and light.
 - f. Alarm relay dry contacts rated 4 amps at 120V ac.
- D. Fuel System:
1. Engine driven, mechanical, positive displacement fuel pump.
 2. Fuel filter with replaceable spin-on canister element.
 3. As specified under Article Integral Subbase Fuel Tank.

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4. Fuel Connections to Engine: Flexible hose, suitable for application.
- E. Governing System:
1. Electro-mechanical or electro-hydraulic type.
 2. Regulates speed as required to hold generating frequency within tolerable limits and within 5 percent of nominal design speed.
 3. Accessories:
 - a. Manual speed control device.
 - b. Positive overspeed trip switch.
- F. Jacket Water Cooling System:
1. Radiator:
 - a. Consisting of jacket water pump, fan assembly, fan guard, and duct flange outlet.
 - b. Cooling System: Rated for full load operation in 122 degrees F (50 degrees C) ambient as measured at alternator air inlet.
 - c. Fan: Suitable for use in a system with 0.5 in H₂O restriction.
 - d. Sized based on a core temperature that is 20 degrees F higher than rated operation temperature.
 2. Engine Thermostat: As recommended by manufacturer to regulate engine water temperature.
 3. Jacket Water Heater:
 - a. Suitable for operation on 120-volt, single-phase, 60-Hz current.
 - b. Maintain engine water temperature at 120 degrees F with an ambient temperature of 50 degrees F.
 - c. Thermostatically controlled.
 4. Engine Cooling Liquid: Fill cooling system with a 50/50-ethylene glycol/water mixture prior to shipping.
- G. Lubrication System:
1. Type: Full-pressure.
 2. Accessories:
 - a. Pressure switch to initiate shutdown on low oil pressure.
 - b. Oil filter with replaceable element.
 - c. Bayonet type oil level stick.
 - d. Valved oil drain extension.
 3. Oil Cooling System: Water-cooled heat exchanger utilizing jacket water.
- H. Exhaust System:
1. Muffler: Rated for as recommended by generator manufacturer to meet noise requirements specified under Article Sound Attenuation.
 2. Exhaust Pipe: ASTM A53, standard wall, with fittings selected to match piping materials.
 3. Pipe Connections: Welded.
 4. Engine Connection:
 - a. Flanged, flexible, corrugated, Type 321 stainless steel expansion fitting, specifically suited for diesel exhaust service.
 - b. Length as required for flexibility.

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- I. Air Intake System: Equip with dry type air cleaner with filter service (restriction) indicator.

2.05 GENERATOR

- A. General:
 - 1. Meet requirements of NEMA MG 1.
 - 2. Synchronous type with 2/3 pitch, revolving field, drip-proof construction, air cooled by a direct drive centrifugal blower fan.
 - 3. Stator Windings:
 - a. Skewed for smooth voltage waveform.
 - b. Reconnectable, 12 lead.
 - 4. Overspeed Capability: 125 percent.
 - 5. Waveform Deviation from Sine Wave: 5 percent maximum.
 - 6. Telephone Interference Factor: 50 maximum.
 - 7. Total Harmonic Current and Voltage Distortion: 5 percent maximum, measured at generator main circuit breaker.
- B. Insulation System:
 - 1. Class H, with a maximum rise of 125 degrees C over 40 degree C ambient in accordance with NEMA MG 1.
 - 2. Epoxy varnish.
- C. Excitation System:
 - 1. Field brushless type or permanent magnet generator (PMG) exciter.
 - 2. PMG and Controls: Capable of providing regulated current, at a rate of 300 percent of nameplate current, to a single-phase or three-phase fault for 10 seconds.
- D. Voltage Regulation:
 - 1. Solid state, three-phase sensing type.
 - 2. Adjustable output voltage level to plus or minus 5 percent.
 - 3. Provisions for proper voltage regulation for existing or future adjustable frequency drives as part of generator load.
- E. Voltage and Frequency Regulation Performance:
 - 1. Steady State Voltage Regulation: Less than plus or minus 1 percent from no load to continuous rating point.
 - 2. NEMA MG 1 Defined Transient Voltage Dip:
 - a. Less than 20 percent at rapid application of rated load.
 - b. Recovery to rated voltage and frequency within 2 seconds following initial load application.
 - 3. Steady State Frequency Regulation: Plus or minus 1.5-Hz overload range.
- F. Motor Starting Capability:
 - 1. Apply loads in the order listed in the following table, as shown on Drawings. Consult with ENGINEER for stepped start of loads from remote controllers.

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Load Table					
Step	Load Description	Rating	Type (Hp, Kw, Amps)	Starting Type	Largest Motor
1	Lighting Transformer	15	kVA	Full Voltage	-
2	Pump 3	50	HP	Full Voltage	50
3	Pump 4	50	HP	Full Voltage	50
4	Pump 2	50	HP	Full Voltage	50
5	Pump 5	20	HP	Full Voltage	20
6	Pump 1	20	HP	Full Voltage	20
7	Seal Water Booster Pump	2	HP	Full Voltage	2

- G. Short Circuit Capabilities: Sustain 300 percent of rated current for 10 seconds for external three-phase bolted fault without exceeding rated temperatures.
- H. Main Circuit Breaker:
1. Type: Molded case.
 2. Current Rating: As recommended by generator manufacturer.
 3. Interrupt Rating: 42,000 amps RMS symmetrical at 480 volts.
 4. Short Time Rating: As required.
 5. Trips:
 - a. Solid state, RMS sensing.
 - b. Adjustable Functions:
 - 1) Long-time current pickup.
 - 2) Long-time delay.
 - 3) Normal range instantaneous short-time pickup short-time delay.
 - 4) Short-time delay with I2t function.
 - 5) Ground fault pickup.
 - 6) Ground fault delay.
 6. Enclosure:
 - a. Rating: NEMA 250, Type 3R.
 - b. Mounted with vibration isolation from engine generator set.
 7. Surge Protective Devices: Three-phase capacitors and arresters mounted in terminal compartment.

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2.06 BASEPLATE

- A. Mount engine generator set on a rigid common steel base frame.
- B. Base frame shall be stiffened to minimize deflections.

2.07 INTEGRAL SUBBASE FUEL TANK

- A. General:
 - 1. Full load operation of generator set for 24 hours.
 - 2. UL 142 listed and labeled.
 - 3. Installation shall be in compliance to NFPA 37.
 - 4. Double-walled, steel construction and shall include the following features:
 - a. Emergency tank and basin vents.
 - b. Mechanical level gauge.
 - c. Fuel supply and return lines, connected to generator set with flexible fuel lines as recommended by engine manufacturer and in compliance to UL 2200 and NFPA 37 requirements.
 - d. Leak detection provisions, wired to generator set control for local and remote alarm indication.
 - e. High and low level float switches to indicate fuel level. Wire switches to generator control for local and remote indication of fuel level.
 - f. Basin drain.
 - g. Integral lifting provisions.

2.08 VIBRATION ISOLATORS

- A. Performance: Meet code requirements specified in Section 01 61 00, Common Product Requirements.
- B. Provide vibration isolators, spring/pad type.
- C. Include seismic restraints if required by Site location.

2.09 AUTOMATIC LOAD TRANSFER CONTROL

- A. Automatic run controls shall be suitable for remote interface and control by automatic transfer switch. Engine generator set shall start and run upon closure of a remote dry contact provided at existing automatic transfer switch.

2.10 CONTROL SYSTEM

- A. Control Panel:
 - 1. Rating: NEMA 250, Type 12.
 - 2. Material: Steel.
 - 3. Instrument Identification: Face label or engraved, black, laminated plastic nameplate with white 1/4-inch-high letters, attached with Type 422 stainless steel screws.
 - 4. UL 508 listed.

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5. Tested to meet or exceed IEEE 587 requirements for voltage surge resistance.
 6. Controls shall be solid-state, microprocessor based. Control panel shall be designed and built by generator manufacturer and shall provide operating, monitoring, and control functions for generator set.
- B. Instrumentation:
1. Type: Suitable for engine-mounted vibration environment.
 2. Mounting: Nonshock mounted.
 3. Alarm and Signal Contacts: Rated 5 amps at 120V ac, dry.
 4. Fault Indication Lamps: Push-to-test type.
 5. Meters: Digital, plus or minus 2 percent accuracy.
- C. Operator Controls and Indicators:
1. HANDCRANK/STOP/AUTO/ENGINE TEST selector switch.
 2. Generator voltage adjustment.
 3. Voltmeter PHASE SELECTOR switch.
 4. Ammeter PHASE SELECTOR switch.
 5. Voltmeter.
 6. Ammeter.
 7. Kilo-Watts (kW).
 8. Power Factor.
 9. FREQUENCY meter.
 10. Engine OIL PRESSURE indicator.
 11. Engine jacket WATER TEMPERATURE indicator.
 12. Engine SPEED indicator (RPM).
 13. Engine OIL TEMPERATURE indicator.
 14. RUNNING TIME indicator.
 15. DC battery voltage.
 16. Emergency Stop button.
- D. Alarm Indicators with Manual Pushbutton RESET:
1. Low oil pressure.
 2. High jacket water temperature.
 3. Engine overspeed.
 4. Engine overcrank.
 5. Low/high dc voltage.
- E. External Interfaces:
1. Furnish a single, common DPDT relay output upon occurrence of alarm condition.
 2. Output: Dry contact rated 5 amps at 120V ac.
 3. Accept remote dry start contact closure from automatic transfer switch, rated 10 amps at 32V dc.
- F. Functional Requirements:
1. LCD text display of alarm/event descriptions.
 2. Recracking Lockout: When engine fires, starting control shall automatically disconnect cranking control to prevent recracking for a preset period of time after engine stop.

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3. Overcranking Lockout: Initiate after four cranking cycles of 10 seconds on and 10 seconds off or provide continuous cranking cycle with crank time limiter.
 4. Cooldown timer, adjustable from 5 minutes to 60 minutes.
 5. Alarms:
 - a. Low coolant level.
 - b. Low fuel level.
 - c. Low battery voltage
 - d. High battery voltage.
 - e. Battery charger failure.
 6. Engine shutdown upon any of the following conditions:
 - a. Engine overspeed.
 - b. Emergency stop button depressed.
 - c. High jacket water temperature
 - d. Low oil pressure alarm setpoint and shutdown setpoint.
 7. Air Inlet Damper Opening:
 - a. Upon engine start sequence initiation, a normally closed, dry contact, rated 5 amps at 120V ac, from engine start circuit shall open to provide a signal to open air inlet dampers.
 - b. Air inlet dampers shall fail open.
- G. Power Requirements: Manufacturers standard internally connected.

2.11 OUTDOOR WEATHER-PROTECTIVE ENCLOSURE

- A. General:
1. Provide generator set with outdoor enclosure, with entire package listed under UL 2200.
 2. Package shall comply with requirements of NEC for wiring materials and component spacing.
 3. Design total assembly of generator set, enclosure, and subbase fuel tank (when used) to be lifted into place using spreader bars.
 4. Housing:
 - a. Provide ample airflow for generator set operation at rated load in ambient temperature of 100 degrees F.
 - b. Doors:
 - 1) Hinged access doors as required to maintain easy access for operating and service functions.
 - 2) Lockable and include retainers to hold door open during service.
 5. Roof: Cambered to prevent rainwater accumulation.
 6. Openings: Screened to limit access of rodents into enclosure.
 7. Electrical power and control interconnections shall be made within perimeter of enclosure.
 8. Finishes:
 - a. Prime sheet metal for corrosion protection and finish painted with manufacturer's standard color using a two-step electrocoating paint process, or equal meeting performance requirements specified below.

