San Diego International Airport

12kV Electrical Distribution System Policy and Guide Specifications
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I. 12kV ELECTRICAL DISTRIBUTION SYSTEM OVERVIEW & POLICY

A. SYSTEM OVERVIEW

Main 12kV power to the Airport is provided through three separate 12kV feeds from the utility company, San Diego Gas & Electric (SDG&E), consisting of two primary and one alternate circuits. The Airport 12kV Electrical Distribution System (Electrical Distribution System) then distributes the power campus wide, utilizing utility grade monitoring and controls systems to ensure reliable and redundant power in support of airport operations.

The Electrical Distribution System and associated infrastructure provide power and ensure continuity of operations at the San Diego International Airport. Accordingly, this manual establishes policies needed to maintain safe operation, and effective maintenance and management of the Electrical Distribution System at all times.

As the Airport is always evolving, these policies also ensure that alterations, modifications and additions to the Electrical Distribution System and associated infrastructure are properly engineered and installed to the highest utility grade standards.

The Electrical Distribution System consist of the following primary elements:

1. Main Electrical Vault (MEV):

   The 12kV Electrical Distribution System begins at the Main Electrical Vault located by the Central Utility Plant, where two primary (A and B) and one alternate (C) SDG&E circuits supply the Airport with its main electrical power.

   The 12kV switchgear and equipment including the Supervisory Control and Data Acquisition (SCADA) system are configured in such a way as to evenly distribute and balance airport facilities and terminals electrical loads across circuits A and B; thereby minimizing peak loads, prevent overload conditions, and ensure reliable and redundant power supply in case of planned or unplanned power interruptions.
2. 12kV Distribution System infrastructure:

Power distribution from the MEV to airport facilities and terminals is achieved through extensive network of underground duct banks, manholes and raceway systems. The electrical underground infrastructure consists of 5 major distribution loops, enabling power feed to the airport facilities and terminals from either of the 2 primary A or B circuits.

Some of main equipment of the electrical distribution system infrastructure are Metal-clad Switchgear lineups located in the MEV and Terminal T2W Electrical Room, Pad-mounted Automatic Throw Over Switchgear (ATO) and associated SCADA cabinets, Capacitor Banks, Medium Voltage Conductors, Distribution Transformers and Overcurrent Protection Devices.

a. 12kV Supervisory Control and Data Acquisition System (SCADA):

The SCADA system function is to monitor and control the delivery of power in the electrical distribution system. This is done both automatically and manually through the SCADA’s Human Machine Interface (HMI) Terminals. The SCADA system is comprised largely of redundant Computers, Servers, Fiber Optic Cables, Fiber Optic Switches, Protection Relays and uninterruptable power supplies. The SCADA system is a stand-alone system that is independent from all other Airport Information Technology Systems partially due to security considerations.

b. 12kV As-built drawings and O&M Manual:

Current 12kV Record Drawings and O&M Manuals are available upon request. These documents must be updated with each planned modification to the system by project requesting such work. Additional infrastructure, equipment, programming, sequence of operations, and O&M requirements must be updated in the As-Built CAD files and O&M Manual accordingly with each project that alters the 12kV system.
B. SYSTEM POLICY

This Policy is intended to achieve the highest level of system functionality and reliability by defining responsibilities along with the standards and specifications to which the system must be maintained and modified.

These policy statements define the Electrical Distribution System best practices, to be implemented for the overall SDIA Electrical Distribution System and Infrastructure. These policies shall be followed to ensure safety, security, and system reliability. These policies shall be adhered to for maintenance and construction as well as for all and any alterations, modifications and additions to the Electrical Distribution System and related SCADA system.

The approach towards effective policy in support of maintaining the 12kV distribution system integrity at all times is to follow same procedures and requirements as those established by the utility company. Accordingly, any modifications to the system as a result of adding new loads or otherwise, shall be submitted to the Authority for review and approval, and the entity requesting such modifications shall adhere to the same requirements as imposed by the utility company, and be responsible for all incidental engineering review and analysis as deemed necessary in support of such request.

The 12kV distribution system loads are monitored by both the Authority and the utility company through the SCADA system, to minimize risks associated with overloading the primary and alternate circuits, help with scheduled maintenance, and trim peak demands and escalating utility usage costs. Accordingly, sufficient time should be provided to engage the utility company on any major changes to the default system configuration and load distribution, including any planned outages or shifting of loads between the 3 circuits that would impact the circuit threshold and available capacity to provide power to other utility clients.
C. OTHER RELATED PROGRAM POLICY REQUIREMENTS

To maintain system integrity and reliability, the Electrical Distribution Systems shall be subject to the following additional policies:


   a) New and Established, dedicated EDS raceways and duct systems, including spares, shall remain closed and unavailable for use to systems outside of the EDS.

   b) EDS Raceways and Utility Structures shall be protected from physical damage and shall remain out of the influence of any and all structures including buildings.

   c) EDS Raceways and Utility Structures shall remain free and clear of obstruction, accessible at all times, for service, and shall maintain all required clearances per CEC, and right-of-way per SDG&E Construction Standards as a minimum. SDIA may require greater clearances on a case-by-case basis.

   d) EDS Medium Voltage Cables and Fiber Optic Cables for SCADA communication shall not share the same Manholes and Vaults, unless approved in writing by the Authority.

   e) EDS Manholes and Vaults shall not contain both Bus A and Bus B Electrical Cables.

2. Electrical Distribution System Preventative Maintenance and Testing shall be administered as described in OPERATIONS MANUAL Volume IV. MAINTENANCE PROGRAM (latest edition). The Maintenance Program is based on Manufacturer and International Electrical Testing Association (NETA) recommendations.

   Electrical Distribution Systems Maintenance responsibilities are summarized per the following:

   a) Airport Owned Equipment - Authority’s 3rd Party Contractor is to maintain the Airports existing Electrical Distribution Systems.
b) Non-Airport Owner Equipment- It shall be the equipment owners’ responsibility to safely operate and maintain all of their equipment to the SDIA Authority Standards, found in the OPERATIONS MANUAL. Said equipment owner is also responsible for any and all associated expenses, related to any said equipment failure which adversely effects Airport equipment or operations, directly, or indirectly.

c) A Predictive and Proactive Maintenance strategy shall be implemented as an aide in determining 12kV Electrical Distribution Systems Infrastructure equipment maintenance and replacement cycles.

3. Electrical Distribution System SCADA conductivity:

a) The Authority shall be granted unrestricted direct access to Monitor Consumption Data or Generation Data of any system directly or indirectly connected to the Electrical Distribution Systems. Data from non-SDIA owned facilities and equipment will be collected and/or stored for Authority’s internal purposes. Note: Failure to provide “unrestricted direct access” may force disconnection from the Airport’s Electrical Distribution Systems to ensure the overall reliability of the system.

4. Electrical Distribution System Modifications

a) It is the responsibility of the project necessitating the alteration of, or connection to, or addition to, the Electrical Distribution System to incur all associated costs of the modification.

b) The Authority shall have full oversight and control of all proposed modifications to the Airport’s Electrical Distribution System.

c) The processes to implement these modifications fall under following three categories and are located in OPERATIONS MANUAL Volume II. SYSTEM INFRASTRUCTURE, Sections C-1, C-2, and C-3:

- Extensions-Additions-Relocations Downstream of Existing LIS.
- New ATO and Major Loop Modification-Extension.
- Elimination of System Components (Permanently Removing Loads).
d) Additional infrastructure, equipment, programming, sequence of operations, and O&M requirements must be updated in the As-Built CAD files and O&M Manual accordingly with each project that alters the 12kV system.

D. CONTROLS RELATED TO THIS POLICY AND PROGRAM

1. Reviewing this policy manual and program.

   a) This Policy and its Associated Program documents shall be reviewed, at a minimum, annually. Or when:

   • Observations “in the field” indicate a lack of understanding of the requirements.
   • As needed for compliance to regulation and state laws.

   b) The reviews shall be undertaken and completed by personnel designated by the Authority and be submitted to the Authority with recommended changes or enhancements, if needed.
II. 12kV ELECTRICAL DISTRIBUTION SYSTEM GUIDE SPECIFICATIONS

A. INTRODUCTION - DESCRIPTION OF WHAT THE SPECIFICATION IS AND ITS INTENDED USE

1. SPECIFICATION - A detailed, exact statement of particulars, especially a statement prescribing materials and quality of work for something to be built, installed, or manufactured.

2. ORIGIN - These specifications are largely adopted from the original 12kV Electrical Distribution Systems project’s construction specification. The specifications have been edited to reflect current standards, and SDIA requirements.

3. INTENDED USE - These Specifications shall be adopted by all SDIA departments, and incorporated into all construction documents for projects connecting to, or modifying, the SDIA’s 12kV Distribution System, in order to ensure continued safety, security, and reliability of the system.

These specifications shall be considered to be standard Guide specifications that shall be adhered to for maintenance and construction as well as any alterations, modifications and additions to the 12kV Electrical Distribution System and its related SCADA System. Standard specifications shall be incorporated without modification in design and construction projects.

4. VARIANCE - Variances from the specification may be requested in writing from Authority and may be granted at Authority’s sole discretion when deemed necessary in order to address unique constructability circumstances that may arise during design or construction phases. At no time shall the Safety, Security, and Reliability of the System be compromised.
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SUMMARY OF WORK

PART 1 GENERAL

1.1 SUMMARY

A. This section includes:

1. Related Requirements
2. Work covered by Contract documents
3. Phasing and General Order of Work
4. Schedule and Time of Performance
5. Work Under Other Contracts
6. Cooperation of Contractor and Coordination with Other Work
7. Contract Milestones and Liquidated Damages
8. Notice to the Authority Labor Disputes
9. Manufacturers’ Labels
10. Laying Out of the Work
11. Manufacturers’ Specifications

1.2 RELATED REQUIREMENTS

A. Related requirements specified in other Sections listed in Index of Project Manual, including all Sections under Division 1, unless otherwise specified.

B. The General Conditions, Special Conditions, and all Division 1 Sections are a part of each Section of the Special Provisions.

C. Exhibits and Appendices listed in Index of Project Specifications.
1.3 WORK COVERED BY CONTRACT DOCUMENTS

A. The scope of work includes the furnishing of all labor, materials, equipment, and incidental items meeting the technical requirements of these specifications. The work, in general, includes providing a new addition to the existing 12kV electrical distribution system. The work consists of, but is not limited to, the following:

1. For each segment of work, upon coordination, survey and mark out all manholes, pull boxes and ductbank routings per contract requirements.

2. For each segment of work, upon coordination, pothole manholes, pull boxes and ductbank locations to verify the exact location of all existing utilities and confirm clearances required for ductbank routings.

3. For each segment of work, upon coordination, sawcut, demo, excavate and install required manholes, pullboxes and ductbanks. Provide ductbank encasement, backfill and install subsurface and surface restoration per Contract. Tie-in to existing ductbanks and pathways as indicated in the Contract Drawings and Specifications.

4. For each segment of work, upon coordination, form and pour all required electrical equipment concrete pads.

5. Install new electrical equipment and before pulling medium voltage, 600V, ground and Communication cables, Splice and terminate as indicated in the Contract Drawings and Specifications. Verify, mandrill and clean all existing and new ductbanks prior to pulling cables.

6. Coordinate and install SCADA hardware per contract requirements and complete all fiber optic connections.

7. Coordinate and perform overall system testing and commissioning as indicated in the Contract Drawings and Specifications.

8. If the duct work requires installation work crossing of Airport perimeter fence and gates. The perimeter fencing and gates consist of a Perimeter Intrusion Detection (PID) system. Where installation of the ductbank would require removal and reinstallation of the PID System and/or portions of fencing, the following provisions shall be implemented:

   a. Bypassing of the PID system including temporary provisions to support PID operation during the construction work shall be performed by the Authority’s maintenance contractor. Contractor shall coordinate,
work with, secure and engage.

b. The Authority’s maintenance contractor to perform the necessary PID system work.
c. Compensation for work performed by Authority’s maintenance contractor is included in the scope of work Refer to Specification Section 01020- Allowances.

B. San Diego International Airport is a fully operational regional air transportation facility. Contractor operations shall not impact the Authority operations or any other part of the airport at any time. All Authority operations shall have precedence over Contractor’s operations. The work shall be fully coordinated and performed in phases to avoid impact to Authority operations.

1.4 GENERAL ORDER OF WORK

A. The sequence of work described below is included for the Contractor’s guidance to plan the work. Only major aspects are included to demonstrate the sequence required to allow construction to proceed while supporting, Authority and airline operations.

The Contractor shall follow the sequence of work as shown on the drawings and as set forth herein.

1. Prepare submittals, shop drawings, safety plan, SWPPP, Quality Control Plan, submittal register, procurement log, schedule, and schedule of values, immediately after Notice of Award.

2. Proceed with security requirements to obtain security badges for all personnel to require unescorted access to the Authority Operations Area (AOA), immediately after Notice of Award.

3. Upon Notice to Proceed, commence and complete Work items as required in Scope of Work. The Work shall be planned, sequenced, and coordinated to minimize impact to the Authority, airport operations and tenants.

B. The sequencing and phasing plan described below is included for Contractor’s guidance to plan the Work. If Contractor wishes to propose an alternate plan that further minimizes the impact to Airport and Airline operations and tenants, Contractor shall prepare and submit an alternate plan for the Authority’s consideration and concurrence.

1. 12kV Distribution System Manholes, Pull Boxes and Ductbanks
   a. The 12kV distribution system utilizes ductbanks and manholes to establish the required campus wide loop. The 12kV ductbanks and manholes have been segmented based on particular locations taking into account operational
restrictions and coordination items required during construction activities.

b. Contractor shall provide work plan for each allocated duct bank segment twenty-one (21) days in advance for Authority review and coordination. At a minimum, the work plan shall include the following information:

2. Schedule indicating work activities, location, dates and duration of work.

3. List of allocated resources and manpower.

4. List of all pertinent submittals and review status. Contractor shall allow sufficient time for submittal approvals and procurement items in support of the required intermediate completion milestones for each segment of work.

5. Layout plan of the work area indicating scope of work and construction footprint required to perform the Work, including proposed equipment routing plan.

6. Traffic control plan and provisions.

7. Identification of adjacent equipment and protective measures to be utilized.

8. Sequence for temporary support, protection, removal and/or replacement of any obstructions during the Work.

9. List of all required coordination items and special provisions required to support airport operations, airport security, stakeholders and tenant’s property, and public use and right of way during the Work.

10. List of provisions implemented to support airport and tenant operations during and in between work shifts.

11. The Work shall be completed in order of the Contractor’s choosing, except as constrained or otherwise restricted as stipulated by Authority or other portions of the Contract Documents.

12. For each segment of work, upon coordination, survey and mark out all manholes, pull boxes and duct bank routings per station numbers assigned on Record Drawings and Specifications fourteen (14) days in advance of scheduled work.

13. For each segment of work, upon coordination, pothole manholes, pull boxes and duct bank locations to verify all existing utilities and
14. For each segment of work, upon coordination, sawcut, demo, excavate and install required manholes, pullboxes and ductbanks. Provide ductbank encasement, specified backfill and subsurface and surface restoration per Contract. Perform explorative excavation to identify tie-in locations to existing ductbanks and pathways as indicated in the Record Drawings and Specifications.

15. Spoils and debris as a result of demolition and excavation work shall be removed off site. No staging of spoils at the work site is allowed. Contractor has the option to haul the spoils to the approved staging area in preparation of hauling off site as required.

16. Contractor shall remove all tools, materials, spoils, and equipment from the work area, and clean the work area thoroughly, so that by end of the shift the area is safe and free from construction debris, dirt or dust and available for normal use.

17. All open trenches shall be protected by use of traffic and/or aircraft rated trench plates based on the area of work. Trench plates shall be beveled and anchored in place as to ensure no displacement due to vehicular and Ground Service Equipment (GSE) traffic and/or aircraft jet blast. All trench plates at the Aircraft Operations Area (AOA) shall be minimum 1” thick.

18. Trench sizes shall be kept to the minimum footprint possible as to minimize impact to adjacent operations and protect the existing systems and equipment in place. Provide appropriately sized shoring and/or trench boxes inside open trenches to protect construction personnel during the work and avoid compromise of trench walls.

19. Underground soil is expected to contain relatively high concentration of clay in certain segments of trench work as indicated on the Contract Drawings. Contractor shall plan and schedule its work such as to minimize duration its trenches are exposed by diligently proceeding with ductbank installation, encasement and backfill upon excavation. The contractor shall be responsible in maintaining integrity of its trenches at all times and shall take appropriate measures to protect trenches by use of shoring and trench-boxes.

20. There are number of connection and tie-in points to existing ductbanks and manholes as indicated on the Contract drawings. These locations as identified are based on the latest information available at the time of preparation of these Documents. As such,
Contractor shall verify these locations through review of record drawings and field conditions minimum 21 days in advance of the work with the Authority. Contractor shall plan to perform explorative excavations up to 10 foot in vertical or horizontal directions and up to additional 5-foot depth from those coordinates shown on the Plans for the required tie-ins.

21. Prior to ductbank excavations, potholing shall be performed to verify exact location of existing utilities. It is anticipated that there are other unknown underground utilities campus wide, and accordingly the Contractor shall perform its excavation work with due diligence and hand dig as required to protect all known and unknown utilities during its work.

22. When working inside AOA, Apron and aircraft taxiway areas, Landside areas (airport property outside the AOA such as leased areas and parking lots), and restricted areas, support the following provisions:

   a. Daily coordination required prior to and after end of each shift with the Authority.

   b. Mark out the proposed trench footprints 14 days in advance to coordinate with airport operations, tenants, and stakeholders.

   c. Do not enter private or restricted areas unless prior coordination and approval is obtained minimum 7 days in advance.

23. If the ductbank installation work require crossing of airport perimeter fence and gates. The Contractor shall not compromise the security provisions in place during its Work. The Contractor shall perform its ductbank work on the secured side of the fence first, and at end of each shift install a vertical steel plate tag welded to the horizontal trench plates as to block any openings over 4” wide between the bottom of the fence and its trench work.

24. Only upon completion of the ductbank installation including encasement and backfill at the secured side, shall the Contractor proceed with the work on the unsecured side of the fence.

25. Airport perimeter fencing and gates consist of a Perimeter Intrusion Detection (PID) system. Provide minimum 72-hour notification when working within 10 feet of the fence. The PID system will be temporary bypassed by Airport Operations on a daily basis during the Work.
26. Where installation of the ductbank would require removal and
reinstallation of the PID System and/or portions of airport perimeter
fencing, the following provisions shall be implemented:

a. Bypassing of the PID system including temporary provisions
to support PID operation during the construction work shall be
performed by the Authority’s maintenance contractor through
the Contractor as an allowance item under the Bid Schedule
A, Item 80.

b. Where a portion of the perimeter fence needs to be
temporarily removed to perform the work, a Security Guard as
approved by the Airport Authority shall be provided by the
Contractor from the time of the perimeter fence removal until
the fence is returned to original configuration.

c. Provide detailed work plan 14 days in advance, stipulating
on a shift by shift basis the provisions planned to maintain
security integrity of the perimeter fence during the Work.

d. Contractor shall repair any landscaping and irrigation
damaged during its work and restore to original conditions.
Contractor shall preserve and protect trees and shrubs in the
area of its work and return to original condition at completion
of the Work.

e. Glideslope and Localizer Critical Areas are defined per FAA
Circular #. The Instrument Landing System (ILS) is activated
during low visibility conditions typically related to early
morning fog to guide aircraft landing and takeoff from runway
9 and 27. At no time shall the Contractor enter these critical
areas when the system is active. When ILS is active, Vehicle
Access Road (VSR) passing through the critical areas is
closed as to prevent any signal interference. Contractor shall
make the following provisions to its construction work when
working within the glideslope and localizer critical areas:

1) Construction work activities will not be allowed when
the ILS system is activated. This restriction also
prohibits people and equipment from being in the area
during those periods.
2) Where portions of the work are located within the glideslope and localizer critical areas, Contractor shall specifically plan and coordinate the work 21 days in advance and obtain approval to proceed by airside operations on a daily basis. Work within the critical areas shall be performed between the hours of 23:30 and 05:00 only.

3) During low visibility conditions based on direction from the Control Tower, Contractor shall be prepared to pullback and clear the area within 20 minutes, relocating to a predetermined hold back position.

4) Contractor shall remove all equipment, materials, stockpiles and spoils, cover open trenches with plywood covered steel plates and clear the area such that no foreign object is projecting above the apron surface within the allocated 20 minutes' pullback period. Steel plates top surface shall be fully covered with plywood bolted to the plates and secured such as to withstand jet blast and ground service equipment loads. Plywood covered steel plates shall be mounted flush to the apron surface.

5) Based on the above restrictions, the Contractor shall plan and sequence its work in such a manner as to support the required activities needed within the allowable pullback duration, and stage such preparedness on site prior to commencing with the work with Airport Operations and FAA.

6) Runway safety zone includes any point within 250 feet of the runway’s centerline or extended centerline, as indicated on the Contract Drawing C-1. At no time shall the Contractor operations enter the runway safety zone areas during its construction activities, unless otherwise noted and coordinated 21 days in advance.

7) Work within the runway safety area shall be performed between the hours of 23:30 and 05:00 only.

8) During low visibility conditions based on direction from the Control Tower, Contractor shall be prepared to pullback and clear the area within 20 minutes, relocating to a predetermined hold back position behind the critical area gate on the Vehicle Service Road located north of the runway.
9) Contractor shall remove all equipment, materials, stockpiles and spoils, cover open trenches with plywood covered steel plates and clear the area such that no foreign object is projecting above the apron surface within the allocated 20 minutes' pullback period. Steel plates top surface shall be fully covered with plywood bolted to the plates and secured such as to withstand jet blast and ground service equipment loads. Plywood covered steel plates shall be mounted flush to the apron surface.

10) Based on the above restrictions, the Contractor shall plan and sequence its work in such a manner as to support the required activities needed within the allowable pullback duration, and stage such preparedness on site prior to commencing with the work with Airport Operations and FAA.

11) When requiring use of a crane at the AOA side, the maximum allowable height shall be established by the Contractor and approved by FAA. Allow minimum 8-10 weeks for FAA to process the required Form 7460. Reference requirements under Appendix 7 and coordinate all forms and documents needed in advance with the Authority in support of the work schedule.

12) Contractor activities on portions of AOA side are limited by the California Least Tern Nesting Site Protection Program in certain segments of work, with conditions and boundaries as established and identified under Appendix 9. The Contractor shall incorporate the seasonal limitations on work performed within the least tern nesting boundaries in its schedule.

13) Contractor shall contain and minimize dust and debris created during its construction work and have a full Foreign Object Debris (FOD) control program in place at all times.

14) When working inside public and/or tenant controlled parking lots and driveways including valet and VIP parking areas and public transportation depots, the Contractor shall comply with the following requirements:
a) Notify the Authority and coordinate with Ground Transportation 21 days in advance of the Work.
b) Provide No Parking signs for each parking space 21 days in advance. Delineate and manage the areas when cleared to ensure the required workspace is available in time and in support of scheduled work.

c) Protect the public and construction personnel by establishing and maintaining positive construction boundaries during the Work.
d) Maintain pedestrian walkways, and vehicle and bus traffic access and flow in and out of the area at all times. Provide temporary signs as required to redirect and support normal airport operations and traffic flow.

e) Return the work area to normal use between work shifts by use of approved trench plates, unless prior approval is obtained to delineate portions of the area in construction by use of k-rails and/or fencing during the work. Delineating equipment shall be adequately sized and rated as to keep vehicle and pedestrian traffic away from the construction area while establishing positive and safe control of the construction boundaries. Provide temporary directional signs and striping as needed during each phase of the work.

f) The Contractor shall submit and follow the traffic control requirements included in the Drawings.

g) At completion of work in each coordinated section or segment, return the area to the same condition found complete with surface restoration, striping and landscaping, prior to proceeding with the work in the subsequent segment.

h) Contractor shall maintain the same number of assigned ADA parking stalls in each parking lot during its work. When delineating an ADA parking stall as a result of the construction work, Contractor shall provide temporary striping and ADA sign in an adjacent parking stall not impacted by construction. Upon completion of
the work, return all parking stalls impacted by the work to original configuration.

15) Maintain safe traffic flow and control, at all times during construction. Approved traffic control submittals are required prior to commencing with the Work. Where the work requires crossing of terminal access and public roads, Contractor shall support vehicular access and throughways at all times and comply with traffic control requirements as indicated in the Drawings.

16) Any damage to airport property as a result of Contractor work, such as but no limited to landscaping, fencing, gates, bollards, signs and barricades shall be replaced by the Contractor and returned to the same condition as prior to start of Work.

C. Complete all punchlist work after all initial Scope of Work is complete.

D. Portion of the Work is in the AOA and security sensitive areas. All Contractor employees performing work must be security cleared and badged.

E. Contractor shall schedule a meeting with the Authority fourteen (14) Calendar days before the start of any work that may impact airport, airline, and tenant operations to coordinate Contractor’s work.

F. In TSA controlled area (sterile areas), construction work must be completed, areas completely cleaned, all tools inventoried, accounted for and removed by latest 4:00 AM. Additional Work hour limitations maybe imposed should any Contractor activity, in the opinion of the Authority, can cause excessive noise, dust, or present any safety hazard or inconvenience to public and/or airline/Authority personnel.

G. Contractor may encounter ground water during its excavation work. In that event, the Contractor shall be responsible for dewatering. When ground water is encountered, the Contractor shall inform the Authority immediately for resolution and further action. The cost for all Work performed for dewatering will be paid for by the Contractor and is included in Scope of Work.

H. If portions of the Work involve excavation for trenches in which conduit is to be placed. Contractor shall protect and conduct Work in each excavation in a way that will optimize progress in each work shift, and shall provide complete protection at the end of each work shift by the time allowed for that Work Segment or area of Work, taking in to account all
restrictions and coordination requirements as stipulated under this Section and other portions of the Contract documents.

I. The Contractor shall provide traffic control measures as indicated on the Contract drawings, and as required by other parts of the Contract documents. Traffic control measures shall include vehicular and pedestrian traffic control in the work area during construction activity for all daytime and overnight conditions. Additional traffic control devices and provisions maybe required in the field to assure safety to the public and airport personnel, at all times during execution of this Contract.

J. Temporary construction fencing and barricades may have to be relocated and or reconfigured during the prosecution of the Work to avoid impact to airport operations and tenants.

K. Contractor shall plan for all tools, equipment, and materials not fastened in place including all construction spoils to be removed from the work site at the end of each work shift.

L. Non-hazardous Municipal Solid Waste

1. The underground soil in certain areas of the campus is classified as “Non-hazardous Municipal Solid Waste”. Contractor shall coordinate with the Authority to determine if any of its Work is within these areas and support the measure specified herein.

2. Any spoils as a result of Contractor work is classified as non-hazardous municipal solid waste. Contractor shall not mix any spoils as a result of its work from adjacent sites including any imported materials with the existing materials at this site. All spoils and stockpile materials staged in this area shall be maintained, protected and kept separate from the existing materials by use of visqueen or other appropriate segregation methods.

3. Contractor shall make the following provisions for handling, hauling and disposal of its spoils at this location per the following:

   a. Materials existing on-site at the start of work include soil, asphalt, and concrete. All existing on-site material being removed from the site shall be hauled and disposed by the Contractor in accordance with local, state, and federal regulations as non-hazardous municipal solid waste. Under no circumstance shall the Contractor mix the spoils removed from the site with other spoils, soils or other imported materials.
b. Any spoils as a result of Contractor work from adjacent sites including any imported material that is mixed by any means and in any manner with the existing on-site materials and that is being removed from the site shall be hauled and disposed by the contractor in accordance with local, state, and federal regulations as non-hazardous municipal solid waste.

c. Any imported material that is not mixed with the existing on-site materials and that is being removed from the site shall be removed, transported, and legally disposed of as surplus material off Authority property.

4. Hauling of Non-hazardous Municipal Solid Waste:

   a. The Contractor shall transport non-hazardous municipal solid waste in accordance with local, state, and federal regulations. The Contractor shall bear all costs for, and comply with the appropriate local, state, and federal permits and licenses required for hauling non-hazardous municipal solid waste.

   b. Prior to departure from the site, Contractor shall cover loads with a tarping device, which shall cover the entire load. Tarp shall remain overload until reaching the disposal site. Each truck leaving the site shall pass over a temporary stabilized construction entrance. Trucks shall not track soil and/or material on pavement.

5. Disposal of Non-hazardous Municipal Solid Waste:

   a. The Contractor shall dispose non-hazardous municipal solid waste in accordance with local, state, and federal regulations. Nonhazardous municipal solid waste shall be disposed at the pre-approved disposal facility listed below. The Contractor shall have prior written approval by the Landfill owner, or from the Engineer, to dispose of the non-hazardous municipal solid waste at the Landfill.

Otay Landfill
1700 Maxwell Road
Chula Vista, CA 91911 Tel. (619) 421-3773

Hours of Operation:
Monday through Friday: 7 am - 4 pm
Saturday: 7 am - 3 pm
Sunday: Closed
b. All trucks must be off the Landfill property by the stated closing time. Thus, the last truck per day shall be at the Landfill at least one-half hour before the Landfill’s stated closing time.

c. The Contractor shall bear all costs for, and comply with the appropriate local, state, and federal permits and licenses required for disposal of non-hazardous municipal solid waste.

1.5 SCHEDULE AND TIME OF PERFORMANCE

A. **TIME IS OF THE ESSENCE.** Contractor shall complete all work within the time specified. Timely completion of the work is critical in order to meet specific facility requirements for cutover of power connecting to the 12KV power distribution system. The Work shall be performed as follows:

B. The Authority anticipates the Contractor may perform the Work by utilizing multiple crews and work shifts to complete the Work.

1.6 WORK UNDER OTHER CONTRACTS

A. Other contract work may be related to this Contract, which may occur concurrently, under separate contracts with the Work of this Contract.

B. Contractor shall coordinate with other contractors as required by these specifications. Contractor shall acknowledge responsibility to coordinate and plan the work activity to mitigate any delay impacts with the adjacent and integrated construction projects.

1.7 COOPERATION OF CONTRACTOR AND COORDINATION WITH OTHER WORK

A. Contractor shall cooperate with all other contractors to the end that any delay or hindrance to their work will be avoided. The cost of such cooperation will be considered as included in the bid prices and no separate or additional payment will be made, therefore.

B. Limit use of premises for Work and for construction operations to allow for:

1. Authority, TSA, and airline operations

2. Authority tenants and stakeholder operations

3. Work by other contractors

C. Cooperate with the Authority, TSA, airlines, other tenants, and their contractors who will occupy and begin work on site and inside the project area prior to completion of Work of this Contract.
D. Cooperate with contractors for work in other areas not included in Contract, but which may take place during construction period.

E. Contractor or any of its subcontractors shall not install any portions of the Work where it is necessary that the work of other contractors shall be installed first or carried forward simultaneously without having first given Authority and the other contractor(s) at least fourteen (14) calendar days’ notice.

1.8 NOTICE TO THE AUTHORITY OF LABOR DISPUTES

A. If the Contractor has knowledge that any actual or potential labor dispute is delaying or threatens to delay the timely performance of this Contract, the Contractor shall immediately give written notice, including all relevant information, to the Engineer.

B. The Contractor agrees to insert the substance of this clause in all subcontracts, which are entered into, under this Contract. All subcontractors shall be required to immediately notify the next higher tier subcontractor or the Prime Contractor of any actual or potential labor disputes that may affect, delay, or threaten the timely completion of this Contract.

1.9 MANUFACTURERS’ LABELS

A. Manufacturer’s labels or stamps are not allowed on any item, piece of equipment or fixture on any surface exposed to view in the finished construction.

1.10 LAYING OUT OF THE WORK

A. Contractor shall immediately locate all general reference points and take such action as is necessary to prevent their destruction; lay out his work and be responsible for all lines, elevations and measurements for work executed under this contract.

B. Contractor shall layout all the systems as complete as field conditions will allow to determine any interference with building structures, utilities or any other equipment before final design or installation of equipment takes place. It is the Contractor’s responsibility to coordinate all clearance requirements with other contractors. No additional payment will be made to Contractor for failure to coordinate the placement of any equipment and to maintain the required clearances.

C. Exercise proper precaution to verify figures shown on Drawings before laying out work and be responsible for any error resulting from his failure to exercise such precaution.
1.11 MANUFACTURERS’ SPECIFICATIONS

A. All materials, items, equipment, etc. shall be installed in accordance with the manufacturers’ applicable specifications and printed installation instructions when not otherwise specified.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION 01 01 00
SPECIAL PROVISIONS

DIVISION 01 GENERAL REQUIREMENTS

SECTION 01 91 00

COMMISSIONING

PART 1  GENERAL

1.1  SUMMARY

A. If a Commissioning (Cx) Process is implemented, it will provide the Authority with independent verification that the systems to be commissioned have been installed and operate according to the Contract Documents.

B. The Authority will contract an Independent Commissioning Agent (CxA) to Facilitate System Commissioning in accordance with “Basis of Design” and “Owner’s Project Requirements.” The CxA will prepare a Commissioning Plan and forward a copy to the selected contractor at the Pre-construction Meeting. The CxA will provide the Authority with an independent, unbiased, objective view of the systems’ installation, operation, and performance. The commissioning process does not alleviate or reduce the responsibility of the design professionals or installing contractors to provide a complete and finished product, installed and fully functional in accordance with the Contract Documents.

C. Commissioning is intended to enhance the quality of system start-up and Aid in the orderly transfer of systems for use by the Authority. Quality commissioning requires participation by all parties involved with the design and construction process, including the Authority, the Design Team, general contractor and subcontractors, and Authority’s personnel. The Commissioning Agent will lead the commissioning team planning and coordinate all commissioning activities in conjunction with the design professionals, project manager, general contractors, manufacturers, and equipment vendors. Commissioning consists of systematically documenting that specified components and systems have been installed and started up properly and then functionally tested to verify and document proper operation and expected performance through all sequences of operation and conditions.

1.2  RELATED SPECIFICATIONS SECTIONS

A. Section 01 43 33 “Manufacturer’s Field Services”

B. Section 26 09 14 “Power System Supervisory Control and Data Acquisition (SCADA)”
C. Section 26 05 70 “Electrical Systems Analysis”
D. Section 26 09 15 “Power System Digital Network and Computer Equipment”
E. Section 26 09 16 “Power System Application Software”
F. Section 26 09 17 “Fiber Optic Communication System”
G. Section 26 12 02 “Oil-Filled Pad Mounted Transformers”
H. Section 26 13 15 “Medium Voltage Pad Mounted Capacitor Banks”
I. Section 26 13 19.02 “Pad-Mounted Switchgear”
J. Section 26 14 13 “Switchboards”
K. Section 26 26 23 “Automatic Transfer Switches”

1.3 **SYSTEMS TO BE COMMISSIONED**

A. **Electrical Systems:**
   1. Switchgear and Switchboard Assemblies
   2. Panelboards
   3. Dry Type Transformers
   4. Liquid Filled Transformers
   5. Low Voltage Cables, 600 Volt Maximum
   6. Medium-Voltage Cables, 15 kV Maximum
   7. Safety Switches, 600 Volts Maximum
   8. Medium-Voltage Line Switches, 15 kV Maximum
   9. Molded and Insulated case Circuit Breakers
   10. Low Voltage Power Circuit Breakers
   11. Medium-Voltage Load Interrupters
   12. Medium-Voltage Switchgear Modifications
   13. Protective Relays
   14. Instrument transformers
   15. Metering
   16. Trenching, Manholes, Conductors, Duct-banks, and Routing
   17. Grounding systems
   18. Ground Fault Systems
   19. Automatic Transfer Switches
20. Battery Systems
21. Medium-Voltage Surge Arrestors
22. Power Factor Correction Capacitors
23. Supervisory Control and Data Acquisition (SCADA) System
24. Fiber Optic Cable system

1.4 DEFINITIONS

A. Commissioning Agent: An entity identified by the Authority who plans, schedules, and coordinates the Commissioning Team to implement the Commissioning Process.

B. Commissioning Plan: Prepared and updated by the Commissioning Agent with input from the Commissioning Team, the Commissioning Plan outlines the organization, schedule, allocation of resources, and documentation requirements of the Commissioning Process.

C. Commissioning Process:
   1. A quality-focused process for enhancing the delivery of a project. The Cx Process focuses on verifying and documenting that the facility, and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner’s Project Requirements.
   2. Commissioning is typically abbreviated by “Cx” and Commissioning Agent by “CxA”.

D. Commissioning Team: The individuals who through coordinated actions are responsible for implementing the Commissioning Process.

E. Construction Checklist: Documents prepared by the CxA and issued to the Contractor early in the Construction Phase. The purpose of the Checklist is to verify that appropriate components are on site, correctly installed and functional & ready for Functional and Performance Testing.

F. Corrective Issue Report: A report generated by the CxA during Verification and Testing, documenting deficiencies found during the testing procedures.

G. Functional Testing: Performed by Contractor to demonstrate the Systems are ready; all factory testing complete and accepted, equipment and systems are installed, initial checks have been performed, mechanical adjustments, if any, complete, preliminary field tests performed and accepted; energized operation to demonstrate each function is then performed.
H. Performance Testing: After successful completion of all Functional Testing for each piece of equipment or for system, the Contractor will operate each piece of equipment or System to demonstrate that it is operating in compliance with the requirements of the Contract Documents. The Performance Testing must demonstrate each required function on a paragraph-by-paragraph, loop-by-loop and site-by-site basis as well as an integrated operation of the system.

1.5 COMMISSIONING TEAM

A. The Commissioning Team shall consist of a minimum of one representative for each of the following:

1. The Authority Project Manager, Construction Manager, and Inspector
3. Design Engineer.
4. Contractor, including Subcontractors, Manufacturers and Vendors, as required.
5. Commissioning Agent.

B. Contractor’s Representative shall have at least five years’ experience in construction administration along with a thorough understanding of construction project documentation procedures.

PART 2 PRODUCTS

2.1 TESTING EQUIPMENT AND INSTRUMENTS

A. Contractor, sub-contractors, and equipment suppliers shall provide tools, instruments, laptop computers, PDAs, software programs and services required to perform system testing procedures. This includes providing the connection to systems to be tested, operation of the test equipment and instrumentation and generating test results as required.

2.2 SUBMITTALS AND OPERATIONS & MAINTENANCE MANUALS

A. Contractor shall provide submittals as defined in the Contract Documents according to requirements established in Specification Section 1D.

B. Contractor shall provide Operation & Maintenance Manual material as defined in the Contract Documents according to requirements established in Specification Section 1D.
PART 3  EXECUTION

3.1  ROLES AND RESPONSIBILITIES

A.  Construction Phase:

1.  Design Team:
   a.  Attend pre-bid and pre-construction meetings as scheduled by the Authority.
   b.  Attend Commissioning coordination meetings.
   c.  Collaborate with Commissioning Agent to develop final detailed Functional and Performance Testing Procedures.

2.  Authority Project Manager:
   a.  Attend construction progress meetings.
   b.  Attend Commissioning Coordination meetings.
   c.  Review Construction Phase Commissioning documentation.

3.  Authority Personnel Construction & Maintenance Personnel:
   a.  Attend Commissioning coordination meetings.
   b.  Attend Construction Phase coordination meetings.
   c.  Periodically visit the construction site to become familiar with the Components as they are installed and prior to being concealed.
   d.  Witness, to the greatest extent desired, equipment cleaning, testing, and startup procedures.
   e.  Communicate with the Construction Manager and Commissioning Agent any concerns regarding system installation.
   f.  Review the equipment training plans with the Commissioning Agent with respect to appropriateness to the potential trainees.

4.  Commissioning Agent (CxA):
   a.  Conduct Commissioning Team Kickoff meeting. The intent of the meeting will be to present the commissioning specification requirements, and scheduling.
   b.  Conduct and document commissioning coordination meetings.
   c.  Receive, review, and assemble the Systems Manual as submitted by the contractors.
   d.  Provide Construction Checklists to be completed by Contractor. Verify completion of Construction Checklists.
   e.  Work with the contractor in resolving any issues identified during QA/QC, Functional, or Performance Testing.
   f.  Assist the Construction Manager, sub-contractors, and Authority’s Project Manager in incorporating Commissioning activities into the master project schedule.
g. Review equipment shop drawings and coordination drawings applicable to systems to be commissioned concurrent with the Design Team’s review for compliance with the Contract Documents. Submit review comments to the Design Team for inclusion with their review comments.

h. Review O&M manuals applicable to systems to be commissioned concurrent with the Design Team’s reviews. Submit review comments to the Design Team.

i. Perform site visits, in conjunction with Commissioning meetings, to observe component and system installations.

j. Review training plans prepared by the installation contractors.

k. Coordinate selected witnessing of systems/equipment cleaning, QA/QC testing, and startup procedures as specified in equipment sections of the specifications with the Construction Manager.

l. Prepare final Functional and Performance Testing Procedures. These will be distributed to the Authority, Design Team and Construction Manager for distribution to all participating contractors for their review, comment, and approval.

5. Authority Construction Manager:
   a. Review Construction Phase Commissioning documentation.
   b. Participate in commissioning coordination meetings.
   c. Notify Commissioning Agent when systems and assemblies are ready for testing.
   d. Copy Meeting Minutes to Commissioning Agent for informational purposes.
   e. Provide Commissioning Agent with Construction Schedule updates at least monthly.
   f. Provide Commissioning Agent with copy of all shop drawings and Submittals associated with the systems being commissioned. These shall be distributed concurrent with the distribution to the Design Team.
   g. Incorporate commissioning activities into the master project schedule. This scheduling shall involve the Commissioning Agent and installation contractors.
   h. Field verify the installation contractor’s red lined Record Drawings for accuracy on a monthly basis and prior to each wall/ceiling closure.
   i. Consolidate and manage the systems/equipment O&M manual preparation process by the installation contractors. Submit the systems/equipment O&M manuals to the Commissioning Agent for review and inclusion in the Systems Manual.
   j. Manage the training plan submittal process by the installation contractors. Submit training plans to the Commissioning Agent for review.
k. Schedule and witness equipment and systems cleaning, QA/QC testing, and startup procedures as specified in equipment sections. Inform Commissioning Agent one week prior to each cleaning, testing, and startup procedure. Submit resultant testing documentation for review by the Authority, Design Team and Commissioning Authority.

l. Coordinate completion of Construction Checklists by appropriate sub-contractor as work is accomplished. Provide completed Checklists to Commissioning Agent.

m. Inform CxA of updated construction phase revisions to systems being commissioned including copies of relevant Requests for Information and Change Orders.

n. Collaborate with Design Team and CxA to develop final detailed Functional and Performance Testing Procedures.

6. Contractor:
   a. Review and provide input to Construction Phase Commissioning documentation.
   b. Participate in regularly scheduled Commissioning coordination meetings.
   c. Complete Construction Checklists as work is accomplished and provide completed Construction Checklists to Construction Manager, the Authority, and CxA.
   d. Continuously maintain Record Drawings and submit as detailed in Contract Documents to reflect installation modifications made in the field.
   e. Provide input into master scheduling process with regards to timing and duration of specified equipment tests.
   f. Submit system/equipment O&M manuals to Construction Manager.
   g. Submit system/equipment training plans to Construction Manager.
   h. Coordinate and accomplish factory tests as detailed in Contract Documents.
   i. Coordinate scheduling and witnessing of systems/equipment cleaning, QA/QC testing, and startup procedures as specified in equipment sections through Construction Manager. Submit documentation for review by the Authority, Design Team and Commissioning Agent.
   j. Collaborate with Design Team and Commissioning Agent to develop final detailed Functional and Performance Testing Procedures.
B. Testing and Training Phase:

1. Design Team:
   a. Participate in Authority Personnel training sessions.
   b. Review systems/equipment cleaning, QA/QC testing, and start-up reports submitted by Contractor.
   c. Review and comment on CxA’s Corrective Issues Reports.
   d. Review and accept record documents as required by Contract documents.
   e. Review and comment on Final Commissioning Report.
   f. Recommend final acceptance of systems to the Authority.

2. Authority Project Manager:
   a. Review and approve O&M manuals concurrent with review by Design Team and CxA.
   b. Provide qualified personnel for videotaping and editing of training sessions.

3. Authority Personnel:
   a. Attend Functional and Performance Testing planning meetings.
   b. Participate in scheduling of equipment and systems training sessions.
   c. Witness, to greatest extent desired, Functional and Performance Tests executed by contractors and overseen by CxA.
   d. Participate in O&M system training sessions.
   e. Review and approve O&M manuals concurrent with review by Design Team and CxA.

4. Commissioning Agent:
   a. Review systems/equipment cleaning, QA/QC testing, and start-up reports submitted by Contractor.
   c. Schedule initial Authority Systems training session so that it will be held immediately before contractor training.

5. Authority Construction Manager:
   a. Submit completed Construction Checklists and appropriate systems/equipment cleaning, QA/QC testing, start-up and balance reports to CxA prior to certifying systems to be commissioned are ready for Functional and Performance Testing. Provide certification to CxA in writing with copy to the Authority and Design Team.
b. Coordinate subcontractor participation and provide required equipment necessary for Functional and Performance Testing.
c. Manage remediation of deficiencies identified by CxA during Functional and Performance Testing and noted within Corrective Issues Report.
d. Issue appropriate final reports to Design Team for review and acceptance.
e. Coordinate scheduling of O&M training sessions by contractors with trainees and Cx Team.
f. Turn over equipment spare parts to Authority Personnel as detailed in Contract Documents.

6. Contractor:
   a. Complete Construction Checklists and submit to Construction Manager prior to start of Functional and Performance Testing.
   b. Demonstrate performance of assemblies and/or operation of systems to CxA as required in order to achieve requirements of Functional and Performance Testing Procedures.
   c. Correct deficiencies identified by Commissioning Team and noted within Corrective Issues Report.
   d. Implement training program as detailed in Contract Documents and documented in Training Forms.
   e. Deliver equipment spare parts to Facility O&M Personnel through Construction Manager as detailed in Contract Documents.

3.2 PROJECT SCHEDULE

A. CxA will provide a Schedule in CPM format identifying Cx Activities for the Project. Contractor shall incorporate these Cx Activities into the Master Project Schedule. CxA will review and update Cx Activities along with Contractor’s Master Schedule Update.

3.3 COMMISSIONING PROGRESS MEETINGS

A. CxA will conduct periodic Cx Progress Meetings throughout construction phase of the project. Commissioning Team Members are required to attend these meetings.

B. Cx progress meetings shall be conducted separate from regular progress meetings to focus on Cx process, activities status, schedule and issues. Reference sample Cx Progress Meeting Agenda at the end of this Section.

C. Cx team members shall attend Cx progress meetings. Initially, the following Cx Progress Meetings will be scheduled:
1. Cx Kick-off Meeting: One meeting shortly after pre-construction meeting.

2. Cx Progress Meetings: One meeting per month.

3. Testing and Training Meeting: Two.

D. Commissioning Progress Meetings will be held at the Authority offices. CxA will conduct meetings, record meeting minutes and distribute minutes to attendees with copies to appropriate entities.

3.4 QUALITY ASSURANCE

A. Contractor Field Testing: CxA will receive one copy of all test reports from the Contractor and assemble for record into Commissioning Systems Manual.

B. Witnessing of Testing by CxA: CxA shall be notified 72 hours in advance of field testing being performed.

3.5 SUBSTANTIATING SYSTEM READINESS

A. CxA will prepare and issue to Contractor a Construction Checklist Form for each system or piece of equipment to be commissioned.

B. CxA will monitor and track completion of Construction Checklist Forms.

C. Contractor, Subcontractor, and equipment suppliers shall complete Construction Checklist Forms, provided by the CxA, as follows:

1. Construction Checklists should be maintained in a binder(s) at Contractor’s project site office and is subject to review for comparison between completion level the Checklists and status of work during site observation visits by Cx Authority.

2. Complete Section 1 “Equipment Delivery” of Construction Checklist after equipment delivery to site.

3. Complete Section 2 “Equipment Installation” of Construction Checklist after equipment installation is complete.

4. Complete Section 3 “Equipment Start-up” of Construction Checklist after equipment has been successfully started.

5. Complete Section 4 “Notification for Testing” of Construction Checklist after equipment if fully operational and ready for Functional and Performance Testing.
6. Completed and signed Construction Checklists are pre-requisite for commencing Functional and Performance Testing.

3.6 FUNCTIONAL AND PERFORMANCE TESTING

A. CxA will coordinate Functional and Performance Test Procedures to be used on systems being commissioned. Test Procedures will be received from the Contractor in advance of scheduled Functional and Performance Testing to give the CxA, Contractor and subcontractors time to review Procedures and make comments or suggest revisions. Functional and Performance Test Procedures will be coordinated with the Acceptance Testing in accordance with the Contract Documents.

B. CxA will witness and document results of Functional and Performance Testing Procedures required for equipment and systems to be commissioned. Functional Testing is performed by Contractor to demonstrate the Systems are ready; all factory testing complete and accepted, equipment and systems are installed, initial checks have been performed, mechanical adjustments, if any, complete, preliminary field tests performed and accepted; energized operation to demonstrate each function is then performed. After successful completion of all Functional Testing for each piece of equipment or for system, the Contractor will operate each piece of equipment or System to demonstrate that it is operating in compliance with the requirements of the Contract Documents. The Performance Testing must demonstrate each required function on a paragraph-by-paragraph, loop-by-loop and site-by-site basis as well as an integrated operation of the system.

C. Contractor, subcontractors, and equipment suppliers shall provide testing instruments and skilled labor required to conduct Functional and Performance Test Procedures. CxA will attend Functional and Performance Testing and record results of testing.

D. Submit following pre-requisite documents to CxA prior to Functional and Performance Testing:

1. Updated/Completed Construction Checklists
2. Test Results Reports (preliminary)
3. Contractors’ QA/QC Testing Reports
4. Contractors’ Start-Up Reports
5. O&M Manuals
3.7 CORRECTIVE ISSUE REPORT

A. CxA will document deficiencies discovered during Functional and Performance Testing of systems on a Corrective Issue Report. CxA will forward this form to the Authority Construction Manager and Contractor for action in correcting deficiencies.

B. When deficiencies have been corrected, Contractor shall note action taken and return Corrective Issue Report to the Authority Construction Manager and CxA.

C. Corrective Issue Reports must be completed as a pre-requisite for Substantial Completion.

3.8 AUTHORITY TRAINING

A. Coordinate training sessions through CxA. CxA will prepare Training Form for each training session required by Contract Documents and issue to Contractor. Training forms shall be used to schedule, perform, and document required training sessions.

B. Training instructors shall be manufacturer’s representative or applications engineer fully qualified in operation, troubleshooting, and maintenance procedures for equipment or systems being covered. Sales representatives or others possessing only general knowledge of equipment or systems will not be acceptable.

C. Contractor, subcontractors, and equipment suppliers shall submit separate training form for each training session required by Contract Documents to CxA. This form shall be submitted minimum of 14 calendar days in advance of proposed training session.

D. Contractor, subcontractors, and equipment suppliers shall complete first section of the form including proposed training session date, name of instructor(s), and proposed length (time) of session(s). Attach agenda training session format and list handouts that will be provided.

E. CxA will review proposed training information with the Authority. If submitted information is complete and proposed dates meet the Authority’s Operations Personnel schedule, CxA will respond to Contractor to proceed with scheduling subject training session.

F. During training session, Contractor, subcontractors, and equipment suppliers shall have each attendee sign in third section of training form. Attach additional pages if necessary. Contractor shall forward training form to CxA. Refer to sample evaluation form at end of this Section.
G. Upon receipt of training form, Cx Authority will have each attendee complete evaluation form to gain feedback on value of session.

1. If session meets objectives and intent of Contract Documents, CxA will approve training form and return to Contractor for Project Records.

2. If negative feedback is received, evaluation forms will be reviewed with Commissioning Team and if necessary, re-scheduling of training may be required.

H. Operations and Maintenance manuals and accurate as-built drawings shall be submitted and approved by Design Team and CxA before training sessions will be scheduled. As-built drawings and O&M information will be reviewed and used as reference during training instructions.

END OF SECTION 01 91 00
PART 1  GENERAL

1.1 DESCRIPTION
A. The Contractor shall perform all cutting and patching required performing and completing the Work, including installation of duct banks, manholes, conduits, equipment pads, and bollards.

1.2 QUALITY ASSURANCE
A. Design Criteria:
   1. Patching shall successfully duplicate undisturbed adjacent finishes, textures, and profiles. Where there is dispute as to whether duplication is successful or has been achieved, the Authority's judgment will be final.
   2. Quality assurance for patching materials used shall be as specified in the applicable Sections of the Specifications.

1.3 SUBMITTALS, to the Authority per contract:
A. The Contractor shall submit written notice before any cutting which affects structural safety of the project.
B. The Contractor shall submit written notice to the Authority seven (7) working days prior to the time the work will be performed.
C. The Contractor shall submit a plan for any landscaping and irrigation to be removed to accomplish the work shown on the contract documents two weeks prior to work occurring. The Authority must approve plan prior to landscape and irrigation removals starting.
   1. Plan shall record location and type of plants and locations of irrigation parts to be removed.
   2. Irrigation system shall function normally after the temporary cuts are made.
3. Plan shall outline the length of time the landscaping and irrigation shall be removed.

4. Plan shall show how and what is to be replaced and when. Plan shall be signed, stamped, and sealed by a Registered Landscape Architect prior to submittal.