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- b. Prime and paint surfaces of metal parts. Painting process shall result in coating that meets the following requirements:
 - 1) Primer: 0.5 mil to 2.0 mils thick.
 - 2) Top Coat: 0.8 mil to 1.2 mils thick.
 - 3) Gloss:
 - a) Per ASTM D523, 80 percent plus or minus 5 percent.
 - b) Gloss retention after 1 year shall exceed 50 percent.
 - 4) Crosshatch Adhesion: Per ASTM D3359, 4B-5B.
 - 5) Impact Resistance: Per ASTM D2794, 120-inch to 160-inch pounds.
 - 6) Salt Spray: Per ASTM B117, plus 1,000 hours.
 - 7) Humidity: Per ASTM D2247, plus 1,000 hours.
 - 8) Water Soak: Per ASTM D2247, plus 1,000 hours.
 - c. Painting of hoses, clamps, wiring harnesses, and other nonmetallic service parts shall not be acceptable.
 - d. Fasteners used shall be corrosion-resistant and designed to minimize marring of painted surface when removed for normal installation or service work.
9. Enclosure shall be constructed of minimum 12-gauge steel for framework and 14-gauge steel for panels.
10. Hardware and hinges shall be austenitic stainless steel.
11. Exhaust Silencer:
- a. Install factory-mounted exhaust silencer inside enclosure.
 - b. Exhaust shall exit enclosure through a rain collar and terminate with a rain cap.
 - c. Exhaust connections to generator set shall be through seamless flexible connections.
12. Maintenance Provisions:
- a. Flexible coolant and lubricating oil drain lines that extend to exterior of enclosure, with internal drain valves.
 - b. External radiator-fill provision.
 - c. External fuel fill provision (if equipped with a subbased fuel tank).
13. Provide motorized louvers to minimize air flow through enclosure when generator set is not operating. Louvers shall include provisions to prevent accumulation of ice or snow that might prevent operation.
14. Inlet ducts shall include rain hoods.
15. Provide external emergency stop switch that is protected from accidental actuation.
16. Provide factory mounted and wired electrical provisions including:
- a. Two duplex GFI receptacles, one inside enclosure, and one weatherproof receptacle on outside of enclosure.
 - b. Two three-way switches controlling three ac lamps mounted in vapor tight and gasketed fixtures.
 - c. Normal ac service from existing panelboard to engine coolant, alternator heaters, and battery charger.
 - d. 120V single phase branch circuits will be provided from existing panelboards, coordinate size of circuit breakers and wiring required with OWNER.
17. Sound Attenuation:

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- a. Provide with sound-attenuated housing which allows generator set to operate at full rated load in an ambient temperature of up to 100 degrees F.
- b. Enclosure shall reduce sound level of generator set while operating at full rated load to a maximum of 74 dBA at any location 7 meters from generator set in a free field environment when tested in accordance with SAE J1074.
- c. Insulate enclosure with nonhydroscopic materials.

2.12 FACTORY FINISHING

- A. Engine Generator Set and Instrument Panel: Factory-applied primer and two finish coats of manufacturer’s standard heat-resistant engine paint.

2.13 FACTORY TESTS

- A. General: Conform to NFPA 110.
- B. Steady Load Test: Test engine generator set at steady load run of 60 minutes minimum duration at 100 percent full-rated load.
- C. Transient Load Test: Conduct transient load test to demonstrate ability to meet load pickup and load release requirements specified.
- D. Harmonic Test: Conduct at full load conditions on actual unit or one of same size and model.
- E. Record and Report:
 - 1. Strip chart recording and full harmonic analysis measuring up to 50th harmonic for both voltage and current and three phases simultaneously.
 - 2. Transient response.
 - 3. Load/speed stability.
 - 4. Engine fuel consumption.
 - 5. Power output.
 - 6. Harmonic analysis.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Level and securely mount engine generator set in accordance with manufacturer’s recommendations.
- B. Install in accordance with NECA 404.
- C. Where applicable, mount engine generator set on vibration isolators in accordance with isolator manufacturer’s recommendations.

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3.02 FIELD FINISHING

- A. Touch up damaged coating with paint system compatible to existing.

3.03 FIELD TESTS

- A. General:
 - 1. Conform to NFPA 110.
 - 2. Fuel provided by CONTRACTOR.
 - 3. Top off fuel after testing.
- B. Performance Test:
 - 1. Perform upon completion of installation.
 - 2. Operate 2 hours minimum.
 - 3. Manufacturer’s representative shall make necessary adjustments.
 - 4. Demonstrate ability of engine generator set to carry specified loads (provide load bank for testing).
 - 5. Demonstrate engine generator set safety shutdowns.
- C. Test Report: Record and report the following:
 - 1. Electric load on generator.
 - 2. Fuel consumption.
 - 3. Exhaust temperature.
 - 4. Ambient air temperature.
 - 5. Safety shutdown performance results.
 - 6. Noise levels at 7 meters.
- D. Post-test Requirements:
 - 1. Make final adjustments.
 - 2. Replace fuel and oil filters.
 - 3. Check belt drive tensions.
 - 4. Demonstrate proper operation of equipment, including automatic operation with control from automatic transfer switch, to ENGINEER and OWNER.

3.04 MANUFACTURER’S SERVICES

- A. Manufacturer’s Representative: Present at Site or classroom designated by OWNER, for minimum person-days listed below, travel time excluded:
 - 1. 1 person-day for installation assistance and inspection.
 - 2. 1 person-day for functional and performance testing and completion of Manufacturer’s Certificate of Proper Installation.
 - 3. 1/2 person-day for prestartup classroom or Site training.
 - 4. 1/2 person-day for facility startup.
 - 5. 1/2 person-day for post-startup training of OWNER’s personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by ENGINEER.
- B. See Section 01 75 05, Testing, Training, and Startup.

END OF SECTION

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SECTION 26 33 53

UNINTERRUPTIBLE POWER SUPPLY

[CLICK HERE TO ENTER PROJECT NAME](#)

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PART 1 GENERAL

1.01 SUMMARY

A. Section includes requirements for:

1. Uninterruptible Power Supplies (UPSs)
2. Automatic Transfer Switches (ATS)
3. Batteries
4. Rack
5. Installation.

1.02 REFERENCES

- A. Refer to Sections 01 42 19 and 26 05 00
- B. American National Standards Institute (ANSI)
- C. National Electrical Manufacturer's Association (NEMA)
- D. Underwriters Laboratories (UL):

1.03 DEFINITIONS

- A. Refer to Section 26 05 00.
- B. Specific definitions and abbreviations:
 1. Conduit Bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to: shapes C, E, LB, T, X, etc.
 2. Conduit Fitting: An accessory that serves primarily a mechanical purpose. Includes, but not limited to: bushings, locknuts, hubs, couplings, reducers, etc.

1.04 SYSTEM DESCRIPTION

- A. Provide UPS, ATS, Battery, Rack, conduits, conduit bodies, fittings, junction boxes and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical UPS system. Rack mounted solution required.

- B. Use existing conduit, provided it is 1 inch or larger, where available, to route new conductors. Verify that the existing conduit meets all NEC requirements including fill and size for the specified cables. Install new conduits and extend existing conduits where necessary to make a complete raceway system. Document the raceway system and label the conduits as required. Document the UPS system and label the UPS to match existing labeling/numbering system, to be coordinated with Owner. Unique designation schemes are not acceptable.
- C. Properly sized UPS inverter section per 1.04.D System shall include conduit systems, cabling and devices, as required to provide power and Ethernet connectivity with SCADA, to the UPS system.
- D. System is to be engineered to provide 30%-50% capacity (measured by volt-amperes) beyond the final applied load of the completed system. If additional run-time is required by any other section of specification, it must be accomplished through expansion batteries, not UPS inverter sizing.
- E. System shall include the following elements:
 - 1. Properly sized UPS inverter Section per 1.04 of this section.
 - 2. An external ATS to provide Utility power on failure of UPS system.
 - 3. Manufacturer specified expansion batteries to provide required run-time.
 - 4. Network connection of UPS and ATS components.
 - 5. Integration of UPS and ATS to existing network monitored system.
 - 6. Cord and Plug connections of all components in UPS enclosure (except in case of expansion battery sections).
 - 7. Output of UPS will be have properly Overcurrent Protection Devices to prevent downstream fault exceeding rating of UPS inverter and ATS. OCPD shall be fast acting breaker or fuse, sized not to exceed 200% individual protected loads.

1.05 SUBMITTALS

- A. Furnish submittals in accordance with Sections 01 33 00 and 26 05 00.
- B. Product Data:
 - 1. Furnish complete manufacturer's catalog sheets for every type and size of UPS, ATS, Battery and accessories to be used on the project.
 - 2. Furnish complete manufacturer's recommended special tools to be used for installation if required.
- C. Certifications:
 - 1. Furnish final documentation of backup power load test.
- D. As Built Documents:
 - 1. Refer to Section 01 78 39.
 - 2. Incorporate all changes on Drawings.
 - 3. Dimension underground and concealed conduits from building lines.
 - 4. Identify and record size and location of existing conduits and stub-ups used to make connections to new or existing equipment.
 - 5. Record conductors with number and size routed in new or existing conduit.

6. Furnish hard copy Drawings and electronic files in AutoCAD format Versions: 2004 - 2015.

1.06 QUALITY CONTROL

- A. Refer to Sections 01 45 00 and 26 05 00.
- B. The UPS shall pass lightning and surge protection ANSI/IEEE C62.41 standards, Category A and B. The UPS shall be UL 1449 listed.
- C. The output waveform shall be a pure sine-wave with less than 5% total harmonic distortion on the inverter.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Sections 01 66 00 and 26 05 00.
- B. Do not expose UPS, ATS, or Battery to outdoor weather conditions.
- C. Do not store in direct contact with the ground.

1.08 PROJECT OR SITE CONDITIONS

- A. Refer to Section 26 05 00.

1.09 SEQUENCING

- A. Before installing any conduit or locating any device box:
 1. Examine the complete set of Drawings and Specifications, and all applicable shop drawings.
 2. Verify all dimensions and space requirements and make any minor adjustments to the conduit and UPS system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

1.10 WARRANTY

- A. Refer to Sections 00 61 15 and 26 05 00.

1.11 SYSTEM START-UP

- A. Refer to Sections 01 75 05 and 26 05 00.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Uninterruptible Power Supply (UPS) with network cards:

1. The following:
 - a. EATON
 - 1) EATON 9PX700RT (up to 450W)
 - 2) EATON 9PX1500RTN (450 – 1200W)
 - 3) EATON 9PX3000RTN (1200 – 2200W)
 - b. GAMATRONIC Power + RM50
- B. Automatic Transfer Switch (ATS):
 1. The following:
 - a. EATS115 1.44kW
 - b. PWATSL530005 2.88kW
 - c. GAMATRONIC
- C. Battery:
 1. The following:
 - a. EATON 9PXEBM36RT
 - b. EATON 9PXEBM48RT
 - c. EATON 9PXEBM72RT
 - d. GAMATORONIC
- D. Rack:
 1. The following or Owner approved equal:
 - a. VLWM2430SB – for configurations 12U or less.
 - b. VLWM3630SB – for configurations 12U - 19U.
 - c. ENT-ENC422442SL – for floor mounted units exceeding 180lbs or 19U
 - d. GAMATRONICS (Integral)
 2. All racking systems shall have front and rear mounting brackets for UPS component mounting.

2.02 COMPONENTS

- A. Galvanized rigid steel conduit and couplings (GRC):
 1. All Threads: NPT standard conduit threads with a 3/4-inch taper per foot:
 - a. Running conduit threads are not acceptable.
 2. Hot-dip galvanized inside and out:
 - a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
 - b. Electro-galvanizing is not acceptable.
 3. Manufactured in accordance with:
 - a. UL6.
 - b. ANSI C801.
- B. PVC coated steel conduit and conduit bodies (PCS):

1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for type GRC.
2. Coated conduit conforms to NEMA Standard RN-1:
 - a. The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
3. Factory Bonded PVC Jacket:
 - a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
 - b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictate otherwise.
 - c. PVC coating on conduit and associated fittings shall have no sags, blisters, lumps, or other surface defects and free of holes and holidays.

2.03 ACCESSORIES

- A. Connectors and fittings:
 1. Manufactured with compatible materials to the corresponding conduit.
- B. Insulated throat metallic bushings
- C. Insulated grounding bushings

2.04 SOURCE QUALITY CONTROL

- A. Refer to Sections 01 45 00 and 26 05 00.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Refer to Section 26 05 00
- B. General:
 1. UPS Location:
 - a. The Electrical Drawings are diagrammatic in nature:
 - 1) Coordinate location, conduit, housekeeping pad, and receptacles.
 2. Use only tools recommended by the manufacturer for assembling system.
 3. Provide adequate clearances from high-temperature surfaces. Provide minimum clearances as follows:
 - a. Clearances of 12 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
 - b. Clearances of 24 inches from surfaces greater than 149 degrees Fahrenheit.
 - c. Where it is necessary to route conduit or install close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
- C. Lighting and Receptacle Conduits:

1. Install conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings:
 - a. Minimum conduit size:
 - 1) 1 inch for exposed conduits.
 - 2) 2 inch for underground or in slab conduits.
2. Provide conduit materials for the installed location as specified in Section 26 05 00.

D. BOXES

1. Provide materials and construction suitable for environmental conditions at the location of the box as indicated in Section 26 05 00
2. Provide outlet box materials to match the conduit system:
 - a. GRC - Cast Ferrous Boxes.
 - b. PCS - PVC Coated Cast Ferrous Boxes.
3. Solid Type Gang Boxes:
 - a. For more than 2 devices.
4. Support all wall mounted NEMA 4 or NEMA 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
 - a. Use machined spacers to maintain air space; built-up washers are not acceptable.
 - b. Use nylon or Stainless Steel materials for spacers.