5. Field alterations or changes shall be recorded on plan.

PART 2 PRODUCTS

2.1 MATERIALS

A. Materials shall be as specified in applicable Sections of the Specifications.

B. Native soil, gravel and building patching shall match existing construction.

PART 3 EXECUTION

3.1 INSPECTION

A. Inspect existing conditions of work and inform Engineer of any elements subject to movement or damage during cutting and patching activities prior to performing the Work.

3.2 PREPARATION PRIOR TO CUTTING

A. Provide shoring, bracing and support as required to maintain structural integrity.

B. Provide protection for other portions of project or items not being removed.

C. Provide protection from elements.

3.3 PERFORMANCE

A. Fit and adjust products to permit the finished installation to comply with specified tolerances and finishes.

B. Perform cutting by methods which will prevent damage to other work and will provide proper surfaces to receive installation of repairs and new work.
C. Perform cutting of chain link type fence fabric at posts so fabric can be terminated with an inserted bar and bolted to fence posts with standard brackets. Installation of brackets and bar shall match the fence end post for that same section of fence. Installation of bracing bars and stiffeners may be required for the early termination of fence fabric on an intermediate line post. Should fence, that is temporary removed for construction purposes, be re-attached at the cut point along an existing post, then connection shall be made as if to an end post. If bracing was added for the cut of the fabric the bracing shall remain after re-attachment.

D. Perform cutting of concrete curbs, gutters, sidewalks, driveways and swales at existing construction joints such that replaced sections of concrete match existing, unless otherwise approved by the Engineer.

E. Do not cut or alter structural members without prior written approval of the Engineer.

F. Irrigation products used shall match the existing product type and size. Landscaping plants shall match type. Size minimums are as follows:

1. Trees, 24” square box.
2. Plants, one-gallon bucket.
3. Shrubs, five-gallon bucket. However, if the area warrants larger replacements or greater number of plants due to the mature nature of the plants being removed the contractor should replace planting so that in the one year the planting will achieve similar grow and appearance as the material removed.

G. Adjust and fit products to provide a neat installation.

H. Finish or refinish cut and patched surfaces to match adjacent finishes.

I. Patching of native soil or gravel shall be installed to the depths indicated on the Plans.

3.4 DUST AND DEBRIS CONTROL

A. Dust and Debris Control:

1. Prevent the spread of dust and debris to adjacent portions of the Work and avoid the creation of a nuisance or hazard in the surrounding area. Do not use water if it results in hazardous or objectionable conditions such as, but not limited to, ice, flooding, or pollution.
2. Sweep and vacuum pavements as often as necessary to control the spread of debris that may result in foreign object damage potential to aircraft or vehicles.

3.5 CLEANUP

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

END OF SECTION 01 04 50
PART 1 GENERAL

1.1 DEFINITIONS

A. Person-Day: One person for 8 hours within regular Contractor working hours.

1.2 REFERENCES

A. All Manufacturers Services shall be coordinated with Section 01910, Commissioning.

1.3 SUBMITTALS

A. Informational Submittals submit to the Authority per contract:

1. Training Schedule: Submit, in accordance with requirements of this Specification, not less than 21 days prior to start of equipment installation and revise as necessary for acceptance.

2. Lesson Plan: Submit, in accordance with requirements of this Specification, proposed lesson plan not less than 21 days prior to scheduled training and revise as necessary for acceptance.

3. Training Session Recordings: Furnish the Authority with two complete sets of recordings fully indexed and cataloged with printed label stating session and date recorded.

1.4 QUALIFICATION OF MANUFACTURER’S REPRESENTATIVE

A. Authorized representative of the manufacturer, factory trained, and experienced in the technical applications, installation, operation, and maintenance of respective equipment, subsystem, or system, with full authority by the equipment manufacturer to issue the certifications required of the manufacturer. Additional qualifications may be specified in the individual specification section.

B. Representative subject to acceptance by the Authority and Engineer. No substitute representatives will be allowed unless prior written approval by such has been given.
PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 FULFILLMENT OF SPECIFIED MINIMUM SERVICES

A. Furnish manufacturers’ services, when required by an individual specification section, to meet the requirements of this section.

B. Where time is necessary in excess of that stated in the Specifications for manufacturers’ services, or when a minimum time is not specified, time required to perform specified services shall be considered incidental.

C. Schedule manufacturer’ services to avoid conflict with other onsite testing or other manufacturers’ onsite services.

D. Determine, before scheduling services, that conditions necessary to allow successful testing has been met.

E. Only those days of service approved by Engineer, the Authority will be credited to fulfill specified minimum services.

F. When specified in individual specification sections, manufacturers’ onsite services shall include:

1. Assistance during product (system, subsystem, or component) installation to include observation, guidance, instruction of Contractor’s assembly, erection, installation or application procedures.

2. Inspection, checking, and adjustment as required for product (system, subsystem, or component) to function as warranted by manufacturer and necessary to furnish Manufacturer’s Certificate of proper installation.

3. Providing, on a daily basis, copies of manufacturers’ representatives Field notes and data to Engineer.

4. Revisiting the Site as required to correct problems and until installation and operation are acceptable to Engineer.

5. Resolution of assembly or installation problems attributable to or associated with respective manufacturer’s products and systems. Assistance during functional and performance testing, and facility startup and evaluation.

6. Training of the Authority’s personnel in the operation and maintenance of respective product as required.
3.2 MANUFACTURER’S CERTIFICATE OF COMPLIANCE

A. When so specified, a Manufacturer’s Certificate of Compliance, a copy of which is attached to this section, shall be completed in full, signed by entity supplying the product, material, or service, and submitted prior to shipment of product or material or execution of the services. Reference Section 1D-Special Conditions, Article 1D-12 Certificates of Compliance.

B. The Authority may permit use of certain materials or assemblies prior to sampling and testing if accompanied by accepted certification of compliance.

C. Such form shall certify proposed product, material, or service complies with that specified. Attach supporting reference data, affidavits, and certifications as appropriate.

D. May reflect recent or previous test results on material or product, if acceptable to the Authority.

3.3 MANUFACTURER’S CERTIFICATE OF PROPER INSTALLATION

A. When so specified, a Manufacturer’s Certificate of Proper Installation form, a copy of which is attached to this section, shall be completed and signed by equipment manufacturer’s representative and in accordance with Section 1D-Special Conditions, Article 1D-12 Certificates of Compliance.

B. Such form shall certify signing party is a duly authorized representative of manufacturer, is empowered by manufacturer to inspect, approve, and operate their equipment and is authorized to make recommendations required to ensure equipment is complete and operational.

3.4 TRAINING

A. General:

1. Furnish manufacturers’ representatives for detailed classroom and hands-on training to the Authority’s personnel on operation and maintenance of specified product (system, subsystem, component) and as may be required in applicable Specifications. Furnish trained, articulate personnel to coordinate and expedite training, to be present during training coordination meetings with the Authority, and familiar with operation and maintenance manual information specified in Section 1D-Special Conditions, Article 1D-51 Project Closeout.

2. Manufacturer’s representative shall be familiar with facility operation and maintenance requirements as well as with specified equipment.

3. Furnish complete training materials, to include operation and maintenance data, to be retained by each trainee.
B. Training Schedule:

1. List specified equipment and systems that require training services and show:
   a. Respective manufacturer.
   b. Estimated dates for installation completion.
   c. Estimated training dates.

2. Allow for multiple sessions when several shifts are involved.

3. Adjust schedule to ensure training of appropriate personnel as deemed necessary by the Authority, and to allow full participation by manufacturers' representatives. Adjust schedule for interruptions in operability of equipment.

4. Coordinate with Section 01910, Commissioning.

C. Lesson Plan: When manufacturer or vendor training of the Authority personnel is specified, prepare a lesson plan for each required course containing the following minimum information:

1. Title and objectives.

2. Recommended attendees (such as, managers, engineers, operators, maintenance).

3. Course description, outline of course content, and estimated class duration.

4. Format (such as, lecture, self-study, demonstration, hands-on).

5. Instruction materials and equipment requirements.

6. Resumes of instructors providing training.

D. Pre-startup Training:

1. Coordinate training sessions with the Authority's operating personnel and manufacturers' representatives, and with submission of operation and maintenance manuals in accordance with Section 1D – Special Conditions, Article 1D-51 Project Closeout.

2. Complete at least 14 days prior to beginning of facility startup.

E. Post-startup Training: If required in Specifications, furnish and coordinate training of the Authority's operating personnel by respective manufacturer's representatives.
F. Recording of Training Sessions:

1. Furnish audio and color recording of pre-startup and post-startup instruction sessions, including manufacturers’ representatives’ hands-on equipment instruction and classroom sessions.

2. Video training materials shall be produced by a qualified, professional video production company.

3. Use DVD format suitable for playback on standard equipment available commercially in the United States. Blu-ray® DVD format is not acceptable without Engineer’s prior approval.

4. Include one training session on each DVD. DVD may contain multiple training sessions. If multiple training sessions included on a DVD, provide with on-screen menu for playback selection.

3.5 SUPPLEMENTS

A. The supplements listed below, following “End of Section”, are part of this Specification.

1. Form: Manufacturer’s Certificate of Compliance.

2. Form: Manufacturer’s Certificate of Proper Installation.

END OF SECTION 01 43 33
MANUFACTURER’S CERTIFICATE OF COMPLIANCE

OWNER: _______________________________ SUBMITTED: ________________
PRODUCT, MATERIAL, OR SERVICE: _______________________________________
PROJECT NAME: _______________________________________________________
PROJECT NO: _________________________________________________________
COMMENTS: ____________________________________________________________

I hereby certify that the above-referenced product, material, or service called for by the Contract for the named Project will be furnished in accordance with all applicable requirements. I further certify that the product, material, or service are of the quality specified and conform in all respects with the Contract requirements and are in the quantity shown.

Date of Execution: ____________________________, 20___
Manufacturer: ________________________________________________
Manufacturer’s Authorized Representative (print) ___________________________

(Authorized Signature)
MANUFACTURER’S CERTIFICATE OF PROPER INSTALLATION

OWNER __________________________
EQPT SERIAL NO: __________________

EQPT TAG NO: _____________________
EQPT/SYSTEM: ___________________

PROJECT NO: ______________________
SPEC. SECTION: ___________________

I hereby certify that the above-referenced equipment/system has been:

☐ (Check Applicable)
☐ Installed in accordance with Manufacturer’s recommendations.
☐ Inspected, checked, and adjusted.
☐ Serviced with proper initial lubricants.
☐ Electrical and mechanical connections meet quality and safety standards.

☐ All applicable safety equipment has been properly installed.
☐ Functional tests

System has been performance tested and meets or exceeds specified performance requirements. (When complete system of one manufacturer)

Note: Attach any performance test documentation from manufacturer.

Comments:

________________________________________________________________________
________________________________________________________________________

I, the undersigned Manufacturer’s Representative, hereby certify that I am (i) a duly authorized representative of the manufacturer, (ii) empowered by the manufacturer to inspect, approve, and operate their equipment and (iii) authorized to make recommendations required to ensure equipment furnished by the manufacturer is complete and operational, except as may be otherwise indicated herein. I further certify that all information contained herein is true and accurate.

Date: ________________________________ , 20_______________________________

Manufacturer: _____________________________________________________________

By Manufacturer’s Authorized Representative: _________________________________

(Authorized Signature) Spec. No.
SPECIAL PROVISIONS
DIVISION 01 – EXISTING CONDITIONS
SECTION 02 41 00

DEMOLITION

PART 1 GENERAL - DEMOLITION SECTION IS INCLUDED FOR REFERENCE IF PROJECT REQUIRES THIS ACTIVITY

1.1 REFERENCES

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


3. Environmental Protection Agency (EPA), U.S. Code of Federal Regulations (CFR), Title 40:
   b. Part 82—Protection of Stratospheric Ozone.

1.2 DEFINITIONS

A. ACM: Asbestos-containing material.

B. Demolition: Dismantling, razing, destroying, wrecking, or clearing and grubbing of any fixed structure, pavement or landscaping, and any part thereof.

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

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

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

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

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

C. Contractor shall contact utility locating service, 811, and have utilities marked prior to performing any demolition work.

D. Blasting or explosives of any kind are not allowed on airport property.

PART 2 - PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.1 EXISTING FACILITIES TO BE DEMOLISHED

A. Asphalt and concrete pavements.

B. Concrete curb, gutters, sidewalks, driveways and swales.

C. Equipment pads.

D. Landscaping and irrigation.

E. Electrical Equipment.

3.2 PROTECTION

A. Dust and Debris Control:

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

   2. Sweep and vacuum pavements as often as necessary to control the spread of debris that may result in foreign object damage potential to aircraft and vehicular traffic.

B. Traffic Control Signs: Where pedestrian and driver safety is endangered in the area of removal Work, apply appropriate traffic control measures.

C. Existing Work:

   1. Survey the site and examine the Drawings and Specifications to determine the extent of the Work before beginning any demolition.
2. Take necessary precautions to avoid damage to existing items scheduled to remain in place, to be reused, or to remain the property of the Authority; any Contractor-damaged items shall be repaired or replaced as directed by Engineer.

3. Do not overload pavements to remain.

D. Protection of Personnel:

1. During demolition, continuously evaluate the condition of the structure being demolished and take immediate action to protect all personnel working in and around the demolition site.

2. Provide temporary barricades and other forms of protection to protect Authority's personnel and the general public from injury due to demolition Work.

3. Provide protective measures as required to provide free and safe passage of Authority’s personnel and the general public to occupied portions of the structure.

3.3 TITLE TO MATERIALS

A. Items designated to be removed shall become the property of Contractor.

3.4 DISPOSITION OF MATERIAL

A. Concrete, masonry, and other noncombustible material, except concrete permitted to remain in place, shall be legally disposed of off the Site.

B. Combustible material shall be legally disposed of off the Site.

C. Unsuitable material shall be handled in accordance with Section 1D - Special Conditions, Article 10-21, Disposal and Construction and Demolition Waste.

3.5 CLEAN UP

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

END OF SECTION 02 41 00
PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, General and Supplementary Conditions and Section 1D – Special Conditions, apply to this Section.

1.2 REFERENCES

A. ASTM:


4. A 615/A 615M, epoxy coated, deformed rebar and plain dowel bars.

5. A 184/A 184M, rebar mats.

6. A 82, plain steel wire.

7. A 185, Plain-Steel Welded Wire Reinforcement.


B. ACI:

1. 301, "Specification for Structural Concrete," Sections 1 through 5.

2. 117, "Specifications for Tolerances for Concrete Construction and Materials."

C. NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
1.3 SUMMARY

A. This section specifies cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes, for the following:

1. Footings for light poles and post footings for fencing.
2. Footings and fill for concrete-filled steel pipe bollards.
3. Concrete encased conduits (ductbanks).

B. Related sections include the following:

1. Section 31 23 23.15, "Trench Backfill".
2. Section 26 05 33, “Raceway and Boxes”.

1.4 DEFINITIONS

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

1.5 SUBMITTALS

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

B. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments. Indicate amounts of mixing water to be withheld for later addition at Project site.

C. Samples: For vapor retarder.

D. Qualification Data: For testing agency.

E. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:

1. Aggregates. Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.

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

1. Admixtures.
2. Form materials and form-release agents.
3. Steel reinforcement and accessories.
4. Fiber reinforcement.
5. Curing compounds.
6. Floor and slab treatments.
8. Adhesives.
9. Vapor retarders.
10. Semi-rigid joint filler.
12. Repair materials.

G. Field quality-control test and inspection reports.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities".

B. Testing Agency Qualifications: An independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.

C. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.

D. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician – Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

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

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

1. ACI 301, "Specification for Structural Concrete," Sections 1 through 5.
2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials".

G. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

1. Review concrete finishes and finishing, cold and hot-weather Concreting procedures, construction contraction and isolation joints, and joint-filler strips, vapor-retarder installation, anchor rod and anchorage device installation tolerances, steel reinforcement installation, floor and slab flatness and levelness measurement, concrete repair procedures, and concrete protection.

1.7 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Products: Subject to compliance with requirements, provide one of the products specified.

2.2 FORM-FACING MATERIALS

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

1. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:
   a. High-density overlay, Class 1 or better.
   b. Medium-density overlay, Class 1 or better; mill-release agent treated and edge sealed.
   c. Structural 1, B-B or better; mill oiled and edge sealed.
   d. B-B (Concrete Form), Class 1 or better; mill oiled and edge sealed.

B. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass- fiber-reinforced plastic, paper, or fiber tubes that will produce surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.
C. Chamfer strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch (19 by 19 mm), minimum.

D. Rustication strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.

E. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces. Formulate form-release agent with rust inhibitor for steel form-facing materials.

2.3 STEEL REINFORCEMENT

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

B. Steel Bar Mats: ASTM A 184/A 184M, fabricated from ASTM A 615/A 615M, Grade 60, deformed bars, assembled with clips.

C. Plain-Steel Wire: ASTM A 82, as drawn.

D. Plain-Steel Welded Wire Reinforcement: ASTM A 185, plain, fabricated from as-drawn steel wire into flat sheets.

2.4 REINFORCEMENT ACCESSORIES

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

B. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI’s “Manual of Standard Practice,” of greater compressive strength than concrete and as follows: For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.

2.5 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:

1. Portland Cement: ASTM C 150, Type V, gray. Supplement with the following:
   a. Fly Ash: ASTM C 618, Class F.

B. Normal-Weight Aggregates: ASTM C 33, coarse aggregate or better, graded. Provide aggregates from a single source with documented service record data of at least 10 years' satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials.

2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.


2.6 **ADMIXTURES**


B. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.

2. Retarding Admixture: ASTM C 494/C 494M, Type B.

3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.

4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.

5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.

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

C. Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete and complying with ASTM C 494/C 494M, Type C.

D. Non-Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, non-set-accelerating, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete.

2.7 **VAPOR RETARDERS**

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

B. Granular Fill: Clean mixture of crushed stone or crushed or uncrushed
C. gravel; ASTM D 448, Size 57, with 100 percent passing a 1-inch sieve and 0 to 5 percent passing a No. 8 sieve.

D. Fine-Graded Granular Material: Clean mixture of crushed stone, crushed gravel, and manufactured or natural sand; ASTM D 448, Size 10, with 100 percent passing a 3/8-inch sieve, 10 to 30 percent passing a No. 100 sieve, and at least 5 percent passing No. 200 sieve; complying with deleterious substance limits of ASTM C 33 for fine aggregates.

2.8 CURING MATERIALS

A. White Waterborne Membrane-Forming Curing Compound: ASTM C309, Type 2, Class B.

1. Available Products:
   a. Burke by Edoco; Resin Emulsion White.
   b. Dayton Superior Corporation; Day-Chem White Pigmented Cure (J-10-W).
   c. Unitex; Hydro White.
   d. Or equal approved by the Authority.

2.9 RELATED MATERIALS


B. Semi-rigid Joint Filler: Two-component, semi-rigid, 100 percent solids, epoxy resin with a Type A shore durometer hardness of 80 per ASTM D 2240.

C. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows: Types I and II, non-load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

2.10 CONCRETE MIXTURES, GENERAL

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

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

2. Trail batch method testing shall not be older than five years old.
B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

1. Fly Ash: 15 percent by weight.
2. Combined Fly Ash and Pozzolan: minimum weight per strength class.

C. Limit water-soluble, chloride-ion content in hardened concrete to 0.05 percent by weight of cement.

D. Other admixtures: Not allowed unless approved by the Authority in writing.

2.11 CONCRETE MIXTURES FOR BUILDING ELEMENTS, RETAINING WALLS AND EQUIPMENT

A. Footings: Proportion normal-weight concrete mixture as follows:

1. Minimum Compressive Strength: 3,500 psi at 28 days.
2. Minimum Cementitious material is 575 pounds per cubic yard.
3. Maximum Water-Cementitious Materials Ratio: 0.450.
4. Slump Limit: 4 inches, plus or minus 1/2-inch.
5. Air Content: 5-1/2 percent, plus or minus 1.5 percent at point of delivery for 1-1/2-inch nominal maximum aggregate size.
6. See Section 04 27 31, “Reinforced Unit Masonry” for specifications on the reinforced unit masonry used in the portion of wall above the footing.

2.12 CONCRETE MIXTURES FOR AIRFIELD PAVEMENTS

A. See Section 32 13 13, “Portland Cement Concrete Pavement.”

2.13 CONCRETE MIXTURES FOR CONCRETE CURBS, GUTTERS AND SIDEWALKS

A. See Section 32 16 00, “Curbs, Gutters and Sidewalks.”

2.14 CONCRETE MIXTURES FOR TRENCH BACKFILL

A. See Section 31 23 23.15 “Trench Backfill”

2.15 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI’s "Manual of Standard Practice."
2.16 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and ASTM C 1116 and furnish batch ticket information.

1. When air temperature is between 85 and 90 degrees F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 degrees F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 FORMWORK

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

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

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


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

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

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

1. Install keyways, reglets, recesses, and the like, for easy removal.

2. Do not use rust-stained steel form-facing material.

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

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

H. Chamfer exterior corners and edges of permanently exposed concrete.
I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

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

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

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

3.2 EMBEDDED ITEMS

A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC's "Code of Standard Practice for Steel Buildings and Bridges."

3.3 REMOVING AND REUSING FORMS

A. General: Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete, if concrete is hard enough not to be damaged by form-removal operations and curing and protection operations are maintained.

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

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

3.4 VAPOR RETARDERS

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

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

2. Seal all penetrations according to manufacturer's recommendations with manufacturer's products.
3.5 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

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

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

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

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

3.6 JOINTS

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

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

1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.

2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches into concrete.

3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.

4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.

5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
6. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

7. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

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

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.

2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8 inch wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

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

1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface, unless otherwise indicated.

2. Terminate full-width joint-filler strips not less than 1/2 inch or more than 1 inch below finished concrete surface where joint sealants, specified in Division 07 Section "Joint Sealants," are indicated.

3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

E. Dowelled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding to one side of joint.

3.7 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items are complete and that required inspections have been performed.

B. Do not add water to concrete during delivery, at Project site, or during placement unless approved by the Authority.

C. Before test sampling and placing concrete, water may be added at Project
site, subject to limitations of ACI 301. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

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

1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.

2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.

3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

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

1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.


3. Screed slab surfaces with a straightedge and strike off to correct elevations.

4. Slope surfaces uniformly to drains where required.

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

F. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
1. When average high and low temperature is expected to fall below 40 degrees F for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.

2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.

3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved by the Authority in mixture designs.

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

1. Maintain concrete temperature below 90 degrees F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

3.8 FINISHING FORMED SURFACES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities. Apply to concrete surfaces not exposed to public view.

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

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

1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
2. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.

3. Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix one part portland cement and one part fine sand with a 1:1 mixture of bonding agent and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.

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

3.9 MISCELLANEOUS CONCRETE ITEMS

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

B. Equipment Bases and Foundations: Provide machine and equipment bases and foundations as shown on Drawings. Set anchor bolts for machines and equipment at correct elevations, complying with diagrams or templates from manufacturer furnishing machines and equipment.

3.10 CONCRETE PROTECTING AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold weather protection and ACI 301 for hot-weather protection during curing.

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

C. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.
D. Cure concrete according to ACI 308.1, by one or a combination of the following methods:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
   a. Water.
   b. Continuous water-fog spray.
   c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
   a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
   b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.
   c. Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies will not interfere with bonding of floor covering used on Project.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.
   a. After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer unless manufacturer certifies curing compound will not interfere with bonding of floor covering used on Project.

3.11 JOINT FILLING

A. Prepare, clean, and install joint filler according to manufacturer's written instructions. Defer joint filling until concrete has aged at least one month(s). Do not fill joints until construction traffic has permanently ceased.

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

C. Install semi-rigid joint filler full depth in saw-cut joints and at least 2 inches (50 mm) deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.
3.12 FIELD QUALITY CONTROL

A. Testing and Inspecting: The Authority will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Inspections:
   1. Steel reinforcement placement.
   2. Steel reinforcement welding.
   3. Headed bolts and studs.
   4. Verification of use of required design mixture.
   5. Concrete placement, including conveying and depositing.
   6. Curing procedures and maintenance of curing temperature.
   7. Verification of concrete strength before removal of shores and forms from beams and slabs.

C. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
   1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 50 cu. yd. or fraction thereof.
   2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
   3. Air Content: ASTM C 231, pressure method, for normal-weight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
   4. Compression Test Specimens: ASTM C 31/C 31M.
      a. Cast and field cure two sets of two standard cylinder specimens for each composite sample.
   a. Test one set of two field-cured specimens at 7 days and one set of two specimens at 28 days.
   b. A compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.

6. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.

7. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

8. Test results shall be reported in writing to Engineer, concrete manufacturer, and the Authority within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

9. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by the Authority but will not be used as sole basis for approval or rejection of concrete.

10. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Engineer. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42/C 42M or by other methods as directed by Engineer.

11. Additional testing and inspecting, at Contractor’s expense, will be performed to determine compliance of replaced or additional work with specified requirements.

12. Correct deficiencies in the Work that test reports and inspections indicate does not comply with the Contract Documents.

END OF SECTION 03 30 00
PART 1 GENERAL

1.1 RELATED SECTIONS

A. Requirements specified within this section apply to Division 26, Electrical. Work specified herein shall be performed as if specified in the individual sections.

1.2 REFERENCES

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

1. Institute of Electrical and Electronics Engineers, Inc.: 1547, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems, 1547.3.


3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000Volts Maximum).


6. Underwriters Laboratories, Inc. (UL).

1.3 SUBMITTALS

A. General:

1. Action and Informational Submittals in accordance with Section 1D-Special Conditions, Article 1D11A Submittals for all Division 26 Sections and Sub-Section specific requirements.

B. Action Submittals:

1. Provide manufacturers’ data for the following:
   a. Electrical service components.
   b. Nameplates, signs, and labels.
1.4 QUALITY ASSURANCE

A. Provide the Work in accordance with CEC. Material and equipment shall be labeled or listed by a nationally recognized testing laboratory or requirements in this specification, in order to provide a basis for approval under the CEC.

B. 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.

C. Provide materials and equipment acceptable to the Authority for Class, Division, and Group of hazardous areas indicated.

1.5 ENVIRONMENTAL CONDITIONS

A. The following areas are classified hazardous Class I, Division 1, Group D, due to the potential for occurrence of hazardous concentrations of combustible gases, and for exposure to corrosive environment. Use materials and methods required for such areas.

1. Airport Hangars.
2. Fuel Dispensing Farms and Stations.
4. Storm Water Pump Stations.

B. The following areas are classified nonhazardous and wet. Use materials and methods required for such areas.

1. Outdoor above grade areas not covered above.
2. Below-grade vaults.

C. Areas that are defined as indoor and dry per CEC Article 100: use NEMA 12 materials and Methods.

D. The following areas are not classified. Use NEMA 12 materials and methods.

1. 12kV Main Switchgear “Vault.”
2. 12kV Terminal 2 West Electrical Room.
3. Areas not covered above but generally meet the classification of indoor and dry per Article 100 of the CEC.
E. Salvage/Salvageable: Remove and deliver, to the specified location(s), the equipment, building materials, or other items so identified to be saved from destruction, damage, or waste; such property to remain that of the Authority. Unless otherwise specified, title to items identified for demolition shall revert to Contractor.