E. Outlet Boxes:

1. Locate outlet boxes as indicated on the Drawings:
 - a. Receptacle feeding UPS to be located within enclosure.
 - b. Adjust locations so as not to conflict with structural requirements or other trades.
2. Use deep threaded-hub malleable iron:
 - a. Where exposed to the weather.
 - b. In unheated areas.
 - c. Where subject to mechanical damage:
 - 1) Defined as exposed boxes less than 10 feet above the floor.
3. Use deep threaded-hub plastic coated malleable iron boxes in corrosive and NEMA 4X area and when the conduit system is PVC coated steel.

F. MISCELLANEOUS:

1. Replace any conduit installed that ENGINEER determines does not meet the requirements of this Specification.

3.02 FIELD QUALITY CONTROL

- A. Refer to Sections 01 4500 and 26 05 00.

3.03 PROTECTION

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- A. Refer to Section 26 05 00.
- B. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.04 CLEANING

- A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.

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SECTION 26 36 00

TRANSFER SWITCHES

[CLICK HERE TO ENTER PROJECT NAME](#)

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PART 1 GENERAL

1.01 RELATED COCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes transfer switches.

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
 - 1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
 - 1. Features and operating sequences, both automatic and manual.
 - 2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.04 QUALITY CONTROL

- A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs at the project with one hours maximum response time.

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- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- C. Source Limitations: Obtain automatic transfer switches and bypass/isolation switches through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NEMA ICS 1.
- F. Comply with NFPA 70.
- G. Comply with NFPA 99.
- H. Comply with NFPA 110.
- I. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.05 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Contractor Transfer Switches:
 - a. Eaton Corp.
 - b. Emerson; ASCO Power Technologies, LP.
 - c. Square D
 - d. Russelectric, Inc.
 - e. Zenith Controls, Inc.

2.02 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

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- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
 - 1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
- C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
 - 1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
 - 2. Switch Action: Double throw; mechanically held in both directions.
 - 3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
- G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles or overlapping neutral contacts.
- H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
- I. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.
- J. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.
- K. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 16 Section "Electrical Identification."
 - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.

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- 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
- L. Enclosures: General-purpose NEMA 250, Type, complying with NEMA ICS 6 and UL 508, unless otherwise indicated. Enclosure shall be NEMA 3R per local amendments.

2.03 AUTOMATIC TRANSFER SWITCHES

- A. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- B. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.
- C. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- D. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- E. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.
- F. Automatic Closed-Transition Transfer Switches: Include the following functions and characteristics:
 - 1. Fully automatic make-before-break operation.
 - 2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
 - 3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
 - a. Initiation occurs without active control of generator.
 - b. Controls ensure that closed-transition load transfer closure occurs only when the 2 sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
 - 4. Failure of power source serving load initiates automatic break-before-make transfer.
- G. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

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- H. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.

- I. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.

- J. Automatic Transfer-Switch Features:
 - 1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
 - 2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
 - 3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
 - 4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
 - 5. Test Switch: Simulate normal-source failure.
 - 6. Switch-Position Pilot Lights: Indicate source to which load is connected.
 - 7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
 - 8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
 - 9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
 - 10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V de minimum.
 - 11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.

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12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine- generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
 - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
 - b. Push-button programming control with digital display of settings.
 - c. Integral battery operation of time switch when normal control power is not available.

2.04 REMOTE ANNUNCIATOR SYSTEM

- A. Functional Description: Remote annunciator panel annunciates conditions for indicated transfer switches. Annunciation includes the following :
 1. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
 2. Switch position.
 3. Switch in test mode.
 4. Failure of communications link.

2.05 SOURCE QUALITY CONTROL

- A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Floor-Mounting Switch: Anchor to floor by bolting.
 1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated.
- B. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
- C. Identify components according to 26 05 53 "Electrical Identification."
- D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

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3.02 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.
- B. Ground equipment according to 26 05 26 "Grounding and Bonding."
- C. Connect wiring according to 26 05 19 "Conductors and Cables."

3.03 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform tests and inspections and prepare test reports.
- B. Testing Agency's Tests and Inspections:
 - 1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
 - 4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
 - 5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - a. Verify grounding connections and locations and ratings of sensors.

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- C. Coordinate tests with tests of generator and run them concurrently.
- D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- E. Remove and replace malfunctioning units and retest as specified above.
- F. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
 - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. A copy of the report shall be delivered directly to the Facilities Division, Attention: Electrical Engineer.
 - 4. Schedule testing with Owner with at least seven days advance notice.

3.04 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below.
- B. Coordinate this training with that for generator equipment.
- C. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
- D. Review data in maintenance manuals.
- E. Schedule training with Owner with at least 14 days advance notice.
- F. Provide a minimum of eight hours of instruction.

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SECTION 26 43 13

SURGE PROTECTIVE DEVICES

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PART 1 GENERAL

1.01 SUMMARY

- A. Section includes requirements for: High-energy surge protective devices.

1.02 REFERENCES

- A. Refer to Sections 01 42 19 Reference Standards, and 26 05 00, Common Work Results for Electrical.
- B. Underwriters Laboratory:
 - 1. UL 1449, 4th Edition, UL Standard for Safety for Surge Protective Devices.
 - 2. UL 1283, 5th Edition, UL Standard for Safety Electromagnetic Interference Filters.

1.03 DEFINITIONS

- A. Refer to Section 26 05 00, Common Work Results for Electrical.
- B. Specific Definitions:
 - 1. SPD - Surge Protective Device.
 - 2. SAD - Silicon Avalanche Diode.
 - 3. MOV - Metal Oxide Varistor.
 - 4. MCOV - Maximum Continuous Operating Voltage.
 - 5. In - Nominal Discharge Current.
 - 6. VPR - Voltage Protection Rating.
 - 7. SCCR - Short Circuit Current Rating

1.04 SYSTEM DESCRIPTION

- A. Surge protective devices as an integral component of the electrical equipment or externally mounted as indicated on the Drawings.

1.05 SUBMITTALS

- A. Furnish submittals in accordance with Sections 01 33 00, Submittal Procedures and 26 05 00 Common Work Results for Electrical.

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- B. Product Data:
1. Furnish complete product data confirming detailed compliance or exception statements to all provisions of this Specification.
 2. Manufacturer's catalog cut sheets indicating:
 - a. Manufacturer and model numbers.
 - b. Ratings of each SPD including but not limited to:
 - 1) Short Circuit Current Rating.
 - 2) Nominal Discharge Current.
 - 3) Maximum Continuous Operating Voltage.
 - 4) Voltage Protection Rating.
 - 5) System voltage.
 - 6) System frequency.
 - 7) Surge Current Capacity.
 3. Submit independent test data from a nationally recognized testing laboratory verifying the following:
 - a. Lifecycle testing.
 - b. Overcurrent protection.
 - c. UL 1449.
 - d. Surge current capacity.
- C. Shop Drawings:
1. Provide electrical and mechanical drawings by the manufacturer that detail:
 - a. Unit dimensions.
 - b. Weights.
 - c. Components.
 - d. Field connection locations.
 - e. Mounting provisions.
 - f. Connection details.
 - g. Wiring diagram.
- D. Operation and Maintenance Manuals:
1. Provide the manufacturer's manual with installation, start-up, spare parts lists, and operating instructions for the specified system.

1.06 QUALITY CONTROL

- A. Refer to Sections 01 45 00 Quality Control and 26 05 00 Common Work Results for Electrical.
- B. Provide SPD units that are designed, manufactured, tested and installed in compliance with the following codes and standards:
1. Institute of Electrical and Electronic Engineers (IEEE C62.41, C62.45).
 2. Federal Information Processing Standards Publication 94 (FIPS PUB 94).
 3. National Electrical Manufacturer Association (NEMA LS-1 1992).
 4. National Fire Protection Association (NFPA 20,75 and 780).
 5. National Electric Code (NFPA 70).
 6. Underwriters Laboratories (UL 1449 4th Edition and UL 1283 5th Edition).
 7. International Electrotechnical Commission (IEC 801).

- C. SPD manufacturer: ISO 9001 certified for manufacturing, design, and service.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Section 26 05 00, Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. Refer to Section 26 05 00, Common Work Results for Electrical.

1.09 SEQUENCING

- A. Coordinate with, and provide SPD equipment to the electrical equipment manufacturer before final assembly and factory testing.

1.10 WARRANTY

- A. Refer to Section 26 05 00, Common Work Results for Electrical.
- B. Extended Warranty:
 - 1. Furnish a manufacturer's full 5-year parts and labor warranty from date of shipment against any part failure when installed in compliance with manufacturer's written instructions, UL Listing requirements, and any applicable national, state, or local electrical codes.
 - 2. Warranty shall include:
 - a. Direct, factory trained, ISO 9001 certified employees must be available within 48 hours for assessment of the problem.
 - b. A 24-hour toll-free 800-number for warranty support.

1.11 SYSTEM STARTUP

- A. Refer to Sections 01 75 05 Testing Training and Startup and 26 05 00 Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following:
 - 1. Liebert.
 - 2. Eaton Cutler Hammer.
 - 3. Siemens.
 - 4. Allen Bradley.

2.02 MANUFACTURED UNITS

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- A. Provide Type 1 or Type 2 SPD units as required for the locations indicated on the Drawings, or specified in equipment specifications under Division 26.
- B. Electrical Requirements:
 - 1. SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
 - 2. Maximum Continuous Operating Voltage (MCOV):
 - a. For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): greater than 115 percent of the nominal system operating voltage.
 - 3. Operating Frequency: 47 to 63 hertz.
 - 4. Short Circuit Current Rating (SCCR):
 - a. Equal to, or greater than the equipment it is connected to.
 - b. The SCCR shall be marked on the SPD in accordance with UL 1449 and the NEC.
 - 5. Nominal Discharge Current (In): 20 KA.
 - 6. Voltage Protection Rating (VPR):

Modes	208Y/120	480/277	480 Delta
L-N, L-G, N-G	800	1200	L-G 2000
L-L	1200	2000	2000

- 7. Peak Surge Current:
 - a. Service entrance locations:
 - 1) 240 KA per phase minimum.
 - 2) 120 KA per mode minimum.
 - b. Motor Control Centers, panelboards:
 - 1) 160 KA per phase, minimum.
 - 2) 80 KA per mode minimum.
 - c. Branch locations:
 - 1) 120 KA per phase, minimum.
 - 2) 60 KA per mode minimum.
- C. Protection Modes:
 - 1. Provide SPD protection modes as follows:
 - a. Line to Neutral (L-N) where applicable.
 - b. Line to Ground (L-G).
 - c. Neutral to Ground (N-G), where applicable.
 - d. Line to Line (L-L).
- D. Environmental Requirements:
 - 1. Storage Temperature: -40 degrees to +60 degrees Celsius.
 - 2. Operating Temperature: -0 degrees to +60 Celsius.
 - 3. Relative Humidity: 5 percent to 95 percent.
 - 4. Audible Noise: Less than 45 dBa at 5 feet (1.5 m).
 - 5. Operating Altitude: Zero to 12,000 feet above sea level.
- E. Provide surge protective devices that are suitable for application in IEEE C62.41 Category A, Band C3 environments, as tested to IEEE C2.11, C62.45

2.03 COMPONENTS

- A. Enclosure: Located in electrical equipment as indicated on the Drawings.
 - 1. External mounting:
 - a. NEMA 12 enclosure: No ventilation openings.
 - b. Hinged cover requiring a tool for internal access.
 - c. Internal drawing pocket.
 - d. All monitoring indications must be visible without opening the door.
- B. Internal Connections:
 - 1. Provide low impedance copper plates for intra-unit connections:
 - a. Attach surge modules using bolted connections to the plates for low impedance connections.
 - 2. Size all connections, conductors, and terminals for the specified surge current capacity.
- C. Surge Diversion Modules:
 - 1. Metal Oxide Varistors (MOV):
 - a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer's defects.
- D. Overcurrent Protection:
 - 1. Individually fuse all components, including suppression, filtering, and monitoring components:
 - a. Rated to allow maximum specified nominal discharge current capacity.
 - b. Provide overall SPD overcurrent protection and disconnecting means rated per manufacturer's recommendations.
 - 2. Fuse individual surge components at a maximum of 7-1/2 amps to prevent violent failure:
 - a. UL listed to be capable of interrupting up to 100 kiloamperes symmetrical fault current with 600 VAC applied.
 - b. Replaceable fusing is unacceptable.
 - c. Overcurrent protection that limits specified surge currents is not acceptable.
- E. Connections: Provide terminals to accommodate wire sizes up to #2 AWG.