PART 2 PRODUCTS

2.1 GENERAL

A. All EMT used on the project should be from the same manufacturer. However, all EMT Couplings and Connectors should be from the same manufacturer, but not necessarily the same as the EMT manufacturer.

B. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 50 degrees F to 104 degrees F.

C. Materials and equipment installed outdoors shall be capable of continuous operation at their specified rating within the ambient temperature range of 40 degrees F to 104 degrees.

D. Equip panels installed outdoors in direct sun with sun shields.

E. Outdoor equipment enclosures to be NEMA 4X Stainless Steel. Polycarbonate maybe substituted upon written Authority approval.

2.2 EQUIPMENT FINISH

A. Manufacturer’s standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment in accordance with color choice provided by the Authority.

B. Color: Munsell 7GY3.29/1.5, olive green for outdoor mounted power and SCADA equipment, except where custom color is required, or as approved in writing by the Authority.

2.3 NAMEPLATES

A. Material: Laminated plastic.

B. Attachment Screws: Stainless steel.

C. Color: White engraved to a black core.

D. Letter Height:

1. Pushbuttons/Selector Switches: 1/4-inch.
2. Other electrical equipment: 3/8-inch.

E. See also Section 26 05 53, Electrical Identification.

2.4 SIGNS AND LABELS

A. Sign size, lettering, and color shall be in accordance with NEMA Z535.4 and Section 26 05 53

PART 3 EXECUTION

3.1 GENERAL

A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned. Contractor shall be responsible for actual location of equipment and devices, in coordination with other disciplines and architectural features, and for proper routing and support of raceways, subject to written approval by the Authority.

B. Free-standing electrical switchgear, which may require a housekeeping pad (HK pad), regardless of voltage, shall follow the installation requirement standard developed by SDG & E and adopted by the City of San Diego and the SDIA. This standard requires that the housekeeping pad extend no further than 1" in front of the electrical gear and that the workspace/headroom requirements cited in the CEC Article 110.26 begin at the flat floor and extend upwards to the height of the equipment plus 6', or the structure whichever is lower. Caution should be exercised when using HK Pads, ensuring that the Center-Line meter heights and disconnect handle heights do not exceed the limits established by SDG & E (6'-3") and the CEC (6'-7"), respectively.

C. Check approximate locations of light fixtures, switches, electrical outlets, equipment, and other electrical system components shown on Drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify Engineer in writing.

D. Install work in accordance with NECA Standard of Installation and in compliance with the CEC, unless otherwise specified.

E. Keep openings in boxes and equipment closed during construction.

F. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific written approval by the Authority. Carefully perform cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces to original condition.
3.2 ANCHORING AND MOUNTING

A. Equipment anchoring and mounting shall be in accordance with manufacturer’s attachment requirements for seismic criteria. Coordinate this requirement with the limitation that the workspace in front of any electrical equipment shall be flat from the standing level to the height of the equipment for the depth and width of the working space.

B. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of the ICC Evaluation Program or an agency acceptable to the Authority.

C. Seismic Anchorage and Bracing Calculations for seismic attachments, braces, and anchorages. Include IBC and project specific criteria in addition to manufacturer’s specific criteria used for the design; signed and sealed by a Structural or Civil Engineer registered in the State of California.

D. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

3.3 COMBINING CIRCUITS INTO COMMON RACEWAY

A. Drawings show each homerun circuit to be provided. Do not combine power or control circuits into common raceways without written authorization of Engineer and the Authority.

3.4 NAMEPLATES, SIGNS, AND LABELS

A. Arc Flash Protection Warning Signs: required in Section 26 05 70, Electrical Systems Analysis as basis for warning signs. Field mark ATOs, switchgear, switchboards, MCCs, motor starters, transformers, terminal junction boxes, disconnect switches and panelboards and similar equipment to warn qualified persons of potential shock and arcflash hazards. Locate marking so to be clearly visible to persons before accessing energized equipment. Use the following informational criteria on labels derived from NFPA 70E 2015:

1. Arc flash boundary distance, in inches.

2. Incident energy in cal/cm² and working distance in inches.

3. Reference Annex H.3(b) for Arc Flash rated PPE selection when Incident Energy is calculated.


5. Shock protection boundaries distance, in inches.

7. Date (month) of label installation.

B. Multiple Power Supply Sign: Install permanent plaque or directory at each service disconnect location denoting other services, feeders, and branch circuits supplying the building, and the area served by each.

C. Equipment Nameplates:

1. Provide a nameplate to label electrical equipment including: ATO’s, switchgear, switchboards, motor control centers, panelboards, motor starters, transformers, terminal junction boxes, disconnect switches, switches and control stations.

2. Switchgear, motor control center, transformer, and terminal junction box nameplates shall include equipment designation.

3. Disconnect switch, starter, and control station nameplates shall include name and number of equipment powered or controlled by that device.

4. ATO’s, switchgear, switchboard, MCC, combination motor starter, transformer, and panelboard nameplates shall include equipment designation, service voltage, phases, source Overcurrent Protective Device (OCPD) name and location.

3.5 LOAD BALANCE

A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.

Balance electrical load between phases as nearly as possible on switchboards, panelboards, motor control centers, and other equipment where balancing is required.

B. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

C. Written approval by the Authority, prior to moving loads. Coordinate all outages with the Authority.

D. Load shifting should be requested by the design Electrical Engineer.
3.6 CLEANING AND TOUCHUP PAINTING

A. Cleaning: Throughout the Work, clean interior and exterior of devices and equipment by removing debris and vacuuming.

B. Touchup Paint:
   1. Touchup scratches, scrapes and chips on exterior and interior surfaces of devices and equipment with finish matching type, color, and consistency and type of surface of original finish.
   2. If damage is done to equipment paint surfaces, refinish entire panel section, door, or section, of equipment by factory authorized representative, to factory finish.

3.7 PROTECTION FOLLOWING INSTALLATION

A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation and contact surfaces.

B. When equipment intended for indoor installation is installed at Contractor's convenience in areas where subject to dampness, moisture, dirt or other adverse atmosphere until completion of construction, ensure adequate protection from these atmospheres are provided and acceptable to Engineer. This includes adding temporary heaters to insure no condensation forms inside the gear.

3.8 TEMPORARY ELECTRICAL SERVICE

A. All temporary connections require approval by the Authority to verify if temporary power source is available from the airport's existing 12kV, 3-phase system. If no existing switch is available for temporary use Contractor may be required to provide additional equipment to accommodate the connection.

B. Submit layout drawings showing point of connections, routing of conduits on site plan, type and size of conductors, conduits, equipment, meter, etc., and load calculations with coordination study to-the Authority's representative for approval within two (2) weeks of Notice to Proceed or two (2) weeks prior to start of temporary power installation.

C. The Contractor shall provide labor and materials required for the installation and maintenance of temporary powercomponents feeding Contractor's equipment, trailer office, construction site lighting and any lighting required for temporary pedestrian walkways during the period of construction.
1. No existing utility services shall be interrupted at any time by the Contractor. Required shutdown shall be done by the Authority qualified staff or designated contractor and scheduled two (2) weeks prior to actual shutdown. Coordinate exact date and time with the Authority.

2. All temporary power equipment shall be lockable type. Provide one key for each temporary switchgear, switchboard and panelboard lock to the Authority for the duration of the installation of the temporary power components.

4. If required: Provide a pad mount transformer of proper size based on the load for temporary power for construction with primary voltage 12KV. Size and secondary voltage shall be as required by the project contractor. Transformer shall have primary disconnect with AIC level based on available fault current. All temporary transformers with 12KV Primaries to have primary and secondary overcurrent protection per CEC Article 450, Table 450.3(A) - “any location”, and all temporary transformers with 480V primaries to have primary and secondary protection in accordance with CEC Article 450, Table 450.3(B). Secondary protection in either case to be located per CEC Article 240.21(C)(4).

5. All 12KV splicing and terminations to be witnessed by the Authority designated contractor.

6. Contractor supplied and installed switch and switch fed conductors, main transformer, primary and secondary main transformer conductors and 600V or 208V main circuit breakers shall be tested by an Authority approved, third-party field testing company, or by the Authority designated electrical contractor.

7. Provide distribution equipment with main and feeder protective devices, wire, etc. as required for construction of the project. Minimum interrupting rating of equipment shall be more than the available fault current at the point of connection. All equipment shall be selected, rated and installed per CEC.

8. All temporary equipment shall be inspected and approved by the Authority before any connections can be completed. All underground conduit plans shall be approved by the Authority prior to commencement of excavations. All installations shall be inspected and accepted by the Authority prior to backfill or encasement.

9. Pay all costs involved with connecting to the airport electrical system including any engineering, testing, material, labor, documentation or other costs.
10. Pay all costs for power consumption to the airport at the airport’s utility rate.

11. Remove all temporary power equipment including wires, concrete pad, equipment, etc. when directed by the airport’s representative after the permanent service and connection to the final project system is complete. Cap and mark underground conduits, below ground (use SDG&E standard #3377.1). No conduit stub ups, voids, or hand holes may remain.

12. Electrical equipment and associated wiring for permanent power shall not be used for temporary power. The building or construction site shall be sufficiently illuminated so that construction work can be safely performed. Special attention shall be given to adequately lighting stairs, ladders, pedestrian walkways, floor openings, etc. Walkway lights shall be controlled by a switch within the building or construction site.

END OF SECTION 26 05 02
SPECIAL PROVISIONS
DIVISION 26 – ELECTRICAL
SECTION 26 05 04
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1  GENERAL

1.1  REFERENCES

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

1.  ASTM International (ASTM):
   b.  E814, Method of Fire Tests of Through-Penetration Fire Stops.


6.  National Electrical Manufacturers Association (NEMA):
   a.  250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b.  C12.1 Code for Electricity Metering
   c.  C12.6 Phase-Shifting Devices Used in Metering, Marking and Arrangement of, Terminals for
   d.  ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
   e.  ICS 5, Industrial Control and Systems: Control Circuit and Pilot Devices.
   f.  KS 1, Enclosed and Miscellaneous Distribution Switches (600 Volts Maximum).

7.  NFPA 70E Standard for Electrical Safety in the Workplace.

9. Underwriters Laboratories Inc. (UL):
   a. 98, Standard for Enclosed and Dead-Front Switches.
   b. 248, Standard for Low Voltage Fuses.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 810, Standard for Capacitors.
   g. 943, Standard for Ground-Fault Circuit-Interrupters.
   h. 1059, Standard for Terminal Blocks.
   i. 1479, Fire Tests of Through-Penetration Fire Stops.

1.2 SUBMITTALS

A. Action Submittals, submit to the Authority per contract:

   1. Provide manufacturers’ data for the following:
      a. Control devices.
      b. Control relays.
      c. Circuit breakers.
      d. Fused switches.
      e. Non-fused switches.
      f. Timers.
      g. Fuses.
      h. Magnetic contactors.
      i. Switchboard matting.
      j. Terminal blocks.
      k. Firestops.
      l. Enclosures: Include enclosure data for products having enclosures.
      m. Electrical equipment supports including support and framing channels, with design including comprehensive engineering analysis by a qualified professional engineer.

B. Informational Submittals, submit to the Authority per contract:

   1. Seismic Anchorage and Bracing Calculations and details for seismic attachments, braces, and anchorages. Include IBC and project specific criteria in addition to manufacturer’s specific criteria used for the design; signed and sealed by a Civil or Structural Engineer registered in the State of California.
1.3 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

1. Fuses, 0 to 600 Volts: Six of each type and each current rating installed.

2. Pushbutton, Indicating Light, and Selector switch: Three of each type installed.

PART 2 PRODUCTS

2.1 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

A. General:

1. Type: Molded case.

2. Trip Ratings: 15-800 amps.

3. Voltage Ratings: 120, 240, 277, 480, and 600V ac.

4. Suitable for mounting and operating in any position.

5. UL 489.

B. Operating Mechanism:

1. Over-center, trip-free, toggle type handle.

2. Quick-make, quick-break action.

3. 100A and larger: locking provisions for padlocking breaker in open position.

4. ON/OFF and TRIPPED indicating positions of operating handle.

5. Operating handle to assume a center position when tripped.

C. Trip Mechanism:

1. Individual permanent thermal and magnetic trip elements in each pole.

2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames 100-175 amps.

3. Two and three pole, common trip.

4. Handle ties where multi-wire branch circuits are indicated.
5. Automatically opens all poles when overcurrent occurs on one pole.

6. GFCI test button on breaker cover.

7. Calibrated for 40 degrees C ambient, unless shown otherwise.

D. Molded-Case Circuit Breakers with Solid State Trip:

1. Breakers 200-Ampere and above: Main and Branch Feeder Protective Devices: Individually mounted, suitable for use with 75 C wire at full 75 C ampacity when mounted in switchboard.

2. Arrangement: Fully rated as shown.

3. Interrupting Rating: as shown with amperes rms symmetrical at rated voltage as shown.

4. Breakers 2,000-Ampere through 3,000-Ampere Frame: Mechanical interlock to prevent opening compartment door while breaker is in closed position.

E. Short Circuit Interrupting Ratings: Equal to, or greater than, available fault current or interrupting rating shown.

F. Ground Fault Interrupter (GFI): Where indicated, equip breaker as specified with ground fault sensor. Ground Fault Sensor to be set and tested per IEEE Standard 243.

1. Ground fault sensor shall be rated same as circuit breaker.

2. Not to exceed 1200 Amperes maximum setting.

G. Accessories: Shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, double lugs as shown or otherwise required. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.

H. Connections:

1. Mechanical wire lugs, except crimp compression lugs where shown.

2. Lugs removable/replaceable for breaker frames greater than 100 amperes.

3. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.

4. Use bolted bus connections, except where bolt-on is not compatible with existing breaker provisions.
I. Enclosures for Independent disconnect or circuit breaker mounting:
   1. See 26 05 04-2.14 D, Enclosures.
   2. Service Entrance Use: Breakers in required enclosure and required accessories shall be UL 489 listed.
   3. Interlock: Enclosure and switch or circuit breaker shall interlock to prevent opening cover with switch in the ON position.

J. Manufacturers:
   1. Square D Co.
   4. Or equal approved by the Authority.

2.2 FUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. UL 98 listed for use and location of installation.

B. NEMA KS 1.

C. Short Circuit Rating: 200,000 amps RMS symmetrical with Class R, Class J, or Class L fuses installed.

D. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

E. Connections:
   1. Mechanical lugs, except crimp compression lugs where shown.
   2. Lugs removable/replaceable.
   3. Suitable for 75 degrees C rated conductors at NEC 75 degrees C ampacity.

F. Fuse Provisions:
   1. 30-amp to 600-amp rated shall incorporate rejection feature to reject all fuses except Class R.
   2. 601-amp rated and greater shall accept Class L fuses, unless otherwise shown.

H. Interlock: Enclosure and switch to prevent opening cover with switch in ON position.

I. Manufacturers:
   1. Square D Co.
   4. Or equal approved by the Authority.

2.3 NONFUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. NEMA KS 1.

B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

C. Lugs: Suitable for use with 75 degrees C wire at NEC 75 degrees C ampacity.

D. Auxiliary Contact, if required:
   1. Operation: Make before power contacts make and break before power contacts break.
   2. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

E. Enclosures: See 26 05 04-2.14 D, Enclosures.

F. Interlock: Enclosure and switch to prevent opening cover with switch in ON position.

G. Manufacturers:
   1. Square D Co.
   4. Or equal approved by the Authority.
2.4 FUSES, 250-VOLT AND 600-VOLT

A. Power Distribution, General:
   1. Current-limiting, with 200,000 ampere rms interrupting rating.
   2. Provide to fit mountings specified with switches. 3.UL 248.

B. Power Distribution, Ampere Ratings 1 Amp to 600 Amps:
   2. Type: Dual element, with time delay.
   3. Manufacturers and Products:
      a. Bussmann; Types LPS-RK (600 volts) and LPN-RK (250 volts).
      b. Littelfuse; Types LLS-RK (600 volts) and LLN-RK (250 volts).
      c. Or equal approved by the Authority.

C. Power Distribution, Ampere Ratings 601 Amps to 6,000 Amps:
   1. Class: L.
   2. Double O-rings and silver links.
   3. Manufacturers and Products:
      a. Bussmann; Type KRP-C.
      b. Littelfuse, Inc.; Type KLPC.
      c. Or equal approved by the Authority.

D. Cable Limiters:
   1. 600V or less; crimp to copper cable, bolt to bus or terminal pad.
   2. Manufacturer and Product:
      a. Bussmann; K Series.
      b. Littlefuse, Inc.
      c. Or equal approved by the Authority.

E. Ferrule:
   1. 600V or less, rated for applied voltage, small dimension.
   2. Ampere Ratings: 1/10 amp to 30 amps.
   3. Dual-element time-delay, time-delay, or nontime-delay as required.
   4. Provide with blocks or holders as indicated and suitable for location and use.
5. Manufacturers:
   a. Bussmann.
   b. Littlefuse, Inc.
   c. Or equal approved by the Authority.

2.5 **PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH**

A. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

B. Selector Switch Operating Lever: Bat lever.

C. Indicating Light: Push-to-test. LED, full voltage.

D. Pushbutton Color:
   1. ON or START: Black.
   2. OFF or STOP: Red.

E. Pushbutton and selector switch lockable in OFF position where indicated.

F. Legend Plate:
   1. Material: Aluminum.
   2. Engraving: Enamel filled in high contrasting color.

G. Manufacturers and Products:
   1. Heavy-Duty, Oil-Tight Type:
      a. Square D Co.; Type T.
      b. Eaton/Cutler-Hammer; Type 10250T.
      c. General Electric Co.; Type CR 104P.
      d. Or equal approved by the Authority.
   2. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
      a. Square D Co.; Type SK.
      b. General Electric Co.; Type CR 104P.
      c. Eaton/Cutler-Hammer; Type E34.
      d. Crouse-Hinds; Type NCS.
      e. Or equal approved by the Authority.
2.6 TERMINAL BLOCK, 600 VOLTS

A. UL 486E and UL 1059.
B. Size components to allow insertion of necessary wire sizes.
C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.
D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.
E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.
F. Yoke shall guide all strands of wire into terminal.
G. Current bar shall ensure vibration-proof connection.
H. Terminals:
   1. Capable of wire connections without special preparation other than stripping.
   2. Capable of jumper installation with no loss of terminal or rail space.
   3. Individual, rail mounted.
I. Marking system, allowing use of preprinted or field-marked tags.
J. Manufacturers:
   1. Weidmuller, Inc.
   2. Ideal.
   3. Electrovert USA Corp.
   4. Or equal approved by the Authority.

2.7 TIME DELAY CONTROL RELAY

A. Industrial relay with contacts rated 5 amps continuous, 3,600VA make, and 360VA break.
B. NEMA ICS 2 Designation: B150 (150 volts).
C. Solid-state electronic, field convertible ON/OFF delay.
D. One normally open and one normally closed contact (minimum).
E. Repeat accuracy plus or minus 2 percent.
F. Timer adjustment from 1 second to 60 seconds, unless otherwise indicated on Drawings.

G. Manufacturers and Products:
   1. Square D Co.; Type F.
   4. Or equal approved by the Authority.

2.8   RESET TIMER

A. Drive: Synchronous motor, solenoid-operated clutch.

B. Mounting: Semiflush panel.

C. Contacts: 10 amps, 120 volts.

D. Manufacturers and Products:
   1. Eagle Signal Controls; Bulletin 125.
   3. Or equal approved by the Authority.

2.9   MAGNETIC CONTACTOR

A. UL listed.

B. Electrically operated, electrically held.

C. Main Contacts:
   1. Power driven in one direction with mechanical spring dropout.
   2. Silver alloy with wiping action and arc quenchers.
   3. Continuous-duty, rated as shown.
   4. Poles: As shown.

D. Control: As shown.

E. Auxiliary Contacts: Quantity as shown, rated 7200VA make, 720VA break, at 600V, A600 per NEMA ICS 5.

F. Enclosures: See 26 05 04-2.14 D, Enclosures.
G. Manufacturers and Products:
   1. Square D Co.; Class 8910.
   2. Eaton/Cutler-Hammer; Class A201.
   4. Or equal approved by the Authority.

2.10 PHASE MONITOR CONTROL RELAY

A. Features:
   1. Voltage and phase monitor relay shall drop out on low voltage, voltage unbalance, loss of phase, or phase reversal.
   2. Contacts: Single-pole, double-throw, 10 amperes, 120/240V ac. Where additional contacts are shown or required, provide magnetic control relays.
   3. Adjustable trip and time delay settings.
   4. Transient Protection: 1,000V ac.

B. Manufacturer and Product:
   1. Automatic Timing and Controls; SLD Series.
   2. Macromatic; PAP Series.
   3. Or equal approved by the Authority.

2.11 SUPPORT AND FRAMING CHANNELS

A. Steel Framing Channel:
   1. Material: Rolled, mild strip steel, 12-gauge minimum, ASTM A1011/A1011M, Grade 33.

B. Extruded Aluminum Framing Channel, where allowed:
   1. Material: Extruded from Type 6063 T6 aluminum alloy.
   2. Fittings fabricated from Alloy 5052 H32.
C. Manufacturers:
   1. B-Line Systems, Inc.
   2. Unistrut Corp.
   3. Aickinstrut.
   4. Allied Tube and Conduit.
   5. ERICO International Corporation.
   7. Or equal approved by the Authority.

2.12 SWITCHBOARD MATTING

A. Provide matting having a breakdown of 20 kV minimum.

B. Manufacturer:
   1. U.S. Mat and Rubber Company.
   4. Or equal approved by the Authority.

2.13 FIRESTOPS

A. General:
   1. Provide UL 1479 classified hourly fire-rating equal to, or greater than, the assembly penetrated.
   2. Prevent the passage of cold smoke, toxic fumes, and water before and after exposure to flame.
   3. Sealants and accessories shall have fire-resistance ratings as established by testing identical assemblies in accordance with ASTM E814, by Underwriters Laboratories Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.
   4. Assembly shall be appropriate for the installation, engineered and stamped by a registered engineer.
B. Firestop System:

1. The following locations within the building, unless otherwise specified, require installation of through-penetration firestop systems, joint systems, perimeter fire containment systems, and/or combinations of materials as described herein and approved in advance to achieve a tight seal that will maintain the fire-resistant rating and prevent the passage of smoke through the assembly containing through-penetrations or voids:

   a. Pipe, tube, duct, conduit, cable bundles, cable trays, or similar through- or membrane-penetrations of fire resistive
   b. walls, floors, floor-ceiling assemblies, and roof-ceiling assemblies.
   c. In areas requiring a liquid-tight floor, seal floor firestopping assemblies at the top, level with the floor surface, with a silicone-based firestopping sealant in addition to the required firestopping materials.

2. The void (gap) at the intersection of a fire-resistive floor or floor-ceiling assembly and the interior face of the exterior wall system. A Perimeter Fire Containment System specified as having movement capabilities shall be used.

3. Seismic joints and expansion joints in the fire resistive walls, floors and floor-ceiling or roof-ceiling assemblies. Joint Systems specified as having movement capabilities shall be used.

4. The void (gap) at the intersections of fire resistive walls with fire resistive floors, floor-ceiling assemblies, or roof-ceiling assemblies. Joint Systems specified as having movement capabilities shall be used.

C. Any of the materials identified in Part 2 of this Section may be used as a part of a listed firestopping system or individually when specifically, approved in advance, except that only firestopping sealant, as specified in Part 2, shall be used where the material is installed in exterior or other locations exposed to the outside environment or direct contact with moisture.

D. Fire Stop Devices: See Section 26 05 33, Raceway and Boxes, for raceway, cable and cable tray fittings.
2.15 ENCLOSURES

A. Finish: Sheet metal structural and enclosure parts shall be completely powder-painted epoxy painted so interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them.

B. Color: Manufacturer’s standard color (gray) baked-on enamel, unless otherwise shown or a specified for outdoor enclosures.

C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.

D. Enclosure Selections: Except as shown otherwise, provide electrical enclosures according to the following table:

<table>
<thead>
<tr>
<th>Location</th>
<th>Finish</th>
<th>Environment</th>
<th>NEMA 250 Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor</td>
<td>Finished</td>
<td>Dry</td>
<td>1</td>
</tr>
<tr>
<td>Indoor</td>
<td>Unfinished</td>
<td>Dry</td>
<td>1</td>
</tr>
<tr>
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<td>Unfinished</td>
<td>Industrial Use</td>
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<td>Indoor and Outdoor</td>
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<td>Wet</td>
<td>4</td>
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<td>Any</td>
<td>Denoted “WP”</td>
<td>3R</td>
</tr>
<tr>
<td>Indoor and Outdoor</td>
<td>Any</td>
<td>Wet and Corrosive</td>
<td>4 x 316 Stainless Steel, or by the Authority approval polycarbonate</td>
</tr>
<tr>
<td>Indoor and Outdoor</td>
<td>Any</td>
<td>Wet, Dust or Oil</td>
<td>13</td>
</tr>
<tr>
<td>Indoor and Outdoor</td>
<td>Any</td>
<td>Hazardous Gas</td>
<td>7</td>
</tr>
<tr>
<td>Indoor and Outdoor</td>
<td>Any</td>
<td>Hazardous Dust</td>
<td>9</td>
</tr>
</tbody>
</table>

PART 3 EXECUTION

3.1 GENERAL

A. Install equipment in accordance with manufacturer’s recommendations.

3.2 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Unless otherwise shown, install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations.

B. Unless otherwise shown, install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas.
3.3 SUPPORT AND FRAMING CHANNEL

A. Install where required for mounting and supporting electrical equipment, raceway, and auxiliary gutter and wireway systems.

B. Channel Type:
   2. Interior Wet (Noncorrosive) Locations: Steel Raceway and Other Systems Not Covered: Hot dipped galvanized steel or Extruded Aluminum channel with the Authority written permission.
   3. Outdoor Locations: Steel Raceway: Hot dipped galvanized channel or Extruded Aluminum channel with the Authority written permission.

C. Paint cut ends prior to installation with the following:
   1. Carbon Steel Channel: Zinc-rich primer.

D. Provide insulating material or coating to separate surface of Aluminum channel from concrete and dissimilar materials.

3.4 SWITCHBOARD MATTING

A. Install 36-inch width at switchgear, switchboard, motor control centers, control panels, server and data cabinets, and panelboards.

B. Matting shall run full length of all sides of equipment that have operator controls.

3.5 FIRESTOPS

A. Install in strict conformance with manufacturer’s instructions. Comply with installation requirements established by testing and inspecting agency.

B. Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide firestops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.

C. Use engineered assemblies signed and sealed by a Registered Professional Engineer in California.

END OF SECTION 26 05 04
PART 1 GENERAL

1.1 REFERENCES

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

1. Association of Edison Illuminating Companies (AEIC):
   CS 8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 kV through 46 kV.

2. ASTM International (ASTM):

3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV Through 500 kV.
   b. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
   c. 404, Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500000 V.
   d. 400.2, Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)

4. Insulated Cable Engineer's Association, Inc. (ICEA):


8. Underwriters Laboratories Inc. (UL):
e. 486C, Standard for Safety for Splicing Wire Connectors.
f. 510, Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
g. 854, Standard for Safety for Service-Entrance Cables.
h. 1072, Standard for Safety for Medium-Voltage Power Cables.
i. 1277, Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
jj. 1569, Standard for Safety for Metal-Clad Cables.
l. 1685, Vertical Tray Fire Propagation and Smoke Release Test for Electrical and Optical Cables.
m. 2556, Wire and Cable Test Methods (Tri-national).

1.2 SUBMITTALS

A. Action Submittals, submit to the Authority per contract:

1. Product Data: Submit manufacturer's product data including catalog cuts for each type of product specified including the following. Indicate each size and type to be used on this project.
a. Wire and cable.
b. Wire and cable splice details.
c. Connectors.
2. Busway:
   a. Product data.
   b. Rating information.
   c. Dimensional drawings.
   d. Special fitting.
   e. Equipment interface information for equipment to be connected to busways.

3. Cable Pulling Calculations:
   a. Ensure submitted and reviewed before cable installation with the following minimum information and parameters:
      1) Pulling point-to-point diagrams identifying manholes, cable, straight runs, vertical and horizontal bends.
      2) Conduit characteristics and coefficients.
      3) Cable characteristics and coefficients.
      4) Conduit bends and radii.
      5) Equations, coefficients, characteristics, methods, and adjustment factors used in calculations.
      6) Conduit horizontal and vertical profiles.
      7) Maximum cable and conduit side wall and cable pulling tensions in and out of bends and sections.
      8) Cable pulling methods (single, dual, cradled, triangular).
   b. Provide for the following cable installations:
      1) All medium voltage cable runs.
      2) Multiconductor 600-volt cable sizes larger than 2 AWG.
      3) Feeder circuits; single conductors #4/0 and larger.

4. Manufacturer’s ISO 9001 certification.

5. Field Test Reports.

B. Informational Submittals, submit to the Authority per contract:
   1. Journeyman electrician medium voltage splicers:
      To be submitted, and approved in writing from the Authority before performing splicing and terminating activates. All persons required to splice, terminate, and supervise the work shall meet and demonstrate the following:
   2. Minimum of (5) years of technical training and experience in splicing and terminating MV cables and splices of the type and size specified to be used on this project.
3. Minimum of (2) years of technical training held at a recognized school. Training held at only the following organizations will be acceptable:

   International Brotherhood of Electrical Workers (IBEW)
   “3M” High Voltage Division Major utility company such as SDG&E, SCE.

4. Subsequent to training, the persons shall have had minimum of five (5) years of recent experience in splicing and terminating MV cables.

5. Cable splicer shall be located within forty (40) mile radius of the project.

6. Cable splicer(s) shall demonstrate a splice of the type and size to be used on this project in witness of, and to the satisfaction of an Authority designated representative, before being approved to splice on this project.

7. Certified Factory Test Report for conductors 600 volts and below.

8. Certified Factory Test Report per AEIC CS 8, including AEIC qualification report for conductors above 600 volts.

9. Table of Manholes with splices of 15kV cable. Include photos of exterior labeled cover and interior of racked splices.

10. Table of Manholes with loops of cable for future use. Include photos of exterior labeled cover and interior of racked splices.

11. Table of Manholes with 15kV cable junctions. Included photos of exterior labeled cover and interior of racked junctions.

1.3 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

   1. Provide the Work in accordance with California Electrical Code (CEC).
      Where required by the Authority, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the Authority in order to provide a basis for approval under CEC.

   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. Conductors and cables shall conform to applicable ASTM and ICEA standards.
C. Conductors and cables shall be of the same manufacturer, and shipped to the job site in original unbroken reels.

D. MV conductors and cables shall be manufactured with in twelve (12) months of installation. Date of manufacture shall be clearly marked on conductors or conductor reels.

E. Manufacturer shall have a minimum of ten (10) years’ experience in the manufacturer of conductors and cables similar to those specified on this project.

F. All medium voltage cables shall be from a single manufacturer.

G. Terminations and Splices for Conductors above 600 Volts: Work shall be performed by Authority pre-approved journeyman with splicing credentials.

1.4 SPECIAL GUARANTEE

A. Provide manufacturer’s extended guarantee or warranty, with the Authority named as beneficiary, in writing, is special guarantee for all medium voltage cable furnished on this project. Special guarantee shall provide for replacement of cable found defective during a period of 40 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be the responsibility of the Contractor for three years after date of Substantial Completion.

PART 2 PRODUCTS

2.1 CONDUCTORS 600 VOLTS AND BELOW

A. Conform to applicable requirements of NEMA WC 70.

B. Conductor Type:
   1. 120-Volt and 277-Volt Lighting, 10 AWG and Smaller: Solid copper except where required for vibration isolation.
   2. 120-Volt Receptacle Circuits, 10 AWG and Smaller: Solid copper except where required for vibration isolation.
   3. All pulled in Control Circuits: Solid copper.

C. Insulation: Type THHN/THWN-2, except for sizes No. 6 and larger, with XHHW-2 insulation.

D. Direct Burial and Aerial Conductors and Cables:
   1. Type USE/RHH/RHW insulation, UL 854 listed, or Type RHW-2/USE-2.
   2. Conform to physical and minimum thickness requirements of NEMA WC 70.
E. Flexible Cords and Cables:

1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.

2. Conform to physical and minimum thickness requirements of NEMA WC 70.

F. XLPE Wire Type SIS - Switchboard Conductors (Manufacturer):

1. Conductors suitable for use in 90 degrees C dry locations and used for wiring of switchgear, switchboards, panelboards, distribution boards, and protective relaying control panels.

Ratings:

a. Standards:

1) UL Listed Type SIS.

2) IEEE 383 Flame tested material.

3) VW-1 Rating.

4) CSA Type SIS Lead Wire.

b. Size:

1) 18 AWG stranded, .030 insulation, thickness .112 inches diameter.

2) 16 AWG stranded, .030 insulation thickness, .123 inches diameter.

3) 14 AWG stranded, .030 insulation thickness, .140 inches diameter.


d. Insulation: Cross-Linked Polyethylene.

e. Temperature Rating: UL 90 degree C. Non UL 150 degrees C.

f. Voltage Rating: 600 Volts R.M.S.

G. Manufacturers: One of the following:

1. General Cable.

2. Okonite.


4. Or equal.
2.2 CONDUCTORS ABOVE 600 VOLTS

A. EPR Insulated Cable:


2. Type: 15 kV, shielded, UL 1072, Type MV-105.

3. Conductors: Aluminum per ASTM B-609, Class B stranded per B-231.


5. Insulation: 133 percent insulation level, ethylene-propylene rubber (EPR) containing no polyethylene, in accordance with NEMA WC 74 & S-97-682, and AEIC CS 8.


7. Insulation Screen: Thermosetting, semiconducting ethylene-propylene rubber (EPR), extruded directly over insulation in accordance with NEMA WC 74 and AEIC CS 8.

8. Metallic Shield: Uncoated, 5-mil, single copper shielding tape, helically applied with 25 percent minimum overlap.

9. Jacket: Extruded polyvinyl chloride (PVC) compound applied in accordance with NEMA WC 71 or NEMA WC 74. PVC jacket shall exhibit a coefficient of friction of less than 0.25 for installation without pulling compound.

10. Operating Temperature: 105 degrees C continuous normal operations, 130 degrees C emergency operating conditions, and 250 degrees C short-circuit conditions.

11. Manufacturers, one of the following or a written Authority approved equal:

   a. Southwire Co.
   b. Okonite Co.
   c. General Cable
2.3 600 VOLT AND BELOW RATED CABLES

A. General:

1. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and CEC, Article 340, or UL 13 meeting requirements of CEC, Article 725.

2. Permanently and legibly marked with manufacturer’s name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.

3. Suitable for installation in open air, in cable trays, or conduit.


5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil- resistant.

B. Type 1, Multiconductor Control Cable:

1. Conductors:
   a. 14 AWG, seven-strand copper.
   b. Insulation: 15-mil PVC with 4-mil nylon.
   c. UL 1581 listed as Type THHN/THWN rated VW-1.
   d. Conductor group bound with spiral wrap of barrier tape.
   e. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.

2. Cable: Passes the UL 1685.

3. Cable Sizes:

<table>
<thead>
<tr>
<th>No. of Conductors</th>
<th>Max. Outside Diameter (Inches)</th>
<th>Jacket Thickness (Mils)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.41</td>
<td>45</td>
</tr>
<tr>
<td>5</td>
<td>0.48</td>
<td>45</td>
</tr>
<tr>
<td>7</td>
<td>0.52</td>
<td>45</td>
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<tr>
<td>12</td>
<td>0.72</td>
<td>60</td>
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<tr>
<td>19</td>
<td>0.83</td>
<td>60</td>
</tr>
<tr>
<td>25</td>
<td>1.00</td>
<td>60</td>
</tr>
<tr>
<td>37</td>
<td>1.15</td>
<td>80</td>
</tr>
</tbody>
</table>

4. Manufacturers:
   a. American Insulated Wire Corp.
   b. Southwire Co.
   c. Okonite Co.
   d. Or equal.
C. Type 3, 16 AWG, Twisted, Shielded Pair, Instrumentation Cable:
Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal thickness.

2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.

3. Dimension: 0.31-inch nominal OD.

4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
   b. 20 AWG, seven-strand tinned copper drain wire.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nominal nylon.
   e. Color Code: Pair conductors, black and red.

5. Manufacturers:
   a. Okonite Co.
   b. Southwire Co.
   c. Belden.
   d. Or equal.

D. Type 4, 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal.

2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.

3. Dimension: 0.32-inch nominal OD.

4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
   b. 20 AWG, seven-strand, tinned copper drain wire.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nylon.
   e. Color Code: Triad conductors black, red, and blue.
5. Manufacturers:
   a. Okonite Co.
   b. Southwire Co.
   c. Belden.
   d. Or equal.

E. Type 5, 18 AWG, Multi-twisted Shielded Pairs, with a Common Overall Shield, Instrumentation Cable: Designed for use as instrumentation process control, and computer cable, meeting NEMA WC 57 requirements.

1. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
   b. Tinned copper drain wires.
   c. Pair drain wire size AWG 20, group drain wire size AWG 18.
   d. Insulation: 15-mil PVC.
   e. Jacket: 4-mil nylon.
   f. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
   g. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.

2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

3. Cable Sizes:

<table>
<thead>
<tr>
<th>Number of Pairs</th>
<th>Maximum Outside Diameter (Inches)</th>
<th>Nominal Jacket Thickness (Mils)</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>50</td>
<td>1.56</td>
<td>80</td>
</tr>
</tbody>
</table>

4. Manufacturers:
   a. Okonite Co.
   b. Southwire Co.
   c. Belden.
   d. Or equal.
F. Type 6, 18 AWG, Multi-twisted Pairs with Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 57.

1. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
   b. Tinned copper drain wire size AWG 18.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nylon.
   e. Color Code: Pair conductors, black a3d red with red conductor numerically printed for group identification.

2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

3. Cable Sizes:

<table>
<thead>
<tr>
<th>Number of Pairs</th>
<th>Maximum Outside Diameter (Inches)</th>
<th>Nominal Jacket Thickness (Mils)</th>
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<tr>
<td>4</td>
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<tr>
<td>50</td>
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<td>80</td>
</tr>
</tbody>
</table>

4. Manufactures:
   a. Okonite Co.
   b. Southwire Co.
   c. Belden.
   d. Or equal.

2.4 SPECIAL CABLES

A. Type 30, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 300V:

1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-C Category 6 requirements.

2. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
3. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket.

4. CEC Plenum (CMP) rated; comply with flammability plenum requirements of CEC 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:
   a. Okonite Co.
   b. Southwire
   c. Belden.
   d. Or equal.

B. Type 40, IRIG-B Coaxial Cables, 300V:
   1. UL listed, and third party verified to comply with IRIG requirements.
   2. Suitable for high speed network applications including time dilation.
   3. CEC Plenum (CMP) rated; comply with flammability plenum requirements of CEC and NFPA 262.
   4. Connectors: BNC.
   5. Manufacturer and Product:
      a. SEL IRIG-B, SEL-C953, SEL-C654 or as recommended by PSS Integrator.
      b. Okonite Co.
      c. Southwire.
      d. Belden.
      e. Or equal.

C. Type 41, RS 485 Cables 300V:
   1. UL listed, and third party verified to comply with TIA/EIA 568-C Category 6 requirements.
   2. Suitable for high speed network applications including time dilation.
   3. CEC Plenum (CMP) rated; comply with flammability plenum requirements of CEC and NFPA 262.
4. Manufacturer and Product:
   a. SEL-C280 or as recommended by PSS Integrator.
   b. Okonite Co.
   c. Southwire
   d. Belden.
   e. Or equal.

D. Type 42, DNP (3) Serial Cables 300V:
   1. UL listed, and third party verified to comply with TIA/EIA 568-C Category 6 requirements.
   2. Suitable for high speed network applications including time dilation.
   3. CEC Plenum (CMP) rated; comply with flammability plenum requirements of CEC and NFPA 262.

4. Manufacturer and Product:
   a. SEL C280.
   b. Okonite Co.
   c. Southwire Co.
   d. Belden.
   e. Or equal.

2.5 GROUNDING CONDUCTORS

A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE or THHN/THWN, insulation.

B. Direct Buried: Bare stranded copper.

2.6 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:
   1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
   2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88 or approved equal.
   3. Arc and Fireproofing:
      a. 30-mil, elastomer.
      b. Manufacturers and Products:
         1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
         2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.
         3) Or equal.
B. Identification Devices:

1. Sleeve:
   a. Permanent, PVC, yellow or white, with legible Machine - printed black markings.
   b. Manufacturers and Products:
      1) Raychem; Type D-SCE or ZH-SCE.
      2) Brady, Type 3PS.
      3) Or equal.


C. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
   a. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon.
      2) Burndy; Insulug.
      3) ILSCO.
      4) Or equal.

2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
   a. Suitable for use with 75 degrees C wire at full CEC, 75 degrees C ampacity.
   b. Seamless.
   c. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon.
      2) Burndy; Insulink.
      3) ILSCO; ILSCONS.
      4) Or equal.

   a. UL 486C.
   b. Plated steel, square wire springs.
   c. Manufacturers and Products:
      1) Thomas & Betts.
      2) Ideal; Twister.
      3) ISLCO
      4) Or equal.

4. Self-Insulated, Set Screw Wire Connector:
   a. Two-piece compression type with set screw in brass barrel.
   b. Insulated by insulator cap screwed over brass barrel.
   c. Manufacturers:
      1) 3M Co.
      2) Thomas & Betts.
      3) Marrette.
      4) Or equal.
D. Cable Lugs:

1. In accordance with NEMA CC 1.
2. Rated 600 volts of same material as conductor metal.
3. Uninsulated Crimp Connectors and Terminators:
   a. Suitable for use with 75 degrees C wire at full CEC, 75 degrees C ampacity.
   b. Manufacturers and Products:
      1) Thomas & Betts; Color-Keyed.
      2) Burndy; Hydent.
      3) ILSCO.
      4) Or equal.
4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
   a. Manufacturers and Products:
      1) Thomas & Betts; Locktite.
      2) Burndy; Quiklug.
      3) ILSCO.
      4) Or equal.

E. Cable Ties:

1. Nylon, adjustable, self-locking, and reusable.
2. Black color, UV resistant.
3. Manufacturer and Product:
   a. Thomas & Betts; TY-RAP.
   b. Burndy.
   c. ILSCO.
   d. Or equal.

F. UV Electrical Vinyl Tape:

1. Primary insulation for splices and jacket repair up to 600V.
2. UL 501 Requirements.
3. Vinyl electrical tape, UV resistant, abrasion, corrosión, alkalies and acid resistant.
4. Manufacturer and Products:
   a. 3M Scotch 33; Conductor Splices.
   b. 3M Scotch 35; Conductor Color Coding.
   c. Plymouth Tape (equivalent styles).
   d. Or equal.
G. Heat Shrinkable Insulation:
   1. Thermally stabilized cross-linked polyolefin.
   2. Single wall for insulation and strain relief.
   3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
   4. Manufacturers and Products:
      a. Thomas & Betts; SHRINK-KON.
      b. Raychem; RNF-100 and ES-2000.
      c. 3M Co.; Heat Shrink.
      d. Or equal.

H. DataCable Accessories: Terminators, connectors, factory jumpers and junctions necessary for a complete DNP, DNP(3), Serial, Modbus RTU, Goose, Ethernet, and IRIG-B networks.

2.7 ACCESSORIES FOR CONDUCTORS ABOVE 600 VOLTS

A. Heat Shrinkable Splice Kits:
   1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
   2. Capable of making splices with a current rating equal to, or greater than, cable ampacity, conforming to IEEE 404.
   3. Class 25 kV, with compression connector, splice insulating and conducting sleeves, stress-relief materials, shielding braid and mesh, and abrasion-resistant heat shrinkable adhesive-lined rejacketing sleeve to provide a waterproof seal for continuous immersion in water.
   4. Manufacturers:
      a. Raychem.
      b. 3M Co.
      c. Or equal.

B. Termination Kits:
   1. Capable of terminating 25 kV, single conductor, polymeric-insulated shielded cables plus a shield ground clamp.
   2. Capable of producing a termination with a current rating equal to, or greater than, cable ampacity meeting Class 1 requirements of IEEE 48.
   3. Capable of accommodating cable shielding or construction without need for special adapters or accessories.
4. Manufacturers:
   a. Raychem.
   b. 3M Co.
   c. Or equal.

C. Bus Connection Insulation:
   1. Heat shrinkable tubing, tape, and sheets of flexible cross-linked polymeric material formulated for high dielectric strength.
   2. Tape and sheet products to have coating to prevent adhesion to metal surfaces.
   3. Insulating materials to be removable and reusable.
   4. Manufacturer: Raychem, or written, FMD approved equal.

D. Elbow Connector Systems:
   1. Molded, peroxide-cured, EPDM-insulated, Class 25 kV, 125 kV BIL, 200A, 15,000A rms load-break and 600A, 40,000 rms nonload-break elbows as shown, having copper current carrying parts in accordance with IEEE386. Include test point on terminator body that is capacitance coupled.
   2. Protective Caps: Class 25 kV, 125 kV BIL, 200 and 600 amperes, with molded EPDM insulated body.
   3. Insulated Standoff Bushings: Class 25 kV, 125 kV BIL, 200 and 600 amperes, complete with EPDM rubber body, stainless Steel eyebolt with brass pressure foot, and stainless steel base bracket.
   7. Fused Elbows for PT’s: EFX 172003-E or equivalent.
   8. SEL VIN600 indicators at all aboveground and below ground load-break and dead-break elbows.
9. 25 kV class equipment shall be used at pad mounted transformers, pad mounted capacitors and pad mounted switchgear.

10. Manufacturers:
   a. Cooper Industries.
   b. Elastimold.
   c. Or equal.

E. Cable Lugs:
   1. In accordance with NEMA CC1.
   2. Rated 15 kV of same material as conductor metal.
   3. Manufacturers and Products, Uninsulated Compression Connectors and Terminators:
      a. Burndy; Hydent.
      b. Thomas & Betts; Color-Keyed.
      c. ILSCO.
      d. Or equal.

4. Manufacturers and Products, Uninsulated, Bolted, Two-Way Connectors and Terminators:
   a. Thomas & Betts; Locktite.
   b. ILSCO.
   c. Or equal.

F. Tape:
   1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
   2. Flame Retardant, Cold and Weather Resistant: 8.5- mil, vinyl plastic, Scotch Brand 88, or written, FMD approved equal.
   3. Arc and Fireproofing:
      a. 30-mil, elastomer.
      b. Manufacturers and Products:
         1) 3M; Scotch Brand 77, with Scotch Brand 39 glass cloth tape binder.
         2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tape binder.
         3) Or equal.
G. Cable Ties:
   1. Nylon, adjustable, self-locking.
   2. Black color, UV resistant.
   3. Manufacturer and Product:
      a. Thomas & Betts.
      b. TY-RAP.
      c. Or equal.

H. Heat Shrinkable Insulation:
   1. Thermally stabilized cross-linked polyolefin.
   2. Single wall for insulation and strain relief.
   3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
   4. Manufacturers and Products:
      a. Thomas & Betts; SHRINK-KON.
      b. Raychem; RNF-100 and ES-2000.
      c. Or equal.

2.8 PULLING COMPOUND 600V AND BELOW

A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Approved for intended use by cable manufacturer and approved in writing by the Authority.

D. Suitable for galvanized steel, PVC, PVC coated steel, bituminized fiber, and fiberglass raceways.

E. Manufacturers:
   1. Polywater, Inc.- “J”.
   2. Ideal- “Velocity” (Yellow #77 is NOT approved).
   3. Or equal.

2.9 WARNING TAPE

A. As specified in Section 26 05 33, Raceway and Boxes.
2.10 SOURCE QUALITY CONTROL

A. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.

B. Conductors Above 600 Volts: Test in accordance with AEIC CS 8 partial discharge level test or VLF Tan-Delta test for EPR insulated cable.

PART 3 EXECUTION

3.1 GENERAL

A. Conductor installation shall be in accordance with manufacturer’s recommended installation practices. Pull all cables and ground wire as a unit.

B. Conductor and cable sizing is to be based on copper conductors, unless noted otherwise for conductors 600 Volt and below and aluminum for conductors above 600 Volt.

C. Do not exceed cable manufacturer’s recommendations for maximum pulling tensions, maximum sidewall pressure and minimum bending radii.

D. Terminate conductors and cables, unless otherwise indicated.

E. Cable splicer(s) shall demonstrate a splice of the type and size to be used on this project in witness of, and to the satisfaction of an Authority designated representative. Sample splice shall not be performed on the cable to be installed for the project.

F. Tighten screws and terminal bolts in accordance with manufacturer and UL 486A-486B for copper conductors.

G. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

H. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 18 inches on center.

I. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

J. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrela approximately 1/4 inch smaller than raceway inside diameter.
3.2 POWER CONDUCTOR COLOR CODING

A. Conductors below 600V:

1. 6 AWG and Larger: Provide manufacturer applied colored insulation on conductors.

2. 8 AWG and Smaller: Provide manufacturer applied colored insulation on conductors.

3. Colors:

<table>
<thead>
<tr>
<th>System</th>
<th>Conductor</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>All System</td>
<td>Equipment Grounding</td>
<td>Green</td>
</tr>
<tr>
<td>240/120 Volts, Single-Phase, Three-Wire</td>
<td>Grounded Neutral One Hot Leg Other Hot Leg</td>
<td>White Black Red</td>
</tr>
<tr>
<td>208Y/120 Volts, Three-Phase, Four-Wire</td>
<td>Grounded Neutral Phase A Phase B Phase C</td>
<td>White Black Red Blue</td>
</tr>
<tr>
<td>240/120 Volts, Three-Phase, Four-Wire, Delta, Center Tap, Ground on Single-Phase</td>
<td>Grounded Neutral Phase A High (wild) Leg Phase C</td>
<td>White Black Orange Blue</td>
</tr>
<tr>
<td>480/277 Volts, Three-Phase, Four-Wire</td>
<td>Grounded Neutral Phase A Phase B Phase C</td>
<td>Gray Brown Orange Yellow</td>
</tr>
<tr>
<td>12000Y/6930 Volts, Three-Phase, Four-Wire</td>
<td>Grounded Neutral Phase A Phase B Phase C</td>
<td>Gray 1-Stripe 2-Stripes 3-Stripes</td>
</tr>
</tbody>
</table>

Note: Phase A, B, C implies direction of positive phase rotation.

4. Neutral or Phase Tracer: Outer covering of white or phase color with three continuous stripes, other than green for the entire length, in accordance with CEC.

B. Conductors Above 600 Volts:

1. Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
3.3 CIRCUIT IDENTIFICATION

A. Identify power, instrumentation, and control conductor circuits at each termination, and in accessible locations such as manholes, handholes, panels, pad mounted switchgear, switchboards, control panels, pull boxes, and terminal boxes.

B. Circuits Appearing in Circuit Schedules: Identify using circuit schedule designations.

C. Circuits Not Appearing in Circuit Schedules:

1. Assign circuit name based on device or equipment at load end of circuit.

2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

D. Method:

1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.

2. Cables and Conductors 2 AWG and Larger:
   a. Identify with marker plates or tie-on cable marker tags.
   b. Attach with nylon tie cord.

3. Taped-on markers or tags relying on adhesives not permitted.

3.4 CONDUCTORS 600 VOLTS AND BELOW

A. Install solid 10 AWG or 12 AWG conductors, except where vibration isolation is necessary, for branch circuit power wiring in runs not to exceed 150’ in length. Install stranded conductors for 8 AWG and larger conductors.

B. Do not splice branch or power distribution conductors 6 AWG and larger, unless specifically indicated or approved in writing by the Authority.

C. Connections and Terminations:

1. Install wire nuts only on solid conductors. Wire nuts are not allowed on stranded conductors or instrumentation conductors smaller than #14 AWG.
2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors.


4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors 4 AWG through 2/0 AWG.

5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.

6. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.

7. Place no more than one conductor in any single-barrel pressure connection.

8. Install crimp connectors with tools approved by connector manufacturer.

9. Install terminals and connectors that are UL Listed and acceptable for type of material used.

10. Compression Lugs:
   a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
   b. Do not use plier type crimpers.

D. Do not use soldered mechanical joints.

E. Splices and Terminations:
   1. Insulate uninsulated connections.
   2. Indoors: UL listed general purpose, flame retardant tape or single wall heat shrink.
   3. Outdoors, Dry Locations: UL listed flame retardant, cold-and weather-resistant tape or single wall heat shrink.
   4. Below Grade and Wet or Damp Locations: UL listed dual wall heat shrink.

F. Cap spare conductors with UL listed end caps.
G. Cabinets, Panels, and Motor Control Centers:

1. Remove surplus wire, bridle and secure.

2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

3. Group multi-wire circuits at least once within enclosure per CEC 210.4(D) unless exception applies.

H. Control and Instrumentation Wiring:

1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.

2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer’s instructions.

3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.

4. Where connections of cables installed under this section are to be made under Section 26 09 14 Power System Supervisory Control and Data Acquisition, leave pigtails of adequate length for bundled connections.