2.04 ACCESSORIES

- A. Unit status indicators:
 - 1. Provide red and green solid-state indicators, with printed labels, on the hinged front cover to redundantly indicate on-line unit status:
 - a. The absence of the green light and the presence of the red light indicates that surge protection is reduced and service is needed to restore full operation.
 - b. Indicates the status of protection on each mode or phase.
- B. Dry contacts for remote monitoring:
 - 1. Electrically isolated Form C dry contacts (10A at 125VAC) for remote monitoring of system integrity, and indication of under voltage, phase, and/or power loss.

- C. Provide on-line circuit which tests and redundantly monitors individual components in all protection modes including neutral to ground:
 - 1. Units that require external test sets or equipment are unacceptable.
- D. Provide adjustable transient counter to count transient voltage surges in normal mode:
 - 1. Minimum of a 7 -digit LCD readout located on the unit's hinged front cover.
 - 2. Provide the counter reset switches that may be inhibited and are remotely located.
 - 3. Counter to utilize batteries with a 10 year nominal life to maintain accurate counts in the event of total power loss.

2.05 SOURCE QUALITY CONTROL

- A. Permanently affix surge rating to the SPD.
- B. Duty life cycle test the SPD system to survive 20 Kilovolts, 10 kiloamperes, IEEE C62.41 Category C3 surge current with less than 5 percent degradation of clamping voltage. In compliance with the following table:

Device Surge Rating		<u>Minimum Number of Life Cycle Surges</u>		
		Per Mode		
Per Mode	Per Phase	L-N	L-G	N-G
50kA	100 kA	3,000	3,000	3,000
100 kA	200 kA	5,000	5,000	5,000
150 kA	300 kA	5,000	5,000	5,000
200kA	400kA	5,000	5,000	5,000

- C. Test the system at the component and fully assembled level, under surge conditions with alternating current power applied for a minimum of 1 hour:
 - 1. Testing includes but not limited to:
 - a. Quality control checks.
 - b. Dielectric voltage withstand test per UL requirements.
 - c. UL ground continuity tests.
 - d. Operational and calibration tests.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Refer to Section 26 05 00, Common Work Results for Electrical.

- B. Follow the manufacturer's recommended installation practices and comply with all applicable codes.
- C. Special Techniques:
 - 1. Install the SPD with as short and straight conductors including ground conductor as practically possible.
 - 2. Twist the input conductors together to reduce input conductor inductance.
 - 3. Interconnect the SPD to the power system using a manufacturer supplied interconnection cable consisting of low impedance coaxial cables installed in a flexible conduit.
 - 4. Do not subject SPD to insulation resistance testing.

3.02 FIELD QUALITY CONTROL

- A. Refer to Section 26 05 00, Common Work Results for Electrical.

3.03 PROTECTION

- A. Refer to Section 26 05 00, Common Work Results for Electrical.

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SECTION 26 51 00

INTERIOR LIGHTING

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PART 1 GENERAL

1.01 RELATED COCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Interior lighting fixtures, lamps, and ballasts.
 - 2. Emergency lighting units.
 - 3. Exit signs.
 - 4. Lighting fixture supports.
 - 5. Lighting fixtures mounted on exterior building surfaces.
- B. Related Sections include the following:
 - 1. Division 16 Section "Wiring Devices" for manual wall-box dimmers for incandescent lamps.
 - 2. Division 16 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.03 DEFINITIONS

- A. BF: Ballast factor.
- B. CRI: Color-rendering index.
- C. CU: Coefficient of utilization.
- D. HID: High-intensity discharge.
- E. LER: Luminaire efficacy rating.
- F. Luminaire: Complete lighting fixture, including ballast housing if provided.
- G. RCR: Room cavity ratio.

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H. LED: Light emitting diode

1.04 SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
 - 1. Physical description of lighting fixture including dimensions.
 - 2. Emergency lighting units including battery and charger.
 - 3. Fluorescent and high-intensity discharge ballasts.
- B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.
 - 1. Wiring Diagrams: Power and control wiring.
- C. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Lighting fixtures.
 - 2. Suspended ceiling components.
 - 3. Structural members to which suspension systems for lighting fixtures will be attached.
 - 4. Other items in finished ceiling including the following:
 - a. Air outlets and inlets.
 - b. Speakers.
 - c. Sprinklers.
 - d. Occupancy sensors.
 - e. Access panels.
 - 5. Perimeter moldings.
- D. Product Certificates: For each type of ballast driver for bi-level and dimmer-controlled fixtures, signed by product manufacturer.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
- G. Warranties: Special warranties specified in this Section.

1.05 QUALITY CONTROL

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.
- C. FMG Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FMG.

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1.06 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.07 WARRANTY

- A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.
- B. Special Warranty for Lamps: Manufacturer's standard form in which ballast manufacturer agrees to repair or replace Lamps that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Lamps: Five years/50,000 from date of Substantial Completion.

1.08 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 2. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 3. Battery and Charger Data: One for each emergency lighting unit.
 - 4. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. See fixture schedule on drawings.

2.02 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A. E26 Base, only, unless special need and benefit can be demonstrated.

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- C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable. T8 configuration, with ballast removed, unless special need and benefit can be demonstrated.
- D. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B. E26 or E39 Base, with ballast removed, unless special need and benefit can be demonstrated.
- E. Metal Parts: Free of burrs and sharp corners and edges.
- F. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- H. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated.
 - 1. White surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
 - 4. Laminated Silver Metallized Film: 90 percent.
- I. Plastic Diffusers, Covers, and Globes:
 - 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - a. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless different thickness is indicated.
 - b. UV stabilized.
 - 2. Glass: Annealed crystal glass, unless otherwise indicated.
- J. Electromagnetic-Interference Filters: Factory installed to suppress conducted electromagnetic-interference as required by MIL-STD-461 E. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.

2.03 EXIT SIGNS

- A. Description: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
 - 1. Lamps for AC Operation: LEDs, 70,000 hours minimum rated lamp life.
 - 2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
 - a. Battery: Sealed, maintenance-free, nickel-cadmium type.
 - b. Charger: Fully automatic, solid-state type with sealed transfer relay.

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- c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
- d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
- e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

2.04 EMERGENCY LIGHTING UNITS

- A. Description: Self-contained units complying with UL 924.
 - 1. Battery: Sealed, maintenance-free, lead-acid type.
 - 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
 - 3. Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - 4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - 5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - 6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
 - 7. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.

2.05 LED LAMPS

- A.** LED Lamps in T8 fixtures: Lamps will be unballasted, line voltage, 120-277v universal, with an integral driver. It shall fit into a standard T8 fixture, and have a frosted lense, glass or plastic material. Efficacy of 125 lm/W or greater, color temperature of 4000k-4200k for interior fixtures, 5000k-5500kfor exterior. CRI of 75 or above, and an expected life of 5-year/50,000 hours or greater (L70/B50)
- B.** LED Lamps in HID Type Fixtures: Lamps will be unballasted, line voltage, 120-277v universal, with an integral driver. (480v only acceptable when voltage drop demands) It shall fit into a standard HID Lamp Base (E26 or E39) fixture. Efficacy of 125 lm/W or greater, color temperature of 4000k-4200k for interior fixtures, 5000k-5500kfor exterior. CRI of 75 or above, and an expected life of 5-year/50,000 hours or greater (L70/B50)

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2.10 LED Lamps in Incandescent Type Fixtures:

Lamps will be unballasted, line voltage, 120v with an integral driver. It shall fit into a standard Lamp Base (E26) fixture. Efficacy of 125 lm/W or greater, color temperature of 4000k-4200k for interior fixtures, 5000k-5500k for exterior. CRI of 75 or above, and an expected life of 5-year/50,000 hours or greater (L70/B50)

- A. Comply with Division 26 Section "Hangers and Supports for Electrical Equipment" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).
- E. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- F. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment cord and locking-type plug.

2.11 INTEGRAL LED FIXTURES

- A. Electrical - Long-life LED's with high efficiency drivers. Rated life to deliver L70 performance at 50,000 hours. Color accuracy in the 80 to 85 range depended on color. Lumens per Watt in the 80 to 85 range depended on color. Only acceptable if special need and benefit can be demonstrated.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.
- B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.
 - 1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners.
 - 2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
 - 3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.

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4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.
- C. Suspended Lighting Fixture Support:
1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
 2. Stem-mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
 3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
 4. Adjust amiable lighting fixtures to provide required light intensities.
 5. Connect wiring according to Division 16 Section "Conductors and Cables."

3.02 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Verify normal operation of each fixture after installation.
- C. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
- D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

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SECTION 26 52 00

EMERGENCY LIGHTING

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PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.
- B. NFPA Sections 70, 70E and 101

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Emergency lighting units.
- B. Related Sections include the following:
 - 1. Division 26 Sections

1.03 DEFINITIONS

- A. BF: Ballast factor.
- B. CRI: Color-rendering index.
- C. CU: Coefficient of utilization.
- D. HID: High-intensity discharge.
- E. LER: Luminaire efficacy rating.
- F. Luminaire: Complete lighting fixture, including ballast housing if provided.
- G. RCR: Room cavity ratio.
- H. LED: Light emitting diode

1.04 SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
 - 1. Emergency lighting units including battery and charger.
- B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.
 - 1. Wiring Diagrams: Power and control wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
- E. Warranties : Special warranties specified in this Section.

1.05 QUALITY CONTROL

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.
- C. FMG Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FMG.

1.06 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.07 WARRANTY

- A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Emergency Lighting Unit Batteries: 3 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Beghelli Tempesta, Beghelli Tempesta-LED, Emergency Lights WLFEL, Isolite FLW Series, or Engineer approved equal

2.02 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

- A. Sanitation Listed
- B. IP65

2.03 EMERGENCY LIGHTING UNITS

- A. Description: Self-contained units
 1. Battery: Ni-Mh type.
 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
 3. Unit Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 4. Outdoor Unit – Emergency – AC Fail only
 5. Indoor Unit – Emergency – AC Fail only
 6. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 7. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.
- B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.
 1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners. Fixtures may be mounted on a Junction box supported by threaded rod.
 2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
 3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
 4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.
- C. Suspended Lighting Fixture Support:
 1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
 2. Stem-mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.

3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
4. Adjust directional lighting fixtures to provide required light intensities.
5. Connect wiring according to Division 26 Section "Conductors and Cables."
6. Support from junction box on 1" GRS and PVC Coated GRS Conduit allowed.
7. Mount no higher than 15' from floor.

3.02 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Verify normal operation of each fixture after installation.
- C. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal. Test per NFPA 101.
- D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION

SECTION 26 56 00

EXTERIOR LIGHTING

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PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Exterior luminaires with lamps and ballasts.
 - 2. Luminaire-mounted photoelectric relays.
 - 3. Poles and accessories.
- B. Related Sections include the following:
 - 1. Division 16 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.03 DEFINITIONS

- A. CRI: Color-rendering index.
- B. HID: High-intensity discharge. Metal Halide, High Pressure Sodium
- C. Luminaire: Complete lighting fixture, including ballast housing if provided.
- D. Pole: Luminaire support structure, including tower used for large area illumination.
- E. Standard: Same definition as "Pole" above.

1.04 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

- A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4.
- B. Live Load: Single load of 500 lbf (2224 N), distributed as stated in AASHTO LTS4.

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- C. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4.
 - 1. Wind speed for calculating wind load for poles exceeding 50 feet (15 m) in height is 110 mph (177 km/h).
 - 2. Wind speed for calculating wind load for poles 50 feet (15 m) or less in height is 110 mph (177 km/h).

1.05 SUBMITTALS

- A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
 - 1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
 - 2. Details of attaching luminaires and accessories.
 - 3. Details of installation and construction.
 - 4. Luminaire materials.
 - 5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.
 - a. For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
 - b. Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
 - 6. Photoelectric relays.
 - 7. Ballasts, including energy-efficiency data.
 - 8. Lamps, including life, output, and energy-efficiency data.
 - 9. Materials, dimensions, and finishes of poles.
 - 10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
 - 11. Anchor bolts for poles.
 - 12. Manufactured pole foundations.
- B. Shop Drawings:
 - 1. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
 - 2. Wiring Diagrams: Power and control wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For luminaires and poles to include in emergency, operation, and maintenance manuals.
- E. Warranty: Special warranty specified in this Section.

1.06 QUALITY CONTROL

- A. Comply with NFPA 70.

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1.07 DELIVERY, STORAGE, AND HANDLING

- A. Package aluminum poles for shipping according to ASTM B 660.
- B. Store poles on decay-resistant-treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- C. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.08 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
 - 1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
 - 2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
 - 3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
 - 4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

1.09 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 2. Glass and Plastic Lenses, Covers, and Other Optical Parts: 5 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 3. Ballasts: 5 for every 100 of each type and rating installed. Furnish at least one of each type.
 - 4. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

I. PRODUCTS

2.01 MANUFACTURERS

- A. See fixture schedule on drawings.

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2.02 LUMINAIRES, GENERAL REQUIREMENTS

- A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
- B. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- C. Metal Parts: Free of burrs and sharp corners and edges.
- D. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.
- E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.
- G. Exposed Hardware Material: Stainless steel.
- H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to - heat, and UV radiation.
- I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.
- J. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- L. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and – tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- M. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove

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mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."

2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color: As selected from manufacturer's standard catalog of colors or custom color as directed by the architect.

2.03 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

- A. Comply with UL 773 or UL 773A.
- B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.
 1. Relay with locking-type receptacle shall comply with NEMA C136.10.
 2. Adjustable window slide for adjusting on-off set points.

2.04 FLUORESCENT BALLASTS AND LAMPS (No Fluorescent Lamps or Ballasts Allowed)

2.05 BALLASTS FOR HID LAMPS (No HID Lamps Or Ballasts Allowed)

2.06 LED LAMPS

- A. LED Lamps in T8 fixtures: Lamps will be unballasted, line voltage, 120-277v universal, with an integral driver. It shall fit into a standard T8 fixture, and have a frosted lense, glass or plastic material. Efficacy of 125 lm/W or greater, color temperature of 4000k-4200k for interior fixtures, 5000k-5500kfor exterior. CRI of 75 or above, and an expected life of 5-year/50,000 hours or greater.
- B. LED Lamps in HID Type Fixtures: Lamps will be unballasted, line voltage, 120-277v universal, with an integral driver. (480v only acceptable when voltage drop demands) It shall fit into a standard HID Lamp Base (E26 or E39) fixture. Efficacy of 125 lm/W or greater, color temperature of 4000k-4200k for interior fixtures, 5000k-5500kfor exterior. CRI of 75 or above, and an expected life of 5-year/50,000 hours or greater (L70/B50)
- C. LED Lamps in Incandescent Type Fixtures: Lamps will be unballasted, line voltage, 120v with an integral driver. It shall fit into a standard Lamp Base (E26) fixture. Efficacy of 125 lm/W or greater, color temperature of 4000k-4200k for interior fixtures, 5000k-5500kfor exterior. CRI of 75 or above, and an expected life of 5-year/50,000 hours or greater (L70/B50)

2.07 LED INTEGRAL FIXTURES

- A. Optics
 1. Provide precision-molded acrylic lenses for optimal luminaire spacing and improved uniformity. Lenses are indexed to the circuit board to provide consistent

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optical alignment and delivering repeatable photometric performance. Choose one of five optimized distributions: Type II, Type II, Type IV, Type V, and Forward Throw. The optical system controls light above 90 degrees,.

B. Electrical

1. High-efficiency 4000K, 75 or Greater. LEDs mounted to a metal-core circuit board and aluminum heat sink, provide optimal thermal management and long life (L85 60,000 hrs, 25°C ambient). Standard drivers rated in 120- 277V and 480V; 60 Hz. Drivers have power factor >90% and THD < 20%. Driver life of 100,000 hours.
2. Replaceable surge protection device is tested in accordance with IEEE/ANSI C62.41.2 meeting Category C Low.
 - a. Acceptable Use - Integral LED Fixtures are only to be used where substantial benefit, not just installed cost, can be demonstrated. (Special or hazardous installations, as an example)

2.08 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

- A. Structural Characteristics: Comply with AASHTO LTS-4.
 1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in Part 1 "Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.
 2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
- B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.
- C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
 1. Materials: Shall not cause galvanic action at contact points.
 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless-steel items are indicated.
 3. Anchor-Bolt Template: Plywood or steel.
- D. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 3.

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2.09 POLE MATERIAL TYPES

2.9.1 STEEL POLES

- A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); 1-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.
 - 1. Shape: As specified.
 - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- B. Steel Mast Arms: Continuously welded to pole attachment plate. Material and finish same as pole.
- C. Brackets for Luminaires: Detachable, cantilever, without underbrace.
 - 1. Adapter fitting welded to pole and bracket, then bolted together with galvanized-steel bolts.
 - 2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
 - 3. Match pole material and finish.
- D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- E. Steps: Fixed steel, with nonslip treads, positioned for 15-inch (381-mm) vertical spacing, alternating on opposite sides of pole; first step at elevation 10 feet (3 m) above finished grade.
- F. Intermediate Handhole and Cable Support: Weathertight, 3-by-5-inch (76-by-127-mm) handhole located at midpoint of pole with cover for access to internal welded attachment lug for electric cable support grip.
- G. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Division 16 Section "Grounding and Bonding," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- H. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
- I. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- J. Galvanized Finish: After fabrication, hot-dip galvanize complying with ASTM A 123/A 123M.
- K. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

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1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - L. Color: As selected by Architect from manufacturer's full range or custom color as selected by architect.
 - M. To be used only where not exposed to corrosive sprays and gasses. (Example: Odor Control overspray areas)

2.9.2 FIBER REINFORCED POLYMER (COMPOSITE POLES)

- A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); 1-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.
 1. Shape: As specified.
 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- B. Mast Arms: Per manufacturer's recommendations for application.
- C. Brackets for Luminaires: Detachable, cantilever, without underbrace.
 1. Adapter fitting to pole and bracket, then bolted together with galvanized- steel bolts.
 2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
 3. Match pole material and finish.
- D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- E. Intermediate Handhole and Cable Support: Weathertight, 3-by-5-inch (76-by-127-mm) handhole located at midpoint of pole with cover for access to internal attachment lug for electric cable support grip.
- F. Grounding and Bonding Lugs: 1/2-inch (13-mm) threaded lug, complying with requirements in Division 16 Section "Grounding and Bonding," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- G. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
- H. Factory Finish:
 1. Interior Surfaces of Pole: Manufacturer's standard finish.

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- 2. Exterior Surfaces: Manufacturer's standard finish.
- I. Color: As selected by Architect from manufacturer's full range or custom color as selected by architect.
- J. To be used where not exposed to corrosive sprays and gasses. (Example: Odor Control overspray areas)

2.10 POLE ACCESSORIES

- A. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

II. EXECUTION

3.01 LUMINAIRE INSTALLATION

- A. Install lamps in each luminaire.
- B. Fasten luminaire to indicated structural supports.
 - 1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources.

3.02 POLE INSTALLATION

- A. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
- B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features, unless otherwise indicated on Drawings:
 - 1. Fire Hydrants and Storm Drainage Piping: 60 inches (1520 mm).
 - 2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet (3 m).
 - 3. Trees: 15 feet (5 m).
- C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 3.
- D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
 - 1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
 - 2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
 - 3. Install base covers, unless otherwise indicated.

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- 4. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- E. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.
- F. Raise and set poles using web fabric slings (not chain or cable).

3.03 BOLLARD LUMINAIRE INSTALLATION

- A. Align units for optimum directional alignment of light distribution.
- B. Install on concrete base with top 2 inches (50 mm) above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 3.

3.04 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

- A. Install on concrete base with top 2 inches (50 mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 3.

3.05 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Division 16 Section "Raceways and Boxes." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.06 GROUNDING

- A. Ground metal poles and support structures according to Division 16 Section "Grounding and Bonding."
 - 1. Install grounding electrode for each pole, unless otherwise indicated.
 - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- B. Ground nonmetallic poles and support structures according to Division 16 Section "Grounding and Bonding."
 - 1. Install grounding electrode for each pole.
 - 2. Install grounding conductor and conductor protector.
 - 3. Ground metallic components of pole accessories and foundations.

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3.07 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
 - 1. Verify operation of photoelectric controls.
- C. Illumination Tests:
 - 1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards.
- D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

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SECTION 26 80 00

PHOTOVOLTAIC SYSTEM

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PART 1 GENERAL

1.01 SUMMARY

- A. The Contractor shall, furnish and install the photovoltaic (solar) system as specified herein and as contained within the contract specifications and shown on the contract drawings.
- B. The complete operational system (module, mounting system, inverter, etc.) using the solar module listed herein and based upon the panel quantity shown in the contract drawings shall produce a minimum peak power output as measured at the output of the inverter as indicated in the project requirements.

1.02 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA, ANSI, NEC and UL.
- C. In addition to the codes cited in Section 260100, specific requirements for individual components of the solar system include but are not limited to the guidelines shown herein.
- D. All electrical work shall be designed and installed in accordance with the latest edition of all applicable codes, standards, and recommendations of the following agencies:
 - 1. ANSI-American National Standards Institute.
 - 2. ASHRAE-American Society Of Heating, Refrigeration, and Air Conditioning Engineer.
 - 3. ASCE-American Society of Civil Engineers
 - 4. ASME-American Society of Mechanical Engineers
 - 5. ETL-Electrical Testing Laboratories.
 - 6. IEEE-Institute of Electrical and Electronic Engineers

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7. ICEA-Insulated Cable Engineer's Association.
8. IAEI-International Association Of Electrical Inspectors.
9. IPMVP- International Performance Measurement and Verification Protocol.
10. NFPA-101-National Fire Protection Association.(Life Safety Code)
11. NEMA-National Electrical Manufacturers Association.
12. NESC-National Electrical Safety Code.
13. NETA-National Electrical Testing Association.
14. NEC-National Electrical Code
15. UL-Underwriters Laboratories.

1.03 SUBMITTALS

- A. Provide shop drawings and product data consisting of the following:
 1. PV System Description and a report detailing the suitability of the mounting system.
 2. Master drawing index showing all drawings to be submitted for review.
 3. Full Electrical Calculations at various stages of the electrical circuit showing Kilowatts (KW), Amperes, Voltages, Line losses (Watts), Efficiency losses (Watts or %), and any other losses (KWH or %) based on such factors as panel mismatch, dirt accumulation, and temperature changes must be shown.
 4. PV module, inverters, AC/DC loadbreak disconnect switches specifications and associated equipment specifications as appropriate.
 5. Photovoltaic modules and inverters must reside on the CEC approved equipment list, including minimum warranty requirements.
 6. Site plan with detailed solar array layout and integrated mounting system that meets the requirements as set forth in the contract documents.
 7. Seismic certification and equipment anchorage details.
 8. Array wiring diagrams: Single line, Electrical Physical Equipment Layout, Combiner Boxes Electrical Details and All Specifications, Switches and Fuses, Physical Layout and Full Electrical Specifications (AC or DC as appropriate), Electronic Revenue Grade Meter Specifications, Data Acquisition System, Wiring Diagram and Specifications.
 9. Nameplate schedules.

10. Conduit entry/exit locations.
 11. Cable terminal sizes.
 12. Product data sheets.
 13. Utility company interconnection agreement.
- B. Qualification data: for qualified testing agency.
- C. Seismic Qualification Certificates: Submit certification that PV modules, inverters, accessories, and components will withstand seismic forces defined in Section 01 81 02 "Seismic Design Criteria." Include the following:
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. The following information shall be submitted for record purposes:
1. Final as-built drawings and information for items listed in paragraph 1.4A
 2. Array wiring diagrams
 3. Certified production test reports
 4. Installation information
 5. Seismic certification and equipment anchorage details.
 6. The final (as-built) drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the installation process.
- E. Operation and Maintenance Data: For inverters, modules and all components include operation and maintenance manuals. Include leaflets, instructions and renewal parts list.

1.04 QUALIFICATIONS

- A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.
- B. The manufacturer and system installer of this equipment shall have produced and commissioned similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this

requirement.

- C. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the International Building Code. This shall include both vertical and lateral required response spectra as specified. Alternatively, the manufacturer's certification may be based on a detailed computer analysis of the entire assembly structure and its components. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment.
- D. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.
 - 1. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed structural engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved methods used to verify the seismic design of the installation.
 - 2. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in the above codes.
 - 3. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.
- E. Mounting system shall be integral with the module and See Architectural contract documents for all mounting system requirements.

1.05 REGULATORY REQUIREMENTS

- A. All equipment supplied shall bear a UL label. Certified copies of production test reports shall be supplied demonstrating compliance with these standards when requested by the Engineer.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. Two (2) copies of these instructions shall be included with the equipment at time of shipment. Equipment shall not be stored on roof areas.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Modules: Sharp, Kyocera, Sanyo or approved equal.

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- B. Micro-Inverters: Approved Eligible inverters per California Energy Commission (CEC)
- C. String-level inverters not acceptable.

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions.

2.02 SYSTEM DESIGN

- A. The complete PV system with mounting system shall be properly grounded per NEC.
- B. The PV system should fully meet or exceed the stated KW, AC peak power output for the sum of all the installed inverters.
- C. Module panels and inverters used on this project shall be listed in the CEC approved list.

2.03 SYSTEM SPECIFICATION

- A. The system will include a complete solar PV generating system as described above and will provide a total expected peak output in excess of (Designed) KW, AC for the System.
The (Designed) kW output shall be determined using the California Energy Commission (CEC) ratings of the PV system equipment and the CEC method of calculation.
- B. The 60 HZ, AC output voltage and configuration must be compatible with the voltage at the buildings main electrical panel.
- C. The layout, number and type of PV panels must be as shown in the contract drawings. Grouping of common conduit runs and proper drainage must also be considered in the design.