5. Cable Protection:
   b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least 1/2 inch in diameter.
   c. Maintain integrity of shielding of instrumentation cables.
   d. Ensure grounds do not occur because of damage to jacket over shield.

I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

3.5 CONDUCTORS ABOVE 600 VOLTS

A. Contractor shall submit all proposed splice locations with required Calculations for written approval by the Authority. Contractor shall not install continuous cable pulls exceeding 900 feet, unless approved by the Authority. Provide splices at every third vault, maximum.
B. Make joints and terminations with splice and termination kits, in accordance with kit manufacturer’s instructions.

C. Install splices or terminations as a continuous operation in accessible locations under clean, dry conditions.

D. When Using Heat-Shrinkable, Single Conductor Cable Terminations: Provide heat shrinkable stress control and outer non-tracking insulation tubing, high relative permittivity stress relief mastic for insulation sheild cutback treatment, and a heat activated sealant for environmental sealing plus a ground braid and clamp.

E. Install terminals or connectors acceptable for type of conductor material used.

F. Provide outdoor rain skirts for outdoor switchgear terminations.

G. Provide shield termination and grounding for terminations.

H. Provide necessary mounting hardware, covers, and connectors.

I. Where elbow connectors are specified, install in accordance with manufacturer’s instructions.

J. Connections and Terminations:

   1. Install uninsulated crimp connectors and terminators for power circuit conductors 4 AWG and larger.

   2. Install uninsulated, bolted, two-way connectors for motor circuit conductors No. 12 and larger.

   3. Insulate bus connections with heat shrinking tubing, tape, and sheets.

K. Give 2 working days’ notice to FMDprior to making splices or terminations to facilitate inspection.
3.6 CONDUCTOR ARC AND FIREPROOFING

A. Install arc and fireproofing tape on 15 kV cables throughout entire exposed length at splices in manholes, handholes, vaults, cable trays, and other other indicated locations. Tape shall extend into duct 1 to 2 inches.

B. Wrap conductors of same circuit entering from separate conduit together as single cable.

C. Follow tape manufacturer’s installation instructions. The tape shall be applied with the coated side towards the cable and shall extend one inch into the ducts.

D. Secure tape at intervals of 5 feet, minimum, with bands of tape binder. Each band to consist of a minimum of two wraps directly over each other.

END OF SECTION 26 05 05
SPECIAL PROVISIONS
DIVISION 26 – ELECTRICAL
SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 REFERENCES

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

1. Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).

2. California Electrical Code (CEC).


1.2 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Product data for the following:
   a. Exothermic weld connectors – where approved by the Authority.
   b. Mechanical connectors.
   c. Compression connectors.

B. Comply with UL467 grounding and bonding materials and equipment.

1.3 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with California Electrical Code (CEC). Where required by the Authority, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the Authority in order to provide a basis for approval under CEC.

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.
PART 2  PRODUCTS

2.1  GROUND ROD
A. Material: Copper-clad steel.
C. Length: 10 feet.

2.2  GROUND CONDUCTORS
A. As specified in Section 26 05 05, Conductors.

2.3  CONNECTORS
A. Exothermic Weld Type (in areas where approved in writing by the Authority within the Airport):
   1. Outdoor Weld: Suitable for exposure to elements or direct burial.
   2. Indoor Weld: Utilize low-smoke, low-emission process.
   3. Manufacturers:
      a. Permission required unless utilized in writing by the Authority, approved areas within the Airport:
         1) Erico Products, Inc Cadweld and Cadweld Exolon.
         2) Thermoweld.
         3) Fushi Copperweld, Inc.
         4) Or equal.

B. Compression Type:
   1. Compress-deforming type; wrought copper extrusion material.
   2. Single indentation for conductors 6 AWG and smaller.
   3. Follow the manufacture specification for Crimping.
   5. Manufacturers:
      a. Burndy Corp.
      b. Thomas and Betts Co.
      c. ILSCO.
      d. Galvan Industries Inc.
      e. Or equal.
C. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy or bi-metallic material for aluminum conductors where permitted.

1. Manufacturers:
   a. Burndy Corp.
   b. Thomas and Betts Co.
   c. Galvan Industries Inc.
   d. ILSCO.
   e. Or equal.

2.4 GROUNDING WELLS

A. Ground rod box complete with cast iron riser ring and traffic cover marked GROUND ROD.

B. Manufacturers and Products:
   3. Or equal.

PART 3 EXECUTION

3.1 GENERAL

A. Grounding and Bonding shall be in compliance with CEC and IEEE C2.

B. Bond electrical service neutral at service entrance equipment to grounding electrode system consisting of The Authority approved grounding electrodes all bonded together in accordance with CEC and IEEE C2.

C. Bond each separately derived system neutral to grounding electrode system. Bond metal piping systems in the area served by the separately derived system to the neutral and to the grounding electrode system.

D. Bond metallic enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, to the grounding system.

E. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer. Carry ground wires separately to ground bus, no “piggyback” of ground wires allowed.
F. Shielded Instrumentation Cables:
   1. Ground shield to ground bus at control panel which receives (monitors) the instrument signal. Ground instrument shield and drain wires to control panel common instrument ground bus. For instruments not monitored by a control panel, ground instrument shield and drain wire at power supply for instrument analog signal.
   2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
   3. Do not ground any single instrumentation cable shield at more than one point.

3.2 WIRE CONNECTIONS

A. Ground Conductors: Install in raceways containing power conductors and control circuits above 50 volts.

B. Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Connect ground conductors to raceway grounding bushings.

D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

E. Bond equipment enclosures containing ground bus to that bus.

F. Bolt connections to equipment ground bus.

G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding screws mounted directly on box, or with 3/8-inch machine screws.

3.3 GROUND RODS

A. Install full length with conductor connection at upper end.

B. Install with connection point below finished grade, unless otherwise shown.

C. Space multiple ground rods by one rod length.

D. Install rods with Manufacturer mark and UL mark visible.
3.4 GROUNDING WELLS

A. Install inside buildings, asphalt, and paved areas.

B. Install riser ring and cover flush with surface.

C. Place 6 inches of crushed rock in bottom of each well.

D. Ground rod connection shall be by bolted connector listed for grounding and bonding use.

3.5 CONNECTIONS

A. General:

1. Above grade Connections: Install exothermic weld (Written permission required unless utilized in areas pre-approved by the Authority) mechanical, or compression-type connectors.

2. Below grade Connections: Install exothermic weld (Written permission required unless utilized in areas pre-approved by the Authority) or compression type connectors.

3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.

4. Notify Engineer, the Authority prior to backfilling ground connections.

B. Exothermic Weld Type (Written permission required unless utilized in pre-approved areas by the Authority):

1. Wire brush or file contact point to bare metal surface.

2. Use welding cartridges and molds in accordance with manufacturer’s recommendations.

3. Avoid using badly worn molds.

4. Mold to be completely filled with metal when making welds.

5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Compression Type:

1. Install in accordance with connector manufacturer’s recommendations.

2. Install connectors of proper size for grounding conductors and ground rods specified.
3. Install using connector manufacturer’s compression tool having proper sized dies.

D. Mechanical Type:

1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.

2. Install in accordance with connector manufacturer’s recommendations.

3. Do not conceal mechanical connections.

3.6 METAL STRUCTURE BONDING

A. Bond metal sheathing and exposed metal vertical structural elements to grounding system.

B. Bond electrical equipment supported by metal platforms to the platforms.

C. Provide bonding contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

3.7 MANHOLE AND HANDHOLE GROUNDING

A. Install one ground rod inside each.

B. Ground Rod Floor Protrusion 4 to 6 inches above floor.

C. Make connections of grounding conductors fully visible and accessible.

D. Connect all noncurrent-carrying metal parts, and any metallic raceway grounding bushings to ground rod with No. 6 AWG copper conductor.

3.8 TRANSFORMER GROUNDING

A. Bond neutrals of transformers within buildings to grounding system, and to any additional indicated grounding electrodes. Ref. 26 05 26-3.1 C & D.

3.9 SURGE PROTECTION EQUIPMENT GROUNDING

A. Connect surge arrestor ground terminals to equipment ground bus.

END OF SECTION 26 05 26
PART 1     GENERAL

1.1 SUMMARY

A. This Section includes the following:

   1. Hangers and supports for electrical equipment and systems. Including all Communication, Class 1, Class 2, Class 3, CATV, Optical fiber and Broadband cabling.
   2. Seismic restraints for electrical equipment and systems.
   3. Construction requirements for concrete bases.

1.2 DEFINITIONS

A. EMT: Electrical metallic tubing where allowed by written permission of the Authority.
C. CBC: California Building Code
D. CEC: California Electrical Code
E. IMC: Intermediate metal conduit where allowed by written permission of the Authority.
F. RMC: Rigid metallic conduit.
G. Seismic Restraint: A structural support element such as a metal framing member, a cable, an anchor bolt or stud, a fastening device, or an assembly of these items used to transmit loads and seismic forces from an item of equipment or system to building structure and to limit movement of item during a seismic event.

1.3 SUBMITTALS

A. Product Data: Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of electrical support and seismic restraint component used.

   1. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of the ICC Evaluation Program, or an evaluation agency acceptable to the Authority.
   2. Annotate to indicate application of each product submitted and compliance with requirements.
B. Shop Drawings: Indicate materials and dimensions and identify hardware, including attachment and anchorage devices, signed and sealed by a professional Structural or Civil engineer registered in the State of California.

1. Fabricated Supports: Representations of field-fabricated supports not detailed on Drawings.

2. Seismic Restraints: Detail anchorage and bracing not defined by details or charts on Drawings. Include the following:
   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   b. Details: Detail 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.
   c. Preapproval and Evaluation Documentation: By an evaluation service member of the ICC Evaluation Program, or an evaluation agency acceptable to the Authority, 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. Qualification Data: For professional engineer and testing agency.

F. Field quality-control test reports.

1.4 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the California Building Code or IBC unless requirements in this Section are more stringent.

B. Testing of Seismic Anchorage Devices: Comply with testing requirements in Part 3 of this Section "Electrical Supports and Seismic Restraints."

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

1.5 PROJECT CONDITIONS

A. Project Seismic Design per the latest version of the ASCE 7
PART 2 PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified, or by written approval of the Authority.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed under this Project, with a minimum structural safety factor of five (5) times the applied force.

B. Steel Slotted Support Systems: Comply with MFMA-3, factory-fabricated components for field assembly.

C. Bridle or “D” rings shall be used on all SDIA projects and standard installation for all Communication, Class1, Class2, Class 3, CATV, Optical fiber and Broadband cabling I.T. to verify. - AB

1. Manufacturers:
   a. Cooper B-Line; a division of Cooper Industries.
   b. ERICO International Corporation.
   c. Allied Support Systems; Power-Strut Unit.
   d. GS Metals Corp.
   e. Michigan Hanger Co., Inc.; O-Strut Div.
   f. National Pipe Hanger Corp.
   g. Thomas & Betts Corporation.
   h. Unistrut; Tyco International, Ltd.
   i. Wesanco, Inc.
   j. Or written Authority approved equal.

2. Finishes:
   a. High strength fire resistive composite material for “D” rings.
   b. Metallic Coatings: Hot-dip galvanized or zinc after fabrication and applied according to MFMA-3.
   c. Nonmetallic Coatings: Manufacturer’s standard PVC, polyurethane, or polyester coating applied according to MFMA-3.
   d. Painted Coatings: Manufacturer’s standard painted coating applied according to MFMA-3.
3. Channel Dimensions: Selected for structural loading and applicable seismic forces

D. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- diameter holes at a maximum of 8 inches o.c., in at least 1 surface.

1. Manufacturers:
   a. Allied Support Systems; Aickinstrut Unit.
   b. Cooper B-Line; a division of Cooper Industries.
   c. Fabco Plastics Wholesale Limited.
   d. Seasafe, Inc.
   e. Or equal

2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.

3. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.

4. Rated Strength: Selected to suit structural loading and applicable seismic forces.

E. Raceway and Cable Supports: As described in NECA 1.

F. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

G. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

H. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

I. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Manufacturers:
      1. Hilti, Inc.
2. Mechanical-Expansion Anchors: Insert-wedge-type, [zinc-coated] [stainless] steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

   a. Manufacturers:
      1) Cooper B-Line; a division of Cooper Industries.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti, Inc.
      4) ITW Construction Products.
      5) MKT Fastening, LLC.
      6) Or equal

3. Concrete Inserts: Steel or malleable-iron slotted-support-system units similar to MSS Type 18; complying with MFMA-3 or MSS SP-58.

4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.

5. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.

6. Toggle Bolts: All-steel springhead type.


2.3 SEISMIC-RESTRAINT COMPONENTS

   A. Rated Strength, Features, and Application Requirements for Restraint Components: As defined in reports by an evaluation service member of the ICC Evaluation Service Program or an agency acceptable to the Authority.

      1. Structural Safety Factor: Strength in tension, shear, and pullout force of components used shall be at least five (5) times the maximum seismic forces to which they will be subjected.

   B. Angle and Channel-Type Brace Assemblies: Steel angles or steel slotted-support-system components; with accessories for attachment to braced component at one end and to building structure at the other end.

   C. Cable Restraints: ASTM A 603, zinc-coated, steel wire rope attached to steel or stainless-steel thimbles, brackets, swivels, and bolts designed for restraining cable service.
1. Manufacturers:
   a. Amber/Booth Company, Inc.
   b. Loos & Co., Inc.
   c. Mason Industries, Inc.
   d. CEAS Tomarco
   e. Or equal

2. Seismic Mountings, Anchors, and Attachments: Devices as specified in Part 2 "Support, Anchorage, and Attachment Components" Article, selected to resist seismic forces.

3. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections, reinforcing steel angle clamped to hanger rod, of design recognized by an evaluation service member of the ICC Evaluation Program or an agency acceptable to the Authority.

4. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings and matched to type and size of anchor bolts and studs used.

5. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings and matched to type and size of attachment devices used.

2.4 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

   A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

   B. Design and materials: Per approved submittal under 1.3 (B)(1) of this section.

PART 3 EXECUTION

3.1 APPLICATION

   A. Comply with NECA 1 for application of hangers and supports for electrical equipment and systems, except if requirements in this Section are stricter.

   B. Maximum support of bridle or "D" rings not to exceed 12 feet. All Communication, Class1, Class2, Class 3, CATV, Optical fiber and Broadband cabling mounted 12" above suspended ceilings. Communication, Class1, Class2, Class 3, CATV, Optical fiber and Broadband cabling mounted above fixed material ceilings shall be readily accessible or installed in enclosed raceways.
1. Bridle or "D" rings shall be installed independent of other utility racks and no attachment to ductwork, electrical conduit, cable trays or other similar items will be permitted.

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where Table 1 lists maximum spacings less than stated in CEC. Minimum rod size shall be 1/4 inch in diameter.

D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 20 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to trapeze member with clamps approved for application by an evaluation service member of the ICC Evaluation Program or an agency acceptable to the Authority.

2. Secure raceways and cables to these supports with single-bolt conduit clamps.

### 3.2 SUPPORT AND SEISMIC-RESTRAINT INSTALLATION

A. Comply with NECA 1 for installation requirements, except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, RMC may be supported by openings through structure members, as permitted in CEC, but must be clamped to the structural member using attachments approved in writing by the Authority.

C. Install seismic-restraint components using methods approved by the evaluation service providing required submittals for component and approved, in writing by the Authority.

D. 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. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

E. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.

2. To New Concrete: Bolt to concrete inserts.

3. To Masonry: Toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.

5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater.

6. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.

7. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts, Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.

8. To Light Steel: Sheet metal screws.

9. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

F. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements per approved submittal under 1.3 (B)(1) of this section.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 HOUSEKEEPING PAD

A. Coordinate concrete work in this Section with Section 03 30 00 "Cast-in-Place Concrete".

B. Housekeeping Pads Anchor equipment to concrete base according to equipment manufacturer’s written instructions and seismic criteria at Project.

C. Construct Housekeeping Pads of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so expansion anchors will be a minimum of 10 bolt diameters from edge of the base.
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 the base.

2. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use supported equipment manufacturer’s setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.

5. Install anchor bolts according to anchor-bolt manufacturer’s written instructions.

6. Use 3500-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified Section 03 30 00 Cast-in-Place Concrete. Base Finish shall be Smooth Finish.

3.5 INSTALLATION OF SEISMIC-RESTRAINT COMPONENTS

A. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

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. Restraint Cables: Provide slack within maximums recommended by manufacturer.

D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, upper truss chords of bar joists, or at concrete members.

3.6 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Make flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross expansion and seismic-control joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to electrical equipment that is anchored to a different structural element from the one supporting them as they approach equipment.
3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.


1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

2. Schedule test with FMD, through FMD’s Representative, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least two (2) days’ advance notice.

3. Obtain FMD Representative’s approval before transmitting test loads to structure. Provide temporary load-spreading members.

4. Test at least three (3) of each type and size of installed anchors and fasteners selected by FMD’s Representative.

5. Test to 90 percent of rated proof load of device.

6. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

C. Record test results.

END OF SECTION 26 05 29
SPECIAL PROVISIONS
DIVISION 26 – ELECTRICAL
SECTION 26 05 33
RACEWAYS AND BOXES

PART 1 GENERAL

1.1 REFERENCES

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


2. FAA AC 150/5370-10, item D-751 and FAA AC 150/5370-6 Appendix 3.

3. ASTM International (ASTM):


6. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. C80.1, Electrical Rigid Steel Conduit (ERSC).
   c. C80.3, Steel Electrical Metallic Tubing (EMT).
   d. C80.5, Electrical Rigid Aluminum Conduit (ERAC).
   e. C80.6, Electrical Intermediate Metal Conduit (EIMC).
f. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
g. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
h. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
i. TC 6, Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation.
j. TC 14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
k. VE 1, Metallic Cable Tray Systems.
l. VE 2, Cable Tray Installation Guidelines


8. Underwriters Laboratories Inc. (UL):
a. 1, Standard for Safety for Flexible Metal Conduit.
b. 5, Standard for Safety for Surface Metal Raceways and Fittings.
c. 6, Standard for Safety for Electrical Rigid Metal Conduit – Steel.
d. 6A, Standard for Safety for Electrical Rigid Metal Conduit – Aluminum, Red Brass and Stainless.
e. 360, Standard for Safety for Liquid-Tight Flexible Steel Conduit.
f. 514B, Standard for Safety for Conduit, Tubing, and Cable Fittings.
g. 651, Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
h. 651A, Standard for Safety for Type EB and A Rigid PVC Conduit and HDPE Conduit.
i. 797, Standard for Safety for Electrical Metallic Tubing.
j. 870, Standard for Safety for Wireways, Auxiliary Gutters, and Associated Fittings.
k. 1242, Standard for Safety for Electrical Intermediate Metal Conduit – Steel.
l. 1660, Standard for Safety for Liquid-Tight Flexible Nonmetallic Conduit.
m. 1684, Standard for Safety for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
n. 2024, Standard for Safety for Optical Fiber and Communication Cable Raceway.

1.2 SUBMITTALS

A. Action Submittals to the Authority per contract:

1. Manufacturer’s Literature:
   a. Rigid galvanized steel conduit and pre-manufactured bends.
   b. EMT conduit and pre-manufactured bends, when approved for use, by the Authority.
   c. PVC Schedule 40 conduit.
   d. PVC Schedule 40 long radii bends.
   e. PVC-coated rigid steel conduit. Submittal to include copy of manufacturer’s warranty.
   f. PVC Coated rigid steel conduit bends
   g. Flexible metal, liquid-tight conduit.
   h. Flexible metal, non-liquid-tight conduit.
   i. Rigid galvanized steel conduit fittings.
   j. EMT fittings, when approved for use in writing by the Authority.
   k. PVC coated rigid steel conduit fittings.
   l. Wireways.
   m. Surface metal raceway.
   n. Junction and pull boxes used at or below grade.
   o. Large junction and pull boxes.
   p. Terminal junction boxes.
   q. 20 mil. GRC tape wrap.

2. Cable Tray Systems:
   a. Dimensional Drawings, calculations, and descriptive information.
   b. NEMA load/span designation and how it was selected.
   c. Support span length and pounds-per-foot actual and future cable loading at locations, with safety factor used.
   d. Location and magnitude of maximum simple beam deflection of tray for loading specified.
   e. Layout Drawings and list of accessories being provided, scaled Drawings and CAD files.

3. Precast Manholes and Handholes:
   a. Dimensional Drawings and descriptive literature.
   b. Traffic loading calculations.
   c. Aircraft loading calculations for manholes in airfield.
   d. Accessory dimensional and installation information.

4. Conduit identification, tagging, and color coding in accordance with this Section.

5. Equipment and machinery proposed for bending metal conduit.

6. Manufactured long radius bends for PVC conduit. Conduit layout dimensions and rating should be included.
7. Drawings and Seismic Anchorage and Bracing Calculations for seismic attachments, braces, and anchorages. Include IBC and project specific criteria in addition to manufacturer’s specific criteria used for the design; sealed by a Structural Engineer registered in the State of California.

8. Conduit Layout:
   a. Provide Drawings coordinating conduit installations between what is shown on Drawings and proposed alternative routing. Alternate routing shall be approved in writing by the Authority prior to performance of any alternative work.
   b. Provide fabrication and installation details including calculations for trapeze hangers, supports for multiple raceways. Provide Drawings and Seismic Anchorage and Bracing Calculations for seismic attachments, braces, and anchorages. Include IBC and project specific criteria in addition to manufacturer’s specific criteria used for the design; sealed by a Structural Engineer registered in the State of California.
   c. Provide plan and section showing arrangement and location of conduit and duct bank required for:
      1) Low and medium voltage feeder and branch circuits.
      2) Instrumentation and control systems.
      3) Communications systems.
      4) Empty conduit for future use.
      5) Modifications to existing conduit routing and support systems including modifications to Terminal 1 and Terminal 2 West exposed primary power and communication raceways.
   d. Electronic CAD files; drawn as one unit equal to one foot with plotable view ports scaled not greater than 1-inch equals 20 feet and limited to 24-inch by 36-inch sheets. Multiple sheets with match lines will be used and coordinates to match SDCRAA datum.

B. Informational Submittals to the Authority per contract:

1. Drawings and Seismic Anchorage and Bracing Calculations for seismic attachments, braces, and anchorages. Include IBC and project specific criteria in addition to manufacturer’s specific criteria used for the design; sealed by a Structural Engineer registered in the State of California.

2. Manufacturer’s certification of training for PVC-coated rigid galvanized steel conduit installer. Reference Section 1D – Special Conditions, Article 1D-12 Certificates of Compliance.
1.3 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ): the Authority

1. Provide work in conformance with the California Electrical Code (CEC). Where required by the Authority, Material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the Authority in order to provide a basis for approval under CEC.

2. Materials and equipment manufactured within scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

B. PVC-Coated, Rigid Galvanized Steel Conduit Installer: Certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.

PART 2 PRODUCTS

2.1 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):

1. Meet requirements of NEMA C80.1 and UL 6.


3. Manufacturers:
   a. Allied Tube and Conduit.
   b. Western Tube and Conduit Corporation.
   c. Or equal.

B. PVC Schedule 40 Conduits:

1. Meet requirements of NEMA TC 2 and UL 651.

2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.

3. Provide with factory-formed bell.

4. Manufacturers:
   a. Carlon.
   b. PW Pipe.
   c. Or equal.
C. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of NEMA RN 1 and ETL.

2. Material:
   a. Meet requirements of NEMA C80.1 and UL 6.
   b. Exterior Finish: PVC coating, 40-mil nominal thickness; bond to metal shall have tensile strength greater than PVC.
   c. Interior finish: Urethane coating, 2-mil nominal thickness.

3. Threads: Hot-dipped galvanized and factory coated with urethane.

4. Bendable without damage to interior or exterior coating.

5. Manufacturers:
   a. Robroy Industries.
   b. Thomas & Betts OCAL.
   c. Or equal.

D. Flexible Metal, Liquid-Tight Conduit:

1. UL 360 listed for 105 degrees C insulated conductors.


3. Manufacturers:
   a. AFC Cable Systems.
   b. Southwire Titan.
   c. Or equal.

E. Flexible Metal, Nonliquid-Tight Conduit:

1. Meet requirements of UL 1.


3. Manufacturers:
   a. AFC Cable Systems.
   b. Southwire Galflex.
   c. Or equal.

F. EMT (when approved by the Authority)

1. Meets Requirements of UL 797

2. Material: Electro-Galvanized Steel Tubing

3. Manufacturers:
   a. Allied.
   b. Western.
   c. Or equal.
G. Innerduct:
   1. Resistant to spread of fire, per requirements of UL 2024.
   2. Factory lubricated.
   3. Color coded pull wire.
   4. Multi-Cell, Textile Type, with pull string, footage markings: a. 2-inch: 3-cell, 2-cell, and 1-cell (as noted).
   5. HDPE Innerduct: Smooth wall or corrugated, 1-1/4 inch diameter, approved by the Authority for direct burial and cable tray placement.

2.2 FITTINGS

A. Rigid Galvanized:
   1. General:
      a. Meet requirements of UL 514B.
      b. Type: Threaded, galvanized. Threadless Steel compression fittings permitted.
   2. Bushing:
      a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
      b. Manufacturers and Products:
         1) Appleton; Series BU-I.
         2) O-Z/Gedney; Type HB.
         3) Or equal.
   3. Grounding Bushing:
      a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
      b. Manufacturers and Products:
         1) Appleton; Series GIB.
         2) O-Z/Gedney; Type HBLG.
         3) Raco/Hubbel; Type WGB.
         4) Or equal.
   4. Conduit Hub:
      a. Material: Malleable iron with insulated throat with bonding screw.
      b. UL listed for use in wet locations.
      c. Manufacturers and Products:
         1) Appleton, Series HUB-B.
         2) O-Z/Gedney; Series CH.
         3) Meyers; ST Series.
         4) Or equal.
5. Conduit Bodies:
   a. Sized as required by CEC.
   b. Manufacturers and Products (For Normal Conditions):
      1) Appleton; Form 35 threaded unilets.
      2) Cooper Crouse Hinds; Form 7 or Form 8 threaded condulets.
      3) Killark; Series O electrolets.
      4) Thomas & Betts; Form 7 or Form 8.
      5) Or equal.

6. Couplings: As supplied by conduit manufacturer.

7. Unions:
   a. Concrete tight, hot-dip galvanized malleable iron.
   b. Manufacturers and Products:
      1) Appleton; Series SCC bolt-on coupling or Series EC three-piece union.
      2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.
      3) Or equal.

8. Drain Seal:
   a. Manufacturers and Products:
      1) Appleton; Type EYD.
      2) Cooper Crouse Hinds; Type EYD or Type EZD.
      3) Or equal.

9. Drain/Breather Fitting:
   a. Manufacturers and Products:
      1) Appleton; Type ECDB.
      2) Cooper Crouse Hinds; ECD.
      3) Or equal.