2.04 PV MODULES AND PANELS

- A. The modules shown in the contract drawings shall be Sharp NU-U240F1, or approved equal. The modules shall work seamlessly with the approved mounting system to meet all contract requirements and applicable building codes. Any approved equal must produce the same or greater PTC-DC power output per square foot.
 - 1. The noted DC-PTC power output for the Sharp NU-U240F1 is 240 watts.
- B. Must meet or exceed the following current requirements:
 - 1. UL Subject 1703-2003, "Standard for Flat Plate Photovoltaic Modules and Panels".
 - 2. IEEE Std 1262-1995 IEEE recommended practice for qualification of photovoltaic (PV) modules, or IEC1215 Crystalline Silicon Terrestrial

Photovoltaic (PV) modules-Design Qualification and Type Approval.

3. Modules shall be provided with 25-year manufacturer warranty on power output as specified. All module electrical specifications including PTC outputs and degradation data shall be listed and utilized in determining the minimum peak output. Panels shall not exhibit more than 0.5% (one half percent) power depreciation per year.
- C. All other thermal parameters and operating temperature coefficients must be clearly indicated and the panels must meet these specifications over their 25 year guarantee.
- D. Weight of the modules and the mounting support equipment must be less than 5 lbs. per square foot and shall maintain a Class C fire rating.
- E. Each solar module shall be grounded with a tin-plated lay-in lug and stainless steel hardware. The ground conductor shall be #10 AWG bare copper minimum. Ground cable shall be installed and concealed with approved method so as not to touch aluminum mounting system. The ground lug shall be ILSCO GBL4 DBT or approved equal.

2.05 INVERTER

- A. Inverters must be sized to properly accommodate the DC input from the PV panels under all expected electrical, thermal, and other operational conditions. Inverters shall be provided with ten (10) year manufacturer warranty on power output as specified.
- B. The inverter must contain all self-protection features as stated in IEEE 929 including over and under voltage and frequency safeguards. An integral, anti-islanding protection scheme shall prevent the inverter from feeding power to the grid in the event of a loss to normal power.
- C. Inverter efficiency shall be rated at greater than or equal to 96%. Standby losses shall be 100mW or less per inverter.
- D. The inverter shall include provisions for automatic operation including start up, shut down, self-diagnosis, and fault detection.
- E. AC current distortion at rated power must be less than 5% THD (Total Harmonic Distortion).
- F. Thermal and other operating parameters specific to the installation site must also be considered for this component of the system with the ambient temperature rated at between - 4 degrees F and 122 degrees F.
- G. Manufacturer's preferred wiring method to be used, unless in violation of applicable Codes.
- H. Complete monitoring system to be implemented, with remote access to system

status and output, as well as history.

- I. Module-integrated microinverters are not acceptable.

2.06 MOUNTING SYSTEM

- A. The PV system for this project shall be suitable for 90 mph wind loading. The system shall be suitable and adjustable to be installed as shown in the contract drawings. Mounting system shall be provided with ten (10) year manufacturer warranty and be suitable for various solar panels that meet the specifications.
- B. The mounting system shall contain the PV panels in a durable, racked mounting system that shall lock the PV modules in a fixed parallel to the existing carport south facing side. All PV panels are to face south.
- C. The system shall not add more than 5 pounds per square foot to the overall solar array system.
- D. Manufacturer of mounting system shall be Unirack or approved equal.

2.07 COMBINER BOXES

- A. Combiner boxes shall not be used in this specification.

2.08 AC INVERTER OUTPUT

- A. Conduit and pull boxes will be sized per NEC code.
- B. Splices in system only allowed at transition to building wire system from manufacturer's prefab cabling system, if any, and termination at AC panelboard.
- C. Dedicated AC panelboard to be installed to combine AC output circuits from micro-inverters, with appropriately sized over current protection devices.
- D. Routing of conduits into and out of the AC panelboard shall afford the addition of future conduits and cabling.
- E. All circuits to be #10 XHHW-2 minimum, and have dedicated neutrals for each circuit where neutrals are used.
- F. PV Inverter output shall be isolated from all other power sources and systems except single common point of connection with owners existing power distribution system. No conduit systems, enclosures, or other cable raceways will be shared between systems.

2.09 OVER CURRENT PROTECTION DEVICES

- A. All fuses and other protective devices and holders must be engineered to safely

protect system components under “worst case” expected field conditions including temperature extremes.

- B. All fuses for disconnects must be current limiting UL class J, RK1, or RK5 and of the appropriate voltage, delay or non-delay characteristic, and current rating to provide both complete short circuit and overload protection per NEC sections regarding component protection.

2.10 CUSTOMER METERING

- A. Meters shall be utility-grade revenue, electronic, bi-directional, with a .5%(one half percent) or better accuracy, Time of Use (TOU), KWh, KVARh and KWD demand meter must be installed to measure the AC output of the inverter at the delivery point to the facility’s electrical system.
- B. The meter shall have capability for connection to the data acquisition system for logging of electrical information and be equipped with optional onboard battery for continuous operation in any condition.
- C. The manufacturer shall be Electro Industries Shark or Nexus, ABB Alpha Plus A1RL+ with 50ESS ERT or approved equal.

2.11 EXTERIOR EQUIPMENT ENCLOSURES

- A. The type of enclosure shall be in accordance with NEMA standards for Type 4 with gasketed doors unless otherwise noted. All enclosing sheet steel, wireways and unit doors shall be gasketed. Where subject to damage, or extended direct sun light, stainless steel enclosures shall be used.

2.12 NAMEPLATES

- A. All equipment, panels, boxes and associated equipment shall be clearly labeled with etched, aluminum photometallic nameplates. Shall be black background with white letters, measuring a minimum of 1.5 in (38 mm) H x 6.25 in (159 mm) W total outside dimensions or as required to contain the pertinent information. Contractor shall submit the proposed nameplates with desired labeling for approval.
- B. Install engraved signs for instruction or warning identifying that a solar PV system is operational on the premises at appropriate locations and that multiple power sources may be present.
- C. Provide identification of all PV power circuits on switches and clearly identify individual inverter output strings in pull boxes and PV panelboard. Use appropriate wire color codes (i.e. Brown, Yellow, Orange & Grey) all circuits.
- D. PV panels must include serial numbers on the frame and be easily viewed from the top side of the panel. Serial Number of microinverter shall be indelibly marked were visible on module from above.

2.13 FACTORY TESTING

- A. All factory tests required by the latest ANSI, NEMA and UL standards shall be

performed.

- B. A certified test report of all standard production tests shall be available to the Engineer upon request.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

- A. Provide the services of a qualified factory-trained manufacturer's representative to assist the contractor in installation and startup of the equipment specified under this section. The manufacturer's representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.
- B. The following minimum work and testing shall be performed by the Contractor but not limited to:
 - 1. Field Testing of the PV Solar System shall include the following:
 - a. PV modules shall be factory tested by the suppliers and upon receipt by the contractor.
 - b. Factory testing of the inverter and transformer shall be performed by the supplier.
 - 2. Procure and install all equipment noted in the contract drawings and items not shown but equally critical to the operation of a complete PV system.
 - 3. New equipment and materials to be used throughout installation, up to point of connection with owners existing systems.
 - 4. Perform insulation tests on each phase conductor and verify low-resistance ground connection on the grounding system. System testing of installed PV array shall be performed on all new circuits, including resistance to ground and line to line resistance. This data will then be recorded in the O &M manual in a clear tabular format.
 - 5. Connect all power wiring and control wiring and verify basic operation.
 - 6. Torque all bolted connections made in the field and verify all factory bolted connections.
 - 7. At such time as Contractor determines that the project is completed notification shall be given to the Owner for the scheduling of the final inspection and testing of the system.
 - 8. Start-up system per manufacturer's recommendations.
 - 9. Conduct initial Operation and Maintenance training as specified.

10. Qualifying period of 12 months begins upon Substantial Completion being granted by owner.

C. The Contractor shall provide three (3) copies of the manufacturer's field startup report.

3.02 MANUFACTURER'S CERTIFICATION

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations. Equipment shall be inspected prior to the generation of any reports.

B. The Contractor shall provide three (3) copies of the manufacturer's representative's certification.

3.03 TRAINING

A. The Contractor shall provide a training session for up to five (5) owner's representatives for 2 normal workdays at the jobsite or other office location chosen by the owner.

B. The training session shall be conducted by a manufacturer's qualified representative.

C. The training program shall consist of the following:

1. Review of the PV system one-line drawings and schedules.

2. Review of the factory record shop drawings and placement of the various PV arrays.

3. Review of each type of PV module, combiner box, inverter, isolation transformer, meter, DAS, etc.

4. Review PV system equipment replacement procedures.

5. Discuss the maintenance timetable and procedures to be followed in an ongoing maintenance program.

6. Provide three-ring binders to participants complete with copies of drawings and other course material covered.

3.04 EXAMINATION

A. Installing Contractor to fully inspect shipments for damage and report damage to manufacturer and file claim upon shipper, if necessary.

B. Fusing at the combiner box must be properly sized and coordinated for each

PV string installed.

- C. Installing Contractor to verify NEC clearances as dictated on the contract drawings prior to installation.
- D. Verify UL labeling of the assembly prior to installation.

3.05 INSTALLATION

- A. Contractor to follow the installation instructions supplied by the manufacturer.
- B. Wiring shall be as shown on the contract drawings except as modified by the approval and submittal process. PV string wiring shall be submitted to the Architect for approval for compliance with the requirements of the SFIA TIG, contract documents and applicable codes.

3.06 FIELD ADJUSTMENTS

- A. Follow the manufacturer's instructions and the contract documents concerning any short-circuit device settings or startup of components.

3.07 ACCEPTANCE TEST

- A. Follow the minimum requirements as stipulated per the manufacturer's recommendation.
- B. After inverter startup, current shall be recorded for each PV string, each sub-array, and the entire array. Each current measurement will also include the same ancillary data as taken above during voltage measurements.
- C. Generate a field report on tests performed, test values experienced, etc., and make available to owner upon request.
- D. The test shall be conducted by an independent testing company, specializing in such test, such as Electro-Test or Power Systems Testing. The cost of the test shall be included in the bid price.
- E. Qualifying period will determine efficacy of system as a whole. Upon completion of qualifying period adjustments and additions to system will be provided, at Contractor's cost, to meet or exceed project's annual generation goal. Goal is to be calculated on overall system kW design multiplied by an aggregate of 6.5 hours per day for the 12 month period. A 12 month period is defined as 365 days
(kW x 6.5 x 365) = __ MWh Annual Generation Goal

3.08 OPERATIONS AND MAINTENANCE

- A. Specific routine PV-related scheduled maintenance shall be undertaken quarterly by the Contractor during qualifying period. It shall comprise of a visual

inspection of the array, testing of power levels at the dedicated PV panelboard using hand held multimeter, and tightening bolts on the inverter equipment per manufacturers' recommendations. Contractor shall prepare a report for submission to the Owner detailing the extent of each scheduled maintenance, the results of those items tested and reviewing items replaced and/or repaired.

- B. Cleaning of the array shall be undertaken by the Contractor the first year (twice) following acceptance of this project. This shall be comprised of cleaning off and removing any loose debris, especially rinsing any accumulated dust, dirt, and bird droppings from the PV modules.