10. Expansion Fitting:
    a. Manufacturers and Products:
       1) Deflection/Expansion Movement:
          a) Appleton; Type DF.
          b) Cooper Crouse Hinds; Type XD.
          c) Or equal.
       2) Expansion Movement Only:
          a) Appleton; Type XJ.
          b) Cooper Crouse Hinds; Type XJ.
          c) Thomas & Betts; XJG-TP.
          d) Or equal.
11. Cable Sealing Fitting:
   a. To form watertight nonslip cord or cable connection to conduit.
   b. For Conductors with OD of 1/2 inch or less: Neoprene bushing at connector entry.
   c. Manufacturers and Products:
      1) Appleton; CG-S.
      2) Cooper Crouse Hinds; CGBS.
      3) Or equal.

B. PVC Conduit:
   1. Meet requirements of NEMA TC 3.
   2. Type: PVC, slip-on.
   3. Coupling to be longline slip with center stop.

C. PVC-Coated Rigid Steel Conduit:
   1. Meet requirements of UL 514B.
   2. Fittings: Rigid steel type, PVC coated by conduit manufacturer.
   3. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC coated by conduit manufacturer.
   5. Overlapping pressure-sealing sleeves.
   7. Manufacturer- PVC Coating field-patching material.
   8. Manufacturers:
      a. Robroy Industries.
      b. Thomas & Betts Ocal.
      c. Or equal.
   9. Manufacturer - Expansion Fitting:
      a. Thomas & Betts Ocal; OCAL-BLUE XJG.
      b. Robroy Industries.
      c. Or equal.
D. Flexible Metal, Liquid-Tight Conduit:

1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.

2. Insulated throat and sealing O-rings.

3. Manufacturers and Products:
   a. Thomas & Betts; Series 5331.
   b. O-Z/Gedney; Series 4Q.
   c. Or equal.

E. Flexible Metal, Nonliquid-Tight Conduit:

1. Meet requirements of UL 514B.

2. Body: Galvanized steel or malleable iron.

3. Throat: Nylon insulated.

4. 1-1/4-Inch Conduit and Smaller: One screw body.

5. 1-1/2-Inch Conduit and Larger: Two screw body.

6. Manufacturer and Product:
   a. Appleton; Series 7400.
   b. Cooper Crouse Hinds.
   c. Or equal.

F. EMT Fittings (When EMT conduit use is approved by FMD)

1. To match manufacturer of conduit.

2. Steel electro-galvanized, compression type only. Listed for wet locations when installed in wet or damp locations.

3. Strut straps to be two-part clamp type with ¼ x 20 bolts and hex nut.

G. Watertight Entrance Seal Device:

1. New Construction or cored application below ground:
   a. Material: Link Seal and sleeve or, oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
   b. Manufacturer and Product:
      1) O-Z/Gedney: Type FSK or Type WSK, as required.
      2) Cooper Crouse Hinds Link Seal with Type “C” bolts, and Steel Sleeve from same manufacturer.
      3) Or equal.
2. Cored-Hole Application, above ground:
   b. Manufacturer and Product:
      1) O-Z/Gedney; Series CSM.
      2) Appleton.
      3) Or equal.

2.3 SURFACE METAL RACEWAY

A. General:
   1. Meet requirements of UL 5.
   3. Finish: Factory applied rust inhibiting primer and gray semi-gloss finish suitable for field painting.

B. Fittings and Accessories:
   1. Wire clips at 30 inches on center.
   2. Couplings, cover clips, supporting clips, ground clamps, and elbows as required; to comply with manufacturer’s recommendations.

C. Outlets:
   1. Provide bracket or device covers as required to support wiring devices indicated.
   2. Wiring Devices and Device Plates: In accordance with Section 26 27 26, Wiring Devices.
   3. Manufacturers:
      a. The Wiremold Co.
      b. Walker.
      c. Or equal.
2.4 JUNCTION AND PULL BOXES

A. Conduit Bodies Used as Junction Boxes: As specified under Article Fittings.

B. Large Sheet Steel Box:
   1. NEMA 250, Type 1.
   3. Cover: Full access, screw type.

C. Large Cast Metal Box:
   1. NEMA 250, Type 4.
   2. Box: Cast malleable or cast iron, electro galvanized finished, with drilled and tapped conduit entrances and exterior mounting lugs.
   3. Cover: Non-hinged with screws.
   5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
   6. Manufacturers and Products, Surface Mounted Non-hinged Type:
      a. Cooper Crouse Hinds; Series W.
      b. O-Z/Gedney; Series Y.
      c. Erickson Electrical Equipment Co.
      d. Hubbell Inc.
      e. Thomas & Betts Corporation.
      f. Wiremold/Legrand.
      g. Or equal.
   7. Manufacturer and Product, Surface Mounted, Hinged Type:
      a. O-Z/Gedney; Series YW.
      b. Cooper Crouse Hinds.
      c. Erickson Electrical Equipment Co.
      d. Hubbell Inc.
      e. Thomas & Betts Corporation.
      f. Wiremold/Legrand.
      g. Or equal.
8. Manufacturers and Products, Recessed Type:
   a. Cooper Crouse Hinds; Type WJBF.
   b. O-Z/Gedney; Series YR.
   c. Erickson Electrical Equipment Co.
   d. Hubbell Inc.
   e. Thomas & Betts Corporation.
   f. Wiremold/Legrand.
   g. Or equal.

D. Large Steel Box:
   1. NEMA 250 Type 12 or Type 3R as shown.
   2. Box: 12-gauge steel, with white enamel painted interior and gray primed exterior, over phosphated surfaces. Provide gray finish as approved by the Authority.
   3. Cover: Hinged with bolts or clamps.
   5. Manufacturers:
      b. Robroy Industries.
      c. Wiegman.
      d. Or equal.

E. Concrete Box, Nontraffic Areas:
   1. Box: Reinforced, cast concrete with extension.
   2. Cover: Steel diamond plate with locking bolts.
   4. Size: 10 inches by 17 inches, minimum.
   5. Manufacturers and Products:
      b. Christy, Concrete Products, Inc.; N9.
      c. Quazite; “PG” Style.
      d. Or equal.
2.5 TERMINAL JUNCTION BOX

A. Cover: Hinged, unless otherwise shown.

B. Interior Finish: Paint with white enamel or lacquer.

C. Terminal Blocks:
   1. Separate connection point for each conductor entering or leaving box.
   2. Spare Terminal Points: 20 percent, minimum.

2.6 CABINETS

A. NEMA 250, Type 3R galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.

B. Hinged door in front cover with flush latch and concealed hinge.

C. Key latch to match panelboards.

D. Metal barriers to separate wiring of different systems and voltage.

E. Accessory feet where required for freestanding equipment.

2.7 METAL WIREWAYS

A. Meet requirements of UL 870.

B. Type: Steel-enclosed, lay-in type.

C. Cover: Hinged with friction latch.

D. Rating: Indoor or Outdoor rain tight as shown.

E. Finish: Rust inhibiting phosphatizing primer and gray baked enamel.

F. Hardware: Plated to prevent corrosion; screws installed toward the inside protected by spring nuts or otherwise guarded to prevent wire insulation damage.

G. Knockouts: Without knockouts, unless otherwise indicated.

H. Manufacturers:
   1. Square D.
   2. Hoffman.
   3. Circle AW.
   4. Or equal.
2.8 CABLE TRAYS

A. Meet requirements of NEMA VE 1.
B. Type: Ladder, Ventilated channel of welded construction.
C. Material: Copper-free aluminum alloy 6063 T6 finish.
D. Dimensions: 12 inches minimum wide, with 3 inch NEMA nominal inside fill depth and fittings with 12 inch bending radius to facilitate routing of fiber-optic, low voltage signal, low voltage AC and low voltage DC cables and conductors in SDIA “Vault” Building.
E. Cover: None.
F. Barrier Strip: Vertical, solid type, with horizontal fittings and strip clamps.
G. Fittings of same material as cross-sectional tray area and hardware of same material as cable tray.
H. Tray Grounding: Conform to CEC and NEMA VE 1.
I. Provide next higher NEMA VE 1 class designation than required for support of designed span length.
J. Design Loads: Use working load adequate for actual cable installed plus 10 percent additional weight allowance for future cables plus 200 pound concentrated static load applied between side rails at mid-span with safety factor of 2 in accordance with NEMA VE 1, Table 3 1.
K. Provide cable tray with no sharp edges, burrs, or weld projections.
L. Warning Signs: 1 ½-inch high black lettering on yellow background with legend, “WARNING, NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL.”
M. Manufacturers:
   1. B Line Systems, Inc.
   2. Square D.
   4. T. J. Cope, Inc.
   5. Or equal.
2.9 PRECAST CONCRETE MANHOLES AND HANDHOLES

A. Concrete Strength: Minimum, 6,000 psi compressive, in 28 days where located in proximity to aprons, taxiways, and runways.

B. ASTM A615 grade 60 epoxy coated rebar shall be used in all precast concrete manholes and handholes.

C. Loading: Aircraft Rated Manholes shall be capable of supporting a dual trolley with 100,000 lbs. wheel load where located in proximity to aprons, taxiways, and runways per FAA AC 150/5370-10, item D-751 and FAA AC 150/5370-6 Appendix 3.

D. Concrete Strength: Minimum, 3600 psi compressive, in 28 days, in roadways where not located in proximity to aprons, taxiways, and runways.

E. Loading: Traffic Rated AASHTO, M306 in accordance with ASTM C857 where not located in proximity to aprons, taxiways, and runways.

F. Concrete Strength: Minimum 3000 psi compressive, in 28 days, where not in roadways or subject to vehicle traffic.

G. Loading: Traffic Rated AASHTO, H-20 in accordance with ASTM C857 where not located in roadways or subject to vehicle traffic.

H. Man access way for manholes shall be in the center of the interior dimensions, round in shape and be a minimum of 30" diameter.

I. Access: Provide pre-cast concrete necking in 6-inch or 12-inch sections between top of manhole and finished grade at required elevations.

J. Standard interior dimension for primary loop vaults is 6’W x 7’H x 12’L. If necessary, a smaller vault may be substituted when encumbrances prevent the installation of this size vault, but only with written permission from the Authority.

K. Embedded Pulling Iron:

1. Material: 3/4-inch-diameter grade 60 smooth stock, fastened with standard hooks and lap splice to overall steel reinforcement before concrete is placed.

2. Location:
   a. Wall: Opposite each group of raceway entrances.
   b. Floor: Centered below manhole or handhole cover.
L. Cable Racks: Glass reinforced polymer.
   1. Non-metallic, embed components fabricated from non-conductive, fiberglass reinforced polymer.
   2. Non-metallic Arms: Adjustable, of sufficient number to accommodate cables for each raceway entering or leaving manhole, including spares.
   3. Wall Attachment:
      a. Embedded inserts, in pre-cast concrete walls, must allow adjustability of rack arms. Bolts or embedded studs not permitted.
      b. Insert Spacing: Maximum 3 feet on center for inside perimeter of manhole.
      c. Arrange in order that spare raceway ends are clear for future cable installation. Arrange sufficient for cabling per raceway openings.

M. Manhole Frames and Covers:
   1. Material: Machined cast iron.
   2. Diameter: 36-inch diameter frame with 30-inch diameter man access.
   3. Frame: Machined lip for cover seat. Weld frame to rebar in necking and bond rebar in necking to vault lid rebar.
   4. Permanently installed ladder at man access.
   5. Cover Loading: Aircraft Loading 125 KIPS rated.
   6. Cover Designation: Cast, on upper side, in integral letters, minimum 2 inches in height, appropriate titles:
      a. Above 600 Volts: ELECTRIC HV and IDENTIFICATION (reference drawings).
      b. 600 Volts and Below: ELECTRIC LV and SCHEDULE IDENTIFICATION (reference Drawings).
      c. FIBER-OPTICS and IDENTIFICATION (reference Drawings).

N. Handhole Frames and Covers:
   1. Material: Steel, hot-dipped galvanized.
   2. Cover Type: Solid checkered diamond and nonskid design.
   3. Cover Loading: Aircraft Loading 125 KIPS rated where located in proximity to aprons, taxiways, and runways.
   4. Cover Loading: Traffic loading where not located in proximity to aprons, taxiways, and runways.
5. Cover Designation: Burn by welder, on upper side in integral letters, minimum 2 inches in height, appropriate titles:
   a. 600 Volts and Below: ELECTRIC LV and IDENTIFICATION (reference Drawings).
   b. FIBER-OPTIC and IDENTIFICATION (reference Drawings).

P. Hardware: Steel, hot-dip galvanized.

Q. Provide knockout for ground rod in each handhole and manhole adjacent to rebar ground.

R. Provide a 4-inch by 4-inch by ½ inch galvanized steel plate welded to the structural rebar, embedded flush with the vault floor at each corner of the vault floor, a maximum of six-inches away from any wall or edge. Plate to have a NC threaded x 3 or 4-inch long galvanized insert for ½ bolt, centered in the plate. Provide the same insert adjacent to the man ladder, at the floor, centered no more than 3-inches away from the ladder foot, for bonding purposes.

S. Manholes shall be provided in a top half and bottom half configuration as shown on the Contract documents. Each half shall have a minimum of two plates, the same as in the floor, welded to the rebar in the walls, located on the walls near opposite corners of the half’s so that when the half’s are mated the bonding plates will be adjacent to each other and to connect the rebar cages to the rebar ground plate adjacent to the knockout for the ground rod.

T. Manufacturers:
   2. Jensen Products, Inc.
   3. Concrete Conduit Co.
   4. Associated Concrete Products, Inc.
   5. Underground Devices Inc.
   6. Or equal.
2.10 SLEEVES

A. Wall sleeves:
   2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Non-Fire-Rated Gypsum Board Assemblies:
   1. Galvanized steel sheet, 0.239 inch (3-gauge) minimum thickness.
   2. Round tube closed with welded longitudinal joint, with tabs for screw fastening the sleeve to the gypsum board.

2.11 ACCESSORIES

A. Duct Bank Spacers:
   1. Modular Type:
      a. Nonmetallic, interlocking, for multiple conduit sizes.
      b. Suitable for all types of conduit.
      c. Manufacturers:
         1) Underground Device, Inc.
         2) Carlon.
         3) Or equal.

B. Identification Devices, Vault:
   1. Raceway Tags:
      b. Shape: Round.
      c. Raceway Designation: Pressure stamped, embossed, or engraved.
      d. Tags relying on adhesives or taped-on markers not permitted.

C. Underground Line Warning Tape: Reference 26 05 53 ELECTRICAL IDENTIFICATION:
   1. Manufacturers and Products:
      a. Panduit; Type HTDU.
      b. Reef Industries; Terra Tape.
      c. Or equal.
D. Raceway Coating: Clean and paint outdoor exposed raceways to match existing. Submit sample colors to the Authority for approval.

E. Heat Shrinkable Tubing:
   2. Semi-flexible with meltable adhesive inner liner.
   4. Manufacturers:
      a. Raychem.
      b. 3M Co.
      c. Or equal.

F. Solvent Cements and Adhesive Primers:
   1. VOC content of 51 and 550g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA method 24).
   2. Comply with the testing and product requirements of the California Department of Health Services, ‘Standard Practice of Volatile Organic Emissions from Various Sources Using Small Scale Environmental Chambers.’

G. Duct Sealing Compound: Non hardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 degrees. Capable of withstanding temperature of 300 degrees F without slump and adhering to clean surfaces of PVC, metallic conduits, as well as conduit coatings, concrete, masonry, cable sheaths, cable jackets, insulation materials and common metals.

H. Concrete Inserts: Steel or malleable iron, slotted support system units similar to ANSI/MSS-SP-58 Type 18.

I. Clamps for attachment to steel structural elements: complying with MSS-SP-58.

J. Through Bolts:
   1. Structural type, hex head, high strength, cold forged and heat treated.
   2. Comply with ASTM A325.
   3. Bolt grade and size to match structural calculations.

K. Toggle bolts: All steel springhead type with grade and size to match structural calculations.
L. Hanger Rods: Threaded steel with grade and size to match structural calculations.

M. Mechanical Expansion Anchors:
   1. Wedge type, stainless steel, for use in hardened Portland cement with tension, shear, and pullout capacities, appropriate for supported loads and building materials in which used, per seismic requirements.
   2. Manufacturers and Products:
      a. Cooper B-Line Inc.
      b. Empire Tool and Manufacturing Co, Inc.
      c. Or equal approved by the Authority.

PART 3 EXECUTION

3.1 GENERAL

A. Conduit sizes shown are based on use of copper or aluminum conductors Section 26 05 05.

B. Comply with NECA Installation Standards.

C. Crushed or deformed raceways not permitted.

D. Maintain raceway entirely free of obstructions and moisture.

E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

F. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

G. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

H. Group raceways installed in same area.

I. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.

J. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

K. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.

L. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.

M. Install watertight fittings in outdoor, underground, or wet locations.
N. Paint threads and cut ends, before assembly of fittings, galvanized conduit, and PVC-coated conduit in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.

O. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.

P. Do not install raceways in concrete equipment pads, foundations, or beams without written approval by the Authority.

Q. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.

R. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.

S. Install conduits for fiber optic cables, telephone cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.

3.2 REUSE OF EXISTING CONDUITS

A. Where Drawings indicate existing conduits may be reused, they may be reused only where they meet the following criteria.

1. Conduit is in useable condition with no deformation, corrosion, or damage to interior or exterior surface.

2. Conduit is sized per the CEC.

3. Conduit is of the type specified in Documents.

4. Conduit is supported as specified in Contract Documents.

B. Conduit shall be reamed with wire brush, then with a mandrel approximately 95 percent of inner diameter and length as approved by the Authority, then cleaned prior to pulling new conductors.

3.3 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

A. Minimum Cover: 3 inches, including fittings.

B. Conduit placement shall not require changes in reinforcing steel location or configuration.

C. Provide nonmetallic support during placement of concrete to ensure raceways remain in position.

D. Conduit larger than 1 inch shall not be embedded in concrete walls, foundations, columns, or beams unless approved by the Authority in writing.
E. Slabs and Walls (Requires written approval by the Authority):

1. Trade size of conduit not to exceed one-fourth of slab or wall thickness.
2. Install within middle two-fourths of slab or wall.
3. Separate conduit less than 2-inch trade size by a minimum ten times conduit trade size, center-to-center, unless otherwise shown.
4. Separate conduit 2-inch and greater trade size by a minimum eight times conduit trade size, center-to-center, unless otherwise shown.
5. Cross conduit at an angle greater than 45 degrees, with minimum separation of 1 inch.
6. Separate conduit by a minimum six times the outside dimension of expansion/deflection fittings at expansion joints.
7. Conduit shall not be installed below the maximum water surface elevation in walls of water holding structures.

F. Columns and Beams (Requires written approval by the Authority):

1. Trade size of conduit not to exceed one-fourth of beam thickness.
2. Conduit cross-sectional area not to exceed 4 percent of beam or column cross section.

3.4 CONDUIT APPLICATION


B. Exterior, Exposed:

1. Rigid galvanized steel.
2. PVC-coated rigid galvanized steel.

C. Interior, Exposed:

1. Rigid galvanized steel.
2. PVC-coated rigid galvanized steel.

D. Interior, Concealed (Not Embedded in Concrete): Rigid galvanized steel, or EMT (if approved in writing by the Authority) if not exposed to physical damage.

E. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors: Rigid galvanized steel.
F. Direct Earth Burial:
   1. PVC Schedule 40.
   2. PVC-coated rigid galvanized steel.

G. Concrete-Encased Ductbank:
   1. PVC Schedule 40.

H. Under Slabs-On-Grade:
   1. PVC Schedule 40.
   2. PVC-coated rigid galvanized steel.

I. Transition from Underground or Concrete Embedded to Exposed: PVC-coated rigid steel conduit.


K. Hazardous Gas Areas: Rigid galvanized steel.

3.5 FLEXIBLE CONNECTIONS

A. For dry type transformers, and instrumentation, and other locations approved by the Authority where flexible connection is required to minimize vibration:
   3. Wet or Corrosive Areas: Flexible metal liquid-tight.

B. Outdoor Areas, Process Areas Exposed to Moisture, and Areas required to be Oil-tight and Dust-Tight: Flexible metal, liquid-tight conduit.

C. Flexible Conduit Length: 18 inches minimum, 60 inches maximum; sufficient to allow movement or adjustment of equipment.
3.6 PENETRATIONS

A. Make at right angles, unless otherwise shown.

B. Notching or penetration of structural members, including footings and beams, not permitted.

C. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating as specified in Section 26 05 04, Basic Electrical Materials and Methods.

D. Use PVC coated rigid steel conduit when protruding through concrete floor slabs-on-grade to a point 2 inches above surface, min.

E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide non-shrink grout dry-pack, or use watertight seal device.

F. Entering Structures:
   1. General: Seal raceway at first box or outlet with oakum, expandable plastic compound or Raychem RDSS system to prevent entrance of gases or liquids from one area to another.
   2. Concrete Roof or Membrane Waterproofed Wall or Floor:
      a. Provide a watertight seal.
      b. Without Concrete Encasement: Install watertight entrance seal device on each side.
      c. With Concrete Encasement: Install watertight entrance seal device on accessible side.
      d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
      e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.
   3. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
   4. Non-waterproofed Wall or Floor (Underground, without Concrete Encasement):
      a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
      b. Use Link Seal device with type “C” bolts.
   5. Non-Fire Rated Gypsum Board Assemblies:
      a. Use circular metal sleeves.
      b. Seal space outside of sleeves with approved by the Authority joint compound for gypsum board assemblies.
6. Manholes and Handholes:
   c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.
   d. Apply waterproofing to exterior surface of handholes and manholes after ducts have been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars.
   e. Seal conduits 2” and larger, against water intrusion, after final conductor installation activities with Raychem RDSS system.

3.7 SUPPORT

A. Support from structural members only, at intervals not exceeding CEC requirements. Do not exceed 10 feet in any application. Do not support from piping, pipe supports, or other raceways.

B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 10 percent extra space for future conduit.

C. Application/Type of Conduit Strap:
   1. Rigid Steel Conduit: Zinc coated steel, pre-galvanized steel or malleable iron.
   2. PVC-Coated Rigid Steel Conduit: PVC-coated metal.

D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:
   1. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts. Do not use for anchorage to light weight aggregate concrete or for slabs less than 4 inches thick.
   2. Existing concrete: Expansion anchor fasteners.
   3. Wood: Lag screws or through bolts.
   4. Masonry: approved by the Authority, toggle type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   5. Steelwork: Machine screws or beam clamps.
   7. Location/Type of Hardware:
      a. Dry, Noncorrosive Areas: Stainless Steel.
      b. Wet, Noncorrosive Areas: Stainless steel.
      c. Corrosive Areas: Stainless steel.
E. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

3.8 BENDS

A. Install concealed raceways with a minimum of bends in the shortest practical distance.

B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.

C. Install with symmetrical bends or cast metal fittings.

D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine.

E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.

F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.

G. PVC Conduit:
   1. Provide factory-made elbows with long radius standard bends with the following minimum radii:
      a. One to six-inch diameter conduit radius is 48 inches.
      b. Four to six-inch diameter conduit horizontal radius is 25 feet.
      c. Box and blanket heaters for 1” and smaller diameter conduits.
   2. Segment horizontal bends shall be multiples of 11.25 degrees. No single bend shall be greater than 90 degrees.
   3. No deflection allowed in joints.

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.9 EXPANSION/DEFLECTION FITTINGS

A. Provide on raceways at structural expansion joints and in long tangential runs.

B. Provide expansion/deflection joints 25 degrees F maximum temperature variation.

C. Install in accordance with manufacturer’s instructions.
3.10 PVC CONDUIT

A. Solvent Welding:
   1. Apply manufacturer recommended solvent to joints.

B. Adapters:
   1. PVC to Metallic Fittings: PVC terminal type, solvent welded to PVC conduit.
   2. PVC to Rigid Metal Conduit: PVC female adapter.

C. Bellend-End Conduit: Bevel unbelled end of joint prior to joining with standard solvent welding coupling.

D. Where terminating at a box or transitioning to metallic conduit above grade, concealed, use a female PVC Sch. 40 adapter only. Transition from PVC fitting to box is to be made with a chase nipple.

3.11 PVC-COATED RIGID STEEL CONDUIT

A. Install in accordance with manufacturer’s instructions.

B. Tools and equipment used in cutting, bending, threading and installation of PVC-coated rigid conduit shall be designed to limit damage to PVC coating.

C. Provide PVC boot to cover exposed threading, standard on fittings.

D. Use manufacturer supplied PVC repair material where coating is marred or scarred.

E. Terminal adapters used correctly are acceptable.

3.12 WIREWAYS

A. Install in accordance with manufacturer’s instructions.

B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.

C. Applications:
   1. Metal wireway in indoor dry locations.
   2. Nonmetallic wireway in indoor wet, outdoor, and corrosive locations.
### 3.13 CABLE TRAYS

A. Install in accordance with NEMA VE 2.

B. Install accessories as necessary for complete system.

C. Install in order that joints are not made at support brackets.

D. Install horizontal section support brackets between support point and quarter point of tray span.

E. Provide ceiling trapeze for horizontal cable tray or other NEMA VE 2 support approved in writing by the Authority.

F. Provide expansion joints in accordance with NEMA VE 2 for 25 degrees F maximum temperature variation. Install support within 2 feet on each side of expansion joints and within 2 feet of fitting extremity.

G. Install horizontal tray level, plumb, straight, and true to line or grade within a tolerance of 1/8 inch in 10 feet and within a cumulative maximum of 1/2 inch.

H. Install vertical tray plumb within a tolerance of 1/8 inch in 10 feet.

I. Install without exposed raw edges.

J. Maintain 12-inch vertical separation between multi-tiered trays having a common support, and at crossover locations.

K. Provide bonding jumper at each expansion joint and adjustable connection.

L. Ground Conductor: Provide properly sized clamps for each section, elbow, tee, cross, and reducer.

### 3.14 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Install manufacturer’s pre-molded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Nonmetallic, Cabinets, and Enclosures:

1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.

2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.
C. Sheet Metal Boxes, Cabinets, and Enclosures:

1. General:
   a. Install insulated bushing on ends of conduit where grounding is not required.
   b. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
   c. Utilize sealing locknuts or threaded hubs on sides and bottom of NEMA 3R and NEMA 12 enclosures.
   d. Terminate conduits at threaded hubs at the tops of NEMA 3R and NEMA 12 boxes and enclosures.
   e. Terminate conduits at threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.

2. Rigid Galvanized Conduit:
   a. Provide one lock nut each on inside and outside of enclosure.
   b. Install grounding bushing at all conduit entrances.
   c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.

3. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.

4. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.

5. PVC Schedule 40 Conduit: Provide PVC Female adapter with chase nipple, except where threaded hubs required above use Female adapter with galvanized steel close nipple.