END OF SECTION

ATTACHMENT 3

Drawings, Diagrams, and
Conventions

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Legend

- Generator
- Bypass Discharge
- Vactor Discharge
- Bypass Piping
- Manhole - Drop
- Gravity Main
- Bypass Suction
- Bypass Pumps
- Suction
- Manhole - Regular
- Force Main
- Water Bridge

Lift Station Data	
Suction Side Cross St	Rive Gauche St & Galore Ave
Discharge Side Cross St	Rive Gauche St & Pureza Ave
Travel Distance & Avg Travel Time	10.2 mi, 54 min
Zoning	Residential
Force Main 1, Dia., Length, & Material	4 in, 389 ft, ACP
Force Main 2, Dia., Length, & Material	None
Onsite Backup Power	No
Generator Receptacle	Yes 25 HP, 100 amp, 240 V
Bypass Design Data	
Bypass Valving	No
Low Flow	6 gpm
Average Flow	22 gpm
Peak Flow	579 gpm
TDH At Peak Flow	30.5 ft, 13.2 psi
Suction Lift	15 ft
Bypass Equipment (CCWRD USE ONLY)	
Pumps	2 - Power Prime DV200
Suction Pipe (For 2 pumps), Dia. x Length	8" x 60'
Discharge Pipe, Dia. x Length	6" x 385'
90 bend, Qua - Dia.	1 - 8"
90 bend, Qua - Dia.	4 - 6"
45 bend, Qua - Dia.	1 - 6"
45 bend, Qua - Dia.	
Adapter, Qua - Dia x Dia	1-6" x 8", 2- 8" x 6"
Water Bridges, Qua - Dia. x Dia.	1 - 8" x 10'
Check Valve, Qua - Dia.	2- 6"
Gate Valve, Qua - Dia.	2- 6"
Wye, Qua - Dia. x Dia. x Dia.	1 - 8" x 6" x 6"
Traffic Control Equipment (CCWRD USE ONLY)	
Vactor (1st Hour Response)	
Vactor Truck Total Capacity	3000 gal
Vactor Truck Usable Capacity	2,250 gal
Fill, Discharge & Travel Cycle Time	16 min
Vactor Trucks Required (Avg Flow, Peak Flow)	0.2, 6



Lift Station & Force Main Bypass Plan

LS Name: North Point (Overview) LS Number: 19

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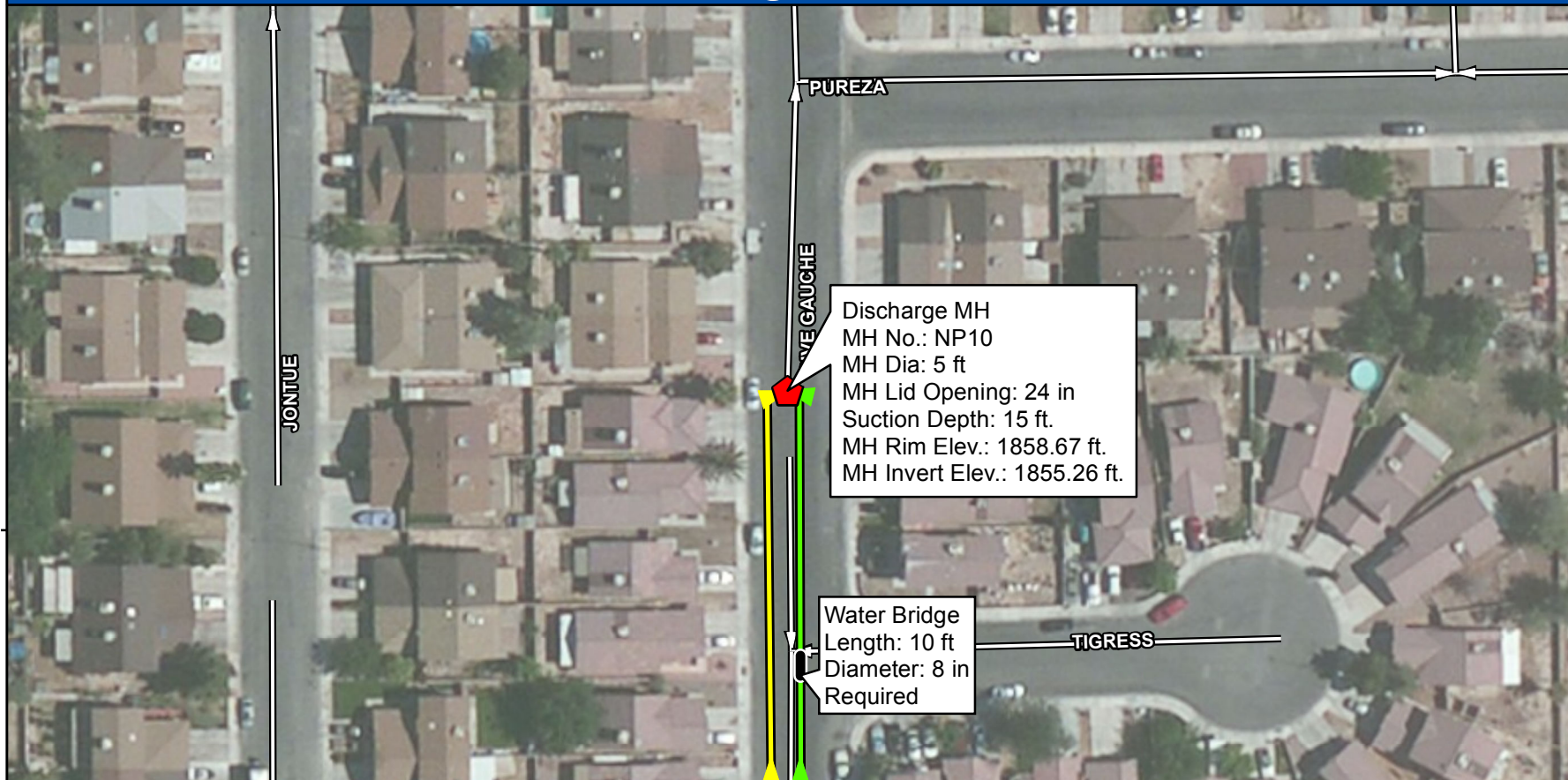
Lift Station & Force Main Bypass Plan

LS Name: **North Point (Overview)** LS Number: **19**

Suction Manhole



Discharge Manhole



Notes

Only one pump required for peak flow, operate lead/standby setup

Legend

- Water Bridge
- Bypass Discharge
- Bypass Suction
- Vector Discharge
- Bypass Pumps
- Bypass Piping
- Suction
- Generator
- Force Main
- Manhole - Drop
- Manhole - Regular
- Gravity Main



IMPORTANT: WATER BRIDGES CAN HANDLE PRESSURES OF UP TO 75 PSI (173 FT OF WATER). MAXIMUM LOADING CAPACITY ON A WATER BRIDGE IS 21,600 POUNDS PER AXLE. H-20 LOADING IS 32,000 LBS PER AXLE.

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Drawings, Diagrams, and Conventions

This section describes the drawings, diagrams, conventions required in the design of an instrumentation and control system for all CCWRD lift station facilities. This section includes guidelines for:

- Process and Instrumentation Drawings (P&IDs)
- Control Panel Drawings
- Input/Output Point Lists

Descriptions of each type of drawing and the related symbols, legends, and conventions are included.

All project designs shall provide electrical power design drawings that include One-line, power distribution, electrical site plans, building electrical plans, conduit and duct bank sections and schedules, power and lighting plans and substation plans. The electrical power design drawings and symbol sheets are not included in the scope of these design standards.

Drawing Media

The final drawings shall be prepared on 24 inch by 36-inch media. Software copies of all as-built drawings shall be supplied without the PE stamp using the latest version of AutoCAD & Adobe Acrobat PDF on CD or DVD.

After the project installation, startup and testing have completed, the as-built drawings must be completed before final acceptance of the project.

The following steps are recommended to assure accurate as-built drawings may be produced:

- During the project, the Contractor maintains the record drawing set in the project office with all changes marked on the drawings in red ink.
- Prior to project final acceptance, the Contractor provides the redlined drawings with as-built changes to the Engineer. The drawings are stamped "AS-BUILT" by the Contractor.
- Engineer updates soft copy (ACAD files) with the as-built changes clouded and noted with the revision number. The Engineer provides the final marked up drawings and the as-built soft copy to the owner (CSE).

-

P&IDs

P&ID Standards

Process and Instrumentation Diagrams (P&IDs) are intended to show process, instrument, and control equipment information. They represent the functional relationships of this equipment relative to the physical process.

P&IDs must be developed based on Process Flow Diagrams and Design Memoranda provided by the process designer. Specific instrumentation items should be added by the Engineer's Control System Designer. Drawings will use plan views unless elevation views would more clearly describe the process.

The P&IDs must include the following:

- Process piping, tanks, structures, and equipment
- Primary elements, transducers, and analyzers
- Actuators and final control elements
- Local panels and MCCs
- Input/output signals to the distributed control system
- Schematic representation of hardware interlocks

P&IDs will not include any software functions of the PCS. These shall be covered in control strategy descriptions.

A layered approach shall be used to separate various levels of control. Horizontal lines will be provided to separate the following three levels of control:

- The PCS in the Top Layer
- The PLC Controller in the Middle Layer
- The Field Equipment in the Bottom Layer

Multiple controls will be shown as a "typical" wherever typifying does not sacrifice clarity. The field devices and tags must be shown as a minimum and loop numbers and panel designations will be shown in the typical box.

Packaged panels are panels supplied with larger equipment systems such as bar screens or emergency power generators / automatic transfer switches. The panel specifications including I/O point interface requirements to the PCS must be included within the equipment specifications. P&IDs will show packaged panels as boxes with I/O signals and face of panel mounted equipment only.

The Engineer will prepare P&IDs, add field instruments, field equipment and control devices. The Engineer will add ISA balloons to field equipment and sensors shown on the P&ID and enter the instrument and device letter codes.

Drawing Layout

The layered concept using vertical hierarchy spacing shall be used to distinguish between the various control locations. The control levels and locations shall be identified by labeling at the side of the drawing or by enclosing and labeling the control locations in solid boxes. The three layers to be separated by horizontal lines are defined below:

PCS Layer

The PCS input/output symbols are at the highest level with the loop and unit process tags. An I/O point count will be made based on the loop and unit process tags in each area. I/O symbols and tags shall be located above at the highest level.

Typical illustrations shall be used when there are multiple equipment items on a drawing that have identical monitoring and control functions. The use of typical is encouraged whenever it increases drawing clarity by reducing duplication. Loop numbers must be listed within the typical box.

PLC Controller Layer

The PLC Controller and MCC equipment are shown in the middle layer with the loop and process tag numbers that correspond to the associated PCS device above and the associated field process device in the layer below. Vertical signal lines connect the associated field equipment device, the PLC controller device and the PCS I/O tag number.

The PLC Controller is shown as a box with hardware signal I/O lines coming from the lower field layer and software signal I/O lines going to the PCS layer at the top of the drawing.

All hardware process interlocks will be shown on the P&IDs in the PLC Controller layer. Software signal lines should be shown in the PLC Controller layer, but the software interlocks are not shown. Software interlocks are defined in the PLC Controller software control strategy narrative document.

Field Equipment Layer

At the lowest level, field process equipment will be shown, and field instrument balloons will be shown above or next to the device. Field operator controls, indicators and local control panels are placed above the field devices at separate levels with balloons indicating control devices in each.

Process piping, tanks, and equipment shall be laid out on P&IDs so that process flow is shown left to right and top to bottom. Representations of tanks and other equipment not shown on the P&ID symbols sheets shall be shown in section (side view) and identified with text.

Multiple controls will be shown as a "typical" wherever typifying does not sacrifice clarity. The field devices and tags will be shown as a minimum and loop numbers and panel designations will be shown in the typical box.

The P&IDs will show a functional representation of MCC equipment, valve motor starters, variable speed drives, packaged controls and controls containing special interlocks. The equipment and controls shall be shown as a box containing interlock symbols and signal function labels. Only the necessary signal interconnections will be shown. Separate electrical schematics or ladder diagrams will be used to define the interlock requirements or illustrate detailed wiring.

The P&IDs will not show detailed control and monitoring logic. Control logic is described by the control strategy narratives and shown in the hardwired ladder and software logic diagrams, which will show actual detailed hardwired/software logic and function. P&ID logic representation shall clearly indicate safety and hardware interlocks with notes describing their function.

Instrument Tags

Instruments and control devices shall be tagged in accordance with ISA Standard S5.1 - Instrumentation Symbols and Identification.

Loop numbers in parallel trains shall be the same for identical functions in each train. Only the least significant digit will be different for each train.

I/O signal symbols shall be labeled with a two or three letter code to identify the signal function. Controller designation letters shall be shown only in the drawing notes or in the upper left-hand corner of the controller functional box. Discrete control outputs are assumed to be of the maintained type unless they are labeled M (momentary) or indicated as such in the I/O Point List.

Electrical Signal Layout

P&IDs will not be used as wiring diagrams however, the P&IDs shall contain enough information for the project team members to complete their design work.

When creating a control scheme that commands a field device to operate, the designer must use a single output from the controller and a single dashed line on the P&ID to show the connection to the field device. For example, a pump motor uses a single, maintained controller contact (DO) and runs as long as that contact is closed. A variable speed or position device uses a single analog output (AO), indicating a 4-20 mA speed or position demand signal, and a single maintained contact (DO) as a run command for motors.

Signal lines shall be arranged to indicate the electrical signal path. For example, signal lines shall indicate that a System/Manual switch selects between a controller output and a hand switch output as alternate sources of control.

Only a limited number of signal lines shall be shown within boxes representing MCCs, valve actuators, variable speed drives, packaged controls or control interlocks. More details shall be specified on wiring diagrams or ladder diagrams.

Electrical Interlocks

Interlock symbols will be shown on the P&IDs in the PLC Controller layer. Hardware interlock symbols are diamond shaped with a capital “I” inside and a number next to them referencing a short explanatory note at the bottom of the sheet. Details of the interlocks will be shown on electrical wiring and ladder diagrams. There are two types of interlocks: process and device protective.

- A process interlock can be defined as a function performed in either software or hardware that is normal to the way the field equipment is used or operated.
- A device protective interlock is a function performed to protect the equipment from potential damage.

All hardware interlocks shall be shown on the P&IDs.

Control Panel Drawings

Drawing Scope

The control panel drawings shall show the physical configuration of the panels, internal wire routing, and control circuitry. These drawings will include the details of instrumentation, monitoring and control circuits. Wire lists are to be prepared as a part of the detailed drawing submittal. Control panel drawings will include the following types of drawings:

- P&ID drawings
- Control Panel Layout with scaled elevation drawings (exterior/interior)
- Control Panel Power distribution drawing
- Hardwired ladder diagrams for Discrete I/O and Analog I/O
- Termination detail drawings integrated with the hardwired Discrete I/O diagrams and the Analog I/O loop diagrams
- PCS and PLC communications drawings

Elevation Drawings (Exterior and Interior)

Elevation drawings shall illustrate the physical configuration of the control panels, including devices, and equipment mounted on or in them. All equipment, footprints, cutouts, and panels will be drawn to scale.

Elevation Drawings Procedure

The procedures and standards for preparation of elevation drawings shall be as follows:

- Panel elevation drawings shall illustrate a frontal elevation view of the control panel with side views if required for equipment mounting. The frontal elevation view shall clearly identify the physical size and configuration of the panel, as well as the scale. Front panel mounted devices shall be illustrated on the enclosure door and identified by nameplates. Interior mounted devices shall also be shown and identified by nameplates. All devices shall be functionally grouped and arranged symmetrically on and inside the panel to enable the operator and maintenance personnel to easily locate the control devices.
- A nameplate engraving designation schedule shall appear on the elevation drawings to identify the required engraving and device identification.
- A Bill of Materials schedule shall appear on the drawing to identify the device along with its size, color, material, and other specifications required to construct the panel.
- The NEMA type of each enclosure will be identified on elevation drawings.
- The fronts of panel mounted devices, switches and lights shall be represented by elevation drawing symbols as shown on Control Panel Symbols Sheet

Hardwired Ladder Diagrams

Hardwired ladder diagrams shall show the interconnecting wiring for any and all devices using relay logic either in or on a control panel or MCC. The drawings are distinct from the software logic ladders discussed in these standards. The hardwired ladder diagrams shall show physical devices such as relays and their contacts, lamps, hand-switches, motor starters, sensing devices with contact outputs, etc.

- All devices shall be identified by distinctive shapes indicating their functions. If a standard shape does not adequately describe the device, a simple box may be employed and the function described in text.

- All devices shall be identified by distinctive tag numbers or alphanumeric identifiers. For example, CR1 and TR2 mean Control Relay #1 and Timer Relay #2, respectively. Devices that are also shown on the P&ID shall have the same tag number.
- All rungs of a ladder shall be numbered in ascending order on the left. The number shall be a four-digit number. The first two digits reflect the Drawing Sheet number on which the ladder appears, although leading zeros are not shown. The last two digits indicate the rung number beginning with 01 at the top. For example, rung number 1509 indicates the ninth rung on Drawing Sheet 15.
- Devices with functional parts shown elsewhere on the ladder (i.e., relay coils and their contacts) shall be cross-referenced on the right with the rung number(s) of where those parts may be found.
- Devices shall have short, narrative descriptions on the right indicating their functional roles in the ladder. Examples include "Start Timer", "High Level Trip", "Run Status", etc.
- All devices shall be shown in the de-energized or "shelf" state.
- The supply voltage and its source shall be shown at the top.
- All devices related to the diagram shall be shown whether they are panel, controller or field mounted. Inter-connections at terminal strips in the panel or junction boxes shall be shown. Wire numbers, colors, terminal numbers, controller points, grounds, etc. shall be shown. Wires that will be pulled inside conduit runs shall be shown with notes.

Analog Input and Output Termination Diagrams

Analog Input and Output Termination Diagrams shall illustrate the field device interfaces to the junction boxes, control panels and the control system analog I/O modules. Analog Termination diagrams should be in conformance with ISA-S5.4-1991. Analog termination diagrams shall illustrate both the physical configuration and interconnecting wiring of the loops. Analog termination diagrams shall show I/O modules with identification of the interconnections, cables, wires, wire numbers, terminals, terminal numbers, grounds, shielding, surge suppressors, and field transmitters.

Analog Termination Diagrams Procedure

The Engineer shall refer to the final site P&ID and the control strategies to develop the Analog Termination Diagrams. Each analog signal device on the P&ID shall be shown with all wiring and panel devices in detail on the drawings.

When the field instrument is located outside the building that the Controller is located, the wiring shall pass through numbered terminals in the surge protection box (SPB) which contain

analog surge protection, then terminate in the controller on the analog terminal block. The wire numbers are assigned after the loop circuit is completed based on the field device tag number. The wire number shall be the same when passing through panel terminals except a suffix of one numeric character will differentiate each segment of the wiring.

Input/Output Point List

General

The I/O Point List identifies all I/O points associated with control and monitoring signals to and from field devices and instruments, and to and from the control system. A listing of the I/O points, including all point attributes, shall be produced by the engineer and provided to the owner and programmer in hardcopy and electronic form (MS Excel.)

I/O Point List Procedure

The Engineer shall utilize the finished P&ID drawing(s) for the site under consideration. At the top of the sheet is a box representing the controller with the inputs and outputs shown as triangles pointing up for inputs and down for outputs. Each point has a unique alphanumeric point tag.

The I/O point list is generated by extracting those unique tag numbers, the signal type (AI, AO, DI or DO; subdivided by attributes if required), supplying a short description (Pmp. No.1 Run, Res. No.2 Level, etc.), and any pertinent attributes (maintained contact, pulse count input, etc.). Two more columns, Data Field 1 and Data Field 2 are then filled in. For Analog Inputs and Outputs, Data Field 1 is the absolute signal range (4-20 mA, etc.) and Data Field 2 is the range in engineering units (0-200 GPM, 0-25 ft, etc.). For Digital Inputs, Data Field 1 is the information supplied by a closed field contact (alarm, HOA in auto, etc.) while Data Field 2 represents the open condition (normal, HOA in hand, etc.). The following should be included on the I/O list spreadsheets:

- System Tag Name
 - 2 character Unit Process–
 - 2 character ISA function code for Controller and PCS
 - 2 character numeric Loop number
 - 2 character numeric Equipment number
- Field Device Tag Name
 - 2 character Unit Process–
 - 4 character ISA function code for Field Device
 - 2 character numeric Loop number
 - 2 character numeric equipment number
- Description

The same description field that is used in the System Point list.

- Signal Type
 - AI for analog input
 - DI for discrete input
 - AO for analog output
 - DO for discrete output
- Data Field 1
 - Raw signal type and span / level (i.e. 4-20 mA)
- Data Field 2
 - Engineering units (i.e. -0 – 100 gpm)
- PLC Cabinet
 - The PLC Controller cabinet where the point is terminated.

Process Signal Requirements

Process signals required to control equipment or process loops are indicated in typical device interface schematics and P&ID standard drawings. The simplest of these is control of a typical single speed motor. This requires the following:

- A discrete input from an HOR (Hand-Off-Remote) switch to indicate remote control
- A maintained contact discrete output for motor run control
- A discrete input from the motor starter auxiliary contact indicating “run” status
- Overload relay failure alarm

A more complex example is a flow control loop that requires the following:

- Remote/Manual discrete input
- Flow control analog output 4-20 mA
- Flow transmitter analog input 4-20 mA
- Valve position transmitter analog input 4-20 mA
- Position switch discrete inputs for open/closed limits

Modulating valves for control of process flows must be properly sized within a controllable range. These valves normally should be no larger than 110 % of maximum design flow and provide for 25-33% of line pressure drop in pump systems. Increasing valve size and reducing head loss tends to cause normal operation in a nearly closed position and make satisfactory flow control impossible.

Control Strategies

The purpose of the control system is to improve the operation of the wastewater pumping process. As part of the design, control strategy descriptions will be required for individual processes. The control strategy descriptions will be developed to the level of detail required to verify that appropriate process instruments and control devices are provided to effectively implement the control objectives.

Instrument Device Schedule

General

The Instrument Device Schedule is a table of all field instruments and field devices that is included in the contract documents for the construction project. The Instrument Device Schedule information will be used after the construction contract is completed for the District's Computerized Maintenance Management System. (Maximo)

Instrument Device Schedule

The Instrument Device Schedule is to be developed by the Engineer after the Field I/O Point List has been extracted from the P&IDs and completed. The Instrument Device Schedule should be included on the contract drawings. The Engineer will supply a soft copy of the Instrument Device Schedule in MS Excel format to the CCWRD Control Systems Engineer. The Contractor's final Instrument Submittal information that includes the instrument manufacturer's name, model number, and calibration information will be supplied in soft copy to the CSE for use in the Computerized Maintenance Management System.

Instrument Device Schedule

The Instrument Device Schedule should include the following fields to provide all information that is required to procure and install the field instruments and other control devices:

- Field Device Tag Number
From I/O Point List
- Description
From I/O Point List
- Data Field 1
From I/O Point List
- Data Field 2
From I/O Point List
- Field Device Description
Equipment description such as 6-inch Magnetic Flowmeter, Polyurethane Liner, with converter"

- Service
50 Character definition of field device process equipment with equipment identification where available such as “RSP #1 discharge flow meter”
- Location
40 Character description of the detailed geographical location for the field device such as “Drywell discharge pipe RSP #1”

Wire List

General

The Wire List identifies all Field Device Tag Numbers, System Tag number, field terminal numbers, wire numbers, Controller terminal block numbers, and Controller I/O point addresses. The Wire List including all point attributes, shall be produced by the engineer and included in the contract documents. This list will provide a standardized reference document for the I+C supplier to work from and assure that the District’s documentation is consistent.

Wire List Procedure

The Wire List Report should include the following fields:

- Field Device Tag Number
- System Device Tag Number
- Point Description
- PLC Point Type
- Data Field 1
- Data Field 2
- PCS Cabinet ID

The Wire List is developed by defining the field wiring, terminal block numbering and PLC address to interface each field point to the PLC and the PCS system. The Termination Diagrams provide the detailed wiring information between the PLC and the field device that is summarized in the Wire List. The following additional fields are entered by the engineer to complete the wire list:

- Field Wire Number Plus
The field wire number is assigned with the Field Device Tag number and a suffix of A. All field wires will be numbered. The wire numbers will be the same when a wire passes through a terminal box.

- Field Wire Number Minus

The field wire number is assigned with the Field Device Tag number and a suffix of B. All field wires will be numbered. The wire numbers will be the same when a wire passes through a terminal box.

Point List Management

General List Management

The I/O point list, Instrument Device Schedule, and the Wire List for each controller will be submitted to the CSE by the Contractor upon completion of the construction project. Also, the Instrument Calibration Data sheets will be submitted the CSE by the Contractor upon completion of the construction project.

Development and Implementation

The I/O point list shall be reviewed by CCWRD staff. The point list shall be developed following P&ID finalization.

ATTACHMENT 4

Submittal Deviation Form

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SUBMITTAL DEVIATION FORM

DATE:		SUBMITTAL PACKAGE:	
PROJECT NO.:		SUBMITTAL NUMBER(s):	
PROJECT NAME:			

The following deviation is submitted in compliance with Section 01 33 00:

DESCRIPTION OF PROPOSED DEVIATION:

The above proposed deviation will result in the following benefits to the DEVELOPER:

MONETARY:	
SCHEDULE:	

DISTRICT'S EVALUATION: CCWRD Use Only

Accepted
 Not Accepted

_____ Signature _____ Date

Comments: _____

THIS FORM IS NOT APPROVED UNTIL SIGNED BY CCWRD ENGINEER

CONTRACTOR:	
Print Name:	
	_____ Signature _____ Date

ENGINEER REVIEW FOR TECHNICAL MERIT

Acceptable
 Not Acceptable

_____ Signature _____ Date

The developer will pay for changes to the design, including engineering design, detailing, and construction costs caused by the requested deviation.

DEVELOPER'S EVALUATION: Developer Use Only

Accepted
 Not Accepted

_____ Signature _____ Date

Comments: _____

THIS FORM IS NOT APPROVED UNTIL SIGNED BY THE DEVELOPER

Submittal Deviation Forms

Developer Projects

For Contractor submitted deviations, use the standard form as shown on the previous page.

District CIP (Capital Improvement Program) Projects

Deviations for CIP projects are submitted by the Contractor directly to the District's Unifier software.