6. All field cuts to be 90° square and reamed free of burrs.

D. Pad Mounted Switchgear, Switchboard, Switchgear, and Free-Standing Enclosures:

1. Terminate metal conduit entering bottom with grounding bushing; provide grounding jumper extending to equipment ground bus or grounding pad.

2. Terminate PVC conduit entering bottom with bell end fittings.

3.15 UNDERGROUND RACEWAYS

A. Grade: Follow specific grade as shown on Contract Drawings.

B. Cover: Maintain minimum 3-foot cover above conduit as measured from the finished surface, unless otherwise shown.
C. Make vertical routing changes as necessary to avoid obstructions or conflicts. All changes horizontal and vertical shall be recorded on as-built sets of Drawings and shall be approved by the Authority in writing prior to construction.

D. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.

E. Union type fittings, underground, not permitted.

F. Spacers:
   1. Provide preformed, nonmetallic spacers designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.
   2. Install at intervals not greater than that specified in CEC for support of the type conduit used, but in no case greater than 10 feet.

G. Support conduit to prevent bending or displacement during backfilling or concrete placement.

H. Transition from Underground to Exposed: PVC-coated rigid steel conduit.

I. Installation with Other Piping Systems:
   1. Crossings: Maintain minimum 12-inch vertical separation measured from concrete encasement to edge of other Utility.
   2. Parallel Runs: Maintain minimum 12-inch separation.
   3. Installation over valves or couplings of other utilities is not permitted.

J. Provide expansion fittings that allow minimum of 4 inches of movement in vertical conduit runs from underground where exposed conduit will be fastened to or will enter building or structure.

K. Provide expansion/deflection fittings in conduit runs that exit building or structure below grade. Conduit from building wall to nearest transition fitting shall be PVC-coated rigid steel.

L. Concrete Encasement:
   1. As specified in Section 03 30 00, Cast-in-Place Concrete. Min. 3-inch cover on all sides.
   2. Concrete Color: Red.
M. Backfill:

1. As specified in Section 31 23 23.15, Trench Backfill. Controlled low strength fill material as shown on Drawings. Backfill material to within 12 inches of surface.

2. Do not backfill until inspected by Engineer, the Authority.

3.16 UNDER SLAB RACEWAYS

A. Make routing changes as necessary to avoid obstructions or conflicts.

B. Support raceways so as to prevent bending or displacement during backfilling or concrete placement.

C. Install raceways with no part (other than vertical) embedded within slab and with no interference with slab on grade construction.

D. Raceway spacing, in a single layer or multiple layers:
   1. 3 inches clear between adjacent 2-inch and larger raceway.
   2. 2 inches clear between adjacent 1-1/2-inch and smaller raceway.

E. Multiple Layers of Raceways: Install under slab on grade in trench below backfill zone, as specified in Section 31 23 23.15, Trench Backfill.

F. Individual Raceways and Single Layer Multiple Raceways: Install at lowest elevation of backfill zone with spacing as specified herein. Where conduits cross at perpendicular orientation, installation of conduits shall not interfere with placement of under slab fill that meets compaction and void limitations of earthwork specifications.

G. Under slab raceways that emerge from below slab to top of slab as exposed, shall be located to avoid conflicts with structural slab rebar. Coordinate raceway stub ups with location of structural rebar.

H. Fittings:
   1. Union type fittings are not permitted.
   2. Provide expansion/deflection fittings in raceway runs where required.
   3. Couplings: In multiple raceway runs, stagger so couplings in adjacent runs are not in same traverse line.
3.17  JUNCTION AND PULL BOXES

A.  General:
   1.  Install plumb and level.
   2.  Installed boxes shall be accessible.
   3.  Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
   4.  Use conduit bodies as pull boxes where no splices are required and allowed by applicable codes.
   5.  Install pull boxes where necessary in raceway system to facilitate conductor installation
   6.  Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
   7.  Install in conduit runs at least every 150 feet or after the equivalent of three quarter bends, max. (270°).
   8.  Every 100 feet or 180 degrees for communication conduits.

B.  Flush Mounted:
   1.  Install with concealed conduit.
   2.  Holes in surrounding surface shall be no larger than required to receive box.
   3.  Make edges of boxes flush with final surface.

C.  Mounting Hardware:
   1.  Noncorrosive Dry Areas: Stainless steel.
D. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.

2. Install bar hangers in frame construction or fasten boxes directly as follows:
   Wood: Wood screws.
   Concrete or Brick: Bolts and expansion shields.
   Hollow Masonry Units: Toggle bolts.
   Steelwork: Machine screws.

3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

4. Boxes embedded in concrete or masonry need not be additionally supported.

5. At or Below Grade:

6. Install boxes for below grade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.

7. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.

8. Obtain Engineer’s written acceptance prior to installation in paved areas, roadways, or walkways.

9. Use boxes and covers suitable to support anticipated weights.

10. Install Drain/breather fittings in NEMA 250 Type 4 and Type 4X enclosures.

3.18 MANHOLES AND HANDHOLES

A. Excavate, shore, brace, backfill, and finish grade in accordance with Section 31 23 16, Excavation, and Section 31 23 23.15, Trench Backfill.

B. Do not install until final raceway grades has been determined.

C. Install such that raceway enters at nearly right angle and as near as possible to end of wall, unless otherwise shown.

D. Grounding: As specified in Section 26 05 26, Grounding and Bonding for Electrical Systems.
E. Identification: Field stamp covers with manhole or handhole number as shown. Stamped numbers to be 1-inch minimum height.

F. 500 feet maximum distance between 12kV manhole.

G. ATO: Vault to be installed under ATO.

3.19 EMPTY RACEWAYS

A. Provide permanent, removable cap over each end.

B. Provide PVC plug with pull tab for underground raceways with end bells.

C. Provide 100 lb rated nylon pull cord (to be used to pull-in pull-rope, pull-cable).

D. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.20 IDENTIFICATION DEVICES

A. Raceway Tags:
   1. Identify origin and destination and Schedule identifications designations.
   2. For exposed raceways, install tags at each terminus, near midpoint, and at minimum intervals of every 50 feet, whether in ceiling space or surface mounted.
   3. Install tags at each terminus for concealed raceways.
   4. Provide nylon strap for attachment.

B. Warning Tape: Install approximately 18 inches above underground or concrete-encased raceways in planter or no-pavement areas and at pavements section boundary at the bottom of the base layer in paved areas. Align parallel to, and within 12 inches of, centerline of run. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches overall.

3.21 IDENTIFICATION COLORS

A. The Contractor shall follow SDIA Conduit Color Code Chart labeling Standards as shown in table below, unless otherwise noted.

B. At each location where color coding is required, Contractor shall submit a written plan showing conduits to be color coded, with sample colors, for approval by the Authority prior to application.
C. The conduit color code shall be applied with highly visible paint or tape to visible conduits or portions thereof, with any enclosure door closed. Color stripe application shall match the length and coverage of existing color marking.

D. Conduits stubbed inside of outdoor equipment (ATO’s, Transformers, Switchgear, Switchboards, etc.) shall not be color coded. They shall be permanently tagged as required in this Section, Drawings, and Cable Schedules.

3.22 FIELD QUALITY CONTROL

A. Demonstrate capability and compliance with requirements on completion of installation of raceway and boxes.

B. For all work, pull solid aluminum or wood test mandrel through underground raceways to prove integrity and adequate bend radii, and as a test for deformed raceways. Provide a minimum 6-inch long mandrel equal to 95 percent of the raceway opening. Remove obstructions found or replace deformed sections and retest. Spot repairs are not allowed, if conduits found to be deformed then the section of conduits from bell to coupling shall be replaced.

C. Conduit alignment and connection at manholes and handholes shall match as-built Drawings and conduit labels.

3.23 PROTECTION OF INSTALLED WORK

A. Protect products from effects of moisture, corrosion, and physical damage during construction.

B. Provide and maintain manufactured watertight and dust-tight seals over conduit openings during construction.

C. Touch up painted conduit threads after assembly to cover nicks or scars.

D. Touch up coating damage to PVCcoated conduit with patching compound approved by manufacturer. Compound shall be kept refrigerated according to manufacturers’ instructions until time of use.
<table>
<thead>
<tr>
<th>Color</th>
<th>Code</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown</td>
<td>HVAC</td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td>277/480V</td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td>with white stripes</td>
<td>Lighting Control</td>
</tr>
<tr>
<td>Orange</td>
<td>EMERGENCY/UPS</td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td>with blue stripes</td>
<td>Emergency 120/208V</td>
</tr>
<tr>
<td>Orange</td>
<td>with yellow stripes</td>
<td>Emergency 277/480V</td>
</tr>
<tr>
<td>Pink</td>
<td>ACS/SECURITY</td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>FIRE ALARM</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>TELEPHONE/DATA/DAS</td>
<td></td>
</tr>
<tr>
<td>Yellow/Black</td>
<td>12KV</td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td>120/208V</td>
<td></td>
</tr>
<tr>
<td>Purple</td>
<td>LOADING BRIDGE</td>
<td></td>
</tr>
<tr>
<td>Gray</td>
<td>FIDS/RIDS/BIDS/VISUAL DISPLAY</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>PAGING/PA/Intercom</td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td>GROUND</td>
<td></td>
</tr>
</tbody>
</table>

Raceways over 600V have black letters in an orange field.

END OF SECTION 26 05 33
PART 1  GENERAL

1.1  REFERENCES – add all from spec here, including 26 05 02

A.  American National Standards Institute (ANSI)
    1.  Z535.4, Product Safety Signs and Labels
    2.  13.1 Standard for Identification of Pipes

B.  Fed/OSHA 1910.145
C.  California Electrical Code (CEC)
D.  NFPA 70E

1.2  SUMMARY

A.  This Section includes the following:

    1.  Identification for raceway and boxes.
    2.  Identification for conductors and communication and control cable.
    4.  Warning labels and signs.
    5.  Instruction signs.
    7.  Miscellaneous identification products.

1.3  SUBMITTALS

A.  Product Data: Submit manufacturer catalog cut sheets 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: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.
1.4 QUALITY ASSURANCE

A. Comply with ANSI/ASME A13.1 and ANSI/IEEE C2, NEMA Z535.4
B. Comply with CEC.

1.5 COORDINATION

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

2.1 RACEWAY AND BOXES

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
B. Color for Printed Legend:
   1. Power Circuits: Reference 2.7 B.
C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather - and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
D. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.
2.4 CONDUCTOR AND COMMUNICATION AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

B. Sleeves:
   1. Permanent PVC, yellow or white, with legible machine printed black markings.
   2. Manufacturers and products:
      a. Raychem; type D-SCE or ZH-SCE
      b. Brady; type 3PS
      c. Or equal.

C. Write-On Tags: Polyester tag, 0.015 inch thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
   1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

D. Medium voltage cable tag: laminated Micrata type, 5" x 3½", nameplates engraved with 5/32-inch high black letters on white background for normal power and red letters on white background for emergency power.

E. Provide tags on Mule Tape of spare conduits showing starting point and end point of spare conduits.

2.3 UNDERGROUND-LINE WARNING TAPE

A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.

   1. Not less than 6 inches wide by 4 mils thick. Color coded for electric lines (red) and for communication lines (orange).
   2. Warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall be “CAUTION - BURIED ELECTRIC (or COMMUNICATION) LINE BELOW”, or similar wording.
   3. Compounded for permanent direct-burial service. Code and letter coloring shall be permanent, unaffected by moisture and other substances contained in trench backfill material.
   4. Embedded continuous metallic strip or core.
2.4 WARNING LABELS AND SIGNS


B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

C. Metal-Backed, Butyrate Warning Signs: For all outdoor equipment. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 10 by 14 inches.

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: For equipment which may require servicing while energized: (Example Language) "WARNING – OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR XX INCHES." (For required distances (XX), reference CEC Article 110 Section II and III).
   3. High Voltage Equipment Warning "DANGER - HIGH VOLTAGE – KEEP OUT".
   4. Provide other warning labels and signs as required.
   5. Arc Flash Warning.

2.5 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.
   1. Engraved legend with black letters on white face.
   2. Punched or drilled for mechanical fasteners.
   3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
2.6 EQUIPMENT IDENTIFICATION LABELS

A. Equipment Identification: Engraved laminated-plastic nameplate mounted with corrosion-resistant screws.

B. Labels shall include the following information in minimum 1/4 inch letters, except designation which will be in 3/8 inch letters. Color of nameplate shall be black for equipment connected to normal power, red for equipment connected to emergency power, and orange for equipment connected to Uninterruptible Power Supply. Color of letters shall be white.

1. Equipment Type.
   Ex. TRANSFORMER, PANELBOARD, DISCONNECT, UNINTERRUPTED POWER SUPPLY, SWITCHBOARD...

2. Equipment Designation. (Made up of the following three components)
   Abbreviated Regional Location: CT, T1E, T1W, SC, AF, CUP, FMD...
   Abbreviated Equipment Type: UPS, XFMR, PNL, DISC...
   Unique Equipment Identifier: T-ESCLW, TSA SERVER, SCLE3, XFMR T-LV1...
   Examples: FMD.DISC.XFMR T-LV1; FMD.PNL.P-HP1; SC.XFMR.T-ESCLW...

3. Rating: Volt, Amps, No. of phase and wires, horsepower, etc.
   Ex. 480V 3 PH, 480/277V 3 PH 4 WIRE-208/120V 3 PH 4 WIRE, 208V 3 PH

4. Amperage, AIC Rating (RMS Symmetrical Amps) Fuse Size, Fuse Type.
   Ex. 125 AMP 22kA-AIC, 30 KVA, 60 AMP FUSES, TD-R

5. Fed from general information. Ex. FED FROM PANELBOARD

6. Fed from equipment designation. Ex. SC.SWBD.ESCHW

7. Date of Installation.
   Ex. INSTALLED OCT-2015

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TRANSFORMER
SC. XFMR.T-ESCLW
480V 3 PH -208/120V 3 PH 4 WIRE
30 KVA
FED FROM SWITCHBOARD
SC. SWBD. ESCHW
INSTALLED FEB. 1999
TRANSFORMER SAMPLE

UNINTERRUPTED POWER SUPPLY
T1.UPS.TSA SERVER
277V
FED FROM PANELBOARD
T1.PNL.HT1E1
INSTALLED NOV. 2013

UPS SAMPLE

DANGER
ELECTRICAL SHOCK HAZARD-
equipment has multiple power
sources
LINE SIDE-T1.PNL.HT1E1
LOAD SIDE-BATTERIES

UPS MULTIPLE FEED DANGER SAMPLE

PANELBOARD
SC.PNL.SCLE3
208/120V 3 PHASE 4 WIRE
125 AMP 22kA-AIC
FED FROM PANELBOARD
SC.PNL.SCLE
INSTALLED OCT. 2015
C. For medium-voltage switchgear:
   1. Use 1 inch to identify equipment designation
   2. Use 3/4 inch to identify voltage rating and source
   3. Use 1/2 inch to identify individual feeder breakers and buckets
   4. Use 1/4 inch to identify control switches, indicating lights, and other miscellaneous devices on the bucket door.

D. Adhesive labels and nameplates are not acceptable.

2.7 WIRING DEVICES

A. Identify wiring devices with clear vinyl polyester tape with black lettering, red lettering for emergency power. Labels shall be printed, flexible, self-adhesive type. For stainless steel cover plates, engrave information on cover plate.

B. Receptacle label shall include panel designation and circuit number.
   1. Switch plates shall include panel designation and circuit number.

C. For receptacles other than 20A, 120V, labels shall include receptacle voltage, phase and amperage at top of receptacle and panel designation and circuit numbers at bottom of receptacles.
2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, UV-resistant Type 6/6 nylon cable ties.
   2. Tensile Strength: 50 lb, minimum.
   3. Temperature Range: Minus 40 to plus 185 deg F.

B. Fasteners for Labels and Signs: Self-tapping, stainless steel screws or stainless-steel machine screws with nuts and flat and lock washers.
   Switch plates shall include panel designation and circuit #.

PART 3 EXECUTION

3.1 APPLICATION – See Section 26 05 33 for raceway color scheme. Refer to:
   Color Code – Electrical Conduits and Boxes

A. Raceways and Duct Banks More Than 600 V Concealed within Buildings:
   Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch high black letters on 20-inch centers.

B. Accessible Raceways More Than 600 V: Identify with "DANGER-HIGH VOLTAGE" in black letters at least 2 inches high, with self-adhesive vinyl labels. Repeat legend at 10-foot maximum intervals.

C. Accessible Raceways, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 50A: Identify with orange self-adhesive vinyl label showing voltage.

D. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands:
   1. Fire Alarm System: Red.
   5. Mechanical and Electrical Supervisory System: Green and blue.
   7. Control Wiring: Green and red.

E. Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in indoor pull and junction boxes, use color coding conductor tape and marker tape unless otherwise noted. Ref. 2.2 B in this Section. Every conductor shall be identified in every j-box. Every j-box shall have the circuit info on the interior and on the cover.

F. For conductors in underground vaults, manholes, and handholes Ref. 2.2 D, this section. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.
G. Branch-Circuit Conductor Identification: Where more than three branch circuits in same junction or pull box are allowed, use marker tape. Identify each ungrounded conductor according to source and circuit number.

H. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source and circuit number.

   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.

J. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for cables in raceway.

K. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. 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 CEC: Unless otherwise indicated, apply to door or cover of equipment.

L. 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- high letters for emergency instructions at equipment used for power transfer and load shedding.
M. 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.

1. Labeling Instructions:
   a. Equipment: Engraved, laminated plastic, screwed on type. Unless otherwise indicated, provide a single line of text 1-1/2-inch high label; where 2 lines of text are required, use labels 2 inches high. Nameplates for switchboards, transformers, MCC, panel boards shall be minimum of 2-inch high by 4-inch wide.
   b. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

2. 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. Battery racks.
   q. Power-generating units.
   r. Voice and data cable terminal equipment.
   s. Master clock and program equipment.
   t. Intercommunication and call system master and staff stations.
   u. Television/audio components, racks, and controls.
   v. Fire-alarm control panel and annunciators.
   w. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
   x. Monitoring and control equipment.
   y. Uninterruptible power supply equipment.
   z. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.
3.2 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. Use only where permitted.

E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

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 maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for feeder and branch-circuit conductors. Ref. 26 05 05.

1. Colors for 208/120-V Circuits:
   a. Phase A: Black
   b. Phase B: Red
   c. Phase C: Blue
   d. Neutral: White
   e. Ground: Green

2. Colors for 480/277-V Circuits:
   a. Phase A: Brown
   b. Phase B: Orange
   c. Phase C: Yellow
   d. Neutral: Grey
   e. Ground: Green

3. When dedicated neutrals are provided, use color spiral to match associated phase.

H. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 12 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall. Ref 26 05 33.

END OF SECTION 26 05 53
PART 1    GENERAL

1.1 REFERENCES

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

1. ASTM International (ASTM):
   c. D924, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
   c. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.

2. Institute of Electrical and Electronics Engineers (IEEE):
   a. 43, Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
   b. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminators Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5kV through 500kV.
   d. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
   e. 95, Recommended Practice for Insulation Testing of AC Electric Machinery (2300V and Above) with High Direct Voltage.
f. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
h. 450, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
k. C37.20.2, Standard for Metal-Clad Switchgear.
l. C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear.
m. C37.23, Standard for Metal-Enclosed Bus.

3. Insulated Cable Engineers Association (ICEA):
b. S-94-649, Concentric Neutral Cables Rated 5 through 46 kV.
c. S-97-682, Standard for Utility Shielded Power Cables Rated 5 through 46 kV.

4. National Electrical Manufacturers Association (NEMA):
a. AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
b. PB 2, Deadfront Distribution Switchboards.
c. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.


a. 70B, Recommended Practice for Electrical Equipment Maintenance.
b. 70E, Standard for Electrical Safety in the Workplace.


10. Association of Edison Illuminating Companies (AEIC) Cable Engineering Committee CS8: Specification for Extruded Dielectric Shielded Power Cables Rated 5 through 46 kV.

1.2 SUBMITTALS

A. Informational Submittals:

1. 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.

2. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test; Submit test reports of any failed items with 48 hours of the test.

3. Operation and Maintenance Data:
   a. In accordance with Section 1D – Special Conditions, Article 1D-51 Project Closeout.
   b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual. Reference Section 1D-Special Conditions, Article 1D-51 Project Closeout and Article 1D-12 Certificates of Compliance.

4. Programmable Settings: At completion of Performance Demonstration Test, submit final hardcopy printout and electronic files on compact disc of as-left setpoints, programs, and device configuration files for:
   a. Protective relays.
   b. Intelligent overload relays.
   c. Power metering devices.
   d. Uninterruptible power supplies.
   e. Electrical communications modules.

1.3 QUALITY ASSURANCE

A. Testing Firm Qualifications:

1. Corporately and financially independent organization functioning as an unbiased testing authority.

2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.

3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.
4. Supervising engineer accredited as Certified Electrical Test Technologist by NICET or NETA and having a minimum of 5 years’ testing experience on similar projects.

5. Technicians certified by NICET or NETA.

6. Assistants and apprentices assigned to Project at ratio not to exceed two certified to one noncertified assistant or apprentice.

7. Registered Professional Engineer to provide comprehensive Project report outlining services performed, results of such services, recommendations, actions taken, and opinions.

8. In compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories or a full member company of NETA.

   B. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.

   C. Test instrument calibration shall be in accordance with NETA ATS.

1.4 SEQUENCING AND SCHEDULING

   A. Perform inspection and electrical tests after equipment listed herein has been installed.

   B. Perform tests with apparatus de-energized whenever feasible.

   C. Inspection and electrical tests on energized equipment shall be:

      1. Notify Engineer and the Authority at least 48 hours prior to performing tests on energized electrical equipment.

      2. Scheduled with Engineer and the Authority prior to de-energization.

      3. Minimized to avoid extended period of interruption to the operating plant equipment.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

   GENERAL

   A. Perform tests in coordination with requirements of Section 1D – Special Conditions, Article 1D-14 Contractor Coordination with Others and this section.
B. Tests and inspections shall establish:

1. Electrical equipment is operational within industry and manufacturer’s tolerances and standards.

2. Installation operates properly.

3. Equipment is suitable for energization.


C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer’s recommendations.

D. Set and test protective relays, circuit breakers, fuses, power monitoring meters, and other applicable devices in accordance with values established by short circuit, and coordination studies as specified in Section 26 05 70, Electrical Systems Analysis. Coordinate all tests with Power System SCADA Integrator (PSS) as identified under Section 26 09 14 Power System Supervisory Control and Data Acquisition (SCADA). All final settings and calibrations shall be performed under Section 26 09 14 Power System Supervisory Control and Data Acquisition (SCADA).

E. Adjust mechanisms and moving parts of equipment for free mechanical movement.

F. Coordinate settings for electromechanical, electronic relays and sensors to correspond with operating conditions, or as recommended by manufacturer. Final settings shall be performed under Section 26 09 14 Power System Supervisory Control and Data Acquisition (SCADA).

G. Verify nameplate data for conformance to Contract Documents and the Authority approved Submittals.

H. Realign equipment not properly aligned or level.

I. Properly anchor electrical equipment found to be inadequately anchored.

J. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer’s recommendations, or as otherwise specified in NETA ATS.

K. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

L. Provide proper lubrication of applicable moving parts.

M. Inform Engineer and THE AUTHORITY of working clearances not in accordance with CEC.
N. Investigate and repair or replace:
   1. Electrical items that fail tests.
   2. Active components not operating in accordance with manufacturer’s instructions.
   3. Damaged electrical equipment.

O. Electrical Enclosures:
   1. Remove foreign material and moisture from enclosure interior.
   2. Vacuum and wipe clean enclosure interior.
   3. Remove corrosion found on metal surfaces.
   4. Repair or replace, as determined by Engineer and the Authority door and panel sections having dented surfaces.
   5. Repair or replace, as determined by Engineer and the Authority poor fitting doors and panel sections.
   6. Repair or replace improperly operating latching, locking, or interlocking devices.
   7. Replace missing or damaged hardware.
   8. Finish:
      a. Provide matching paint and touch up scratches and mars.
      b. If required due to extensive damage, as determined by Engineer and the Authority refinish entire assembly.

P. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or the Authority approved Submittals.

Q. Transformer Dielectric Fluid: Recondition or replace insulating liquid if required per test results on liquid sample.

### 3.2 CHECKOUT AND STARTUP

A. Voltage Field Test:
   1. Check voltage at point of termination of power company and individual pad mounted switchgear (ATO) location supply system to Project when installation is essentially complete and is in operation.
   2. Check voltage level and phase rotation at secondary terminals of all transformers.
3. Check voltage amplitude and balance between phases for loaded and unloaded conditions.

4. Record supply voltage (all three phases simultaneously on same graph) for 24 hours during normal working day. Submit Voltage Field Test Report within 5 days of test.

5. Unbalance Corrections:
   a. Make written report to the Authority to provide notification of condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 3 percent of nominal.

3.3 SWITCHGEAR AND SWITCHBOARD ASSEMBLIES

A. Visual and Mechanical Inspection:

1. Insulator damage and contaminated surfaces.

2. Proper barrier and shutter installation and operation.

3. Proper operation of indicating devices.

4. Improper blockage of air-cooling passages.

5. Proper operation of drawout elements.

6. Integrity and contamination of bus insulation system.

7. Check door and device interlocking system by:
   a. Closure attempt of device when door is in OFF or OPEN position.
   b. Opening attempt of door when device is in ON or CLOSE position.

8. Check key interlocking systems for:
   a. Key captivity when device is in ON or CLOSED position.
   b. Key removal when device is in ON or CLOSED position.
   c. Closure attempt of device when key has been removed.
   d. Correct number of keys in relationship to number of lock cylinders.
   c. Existence of other keys capable of operating lock cylinders: Destroy duplicate sets of keys.
9. Check nameplates for proper identification of:
   a. Equipment title and tag number with latest one-line diagram.
   b. Pushbutton.
   c. Test and Isolation Switches.
   d. Control switch.
   e. Pilot light.
   f. Control relay.
   g. Protective Device (Vacuum Breaker, Circuit breaker, Load Interrupter).
   h. Indicating meter.
   i. Power Distribution Equipment: Transformers, Switchgear,
   j. Panelboards, Switchboards, and Primary Junctions.

10. Verify fuse and circuit breaker ratings, sizes, and types conform to those specified.

11. Check bus and cable connections for high resistance by low resistance ohmmeter applied to bolted joints. Ohmic value to be zero.

12. 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.

13. Verify performance of each control device and feature.

14. Control Wiring:
   a. Compare wiring to local and remote control and protective devices with elementary diagrams.
   b. Proper conductor lacing and bundling.
   c. Proper conductor identification.
   d. Proper conductor lugs and connections.

15. Exercise active components.

16. Perform phasing check on double-ended equipment to ensure proper bus phasing from each source.
B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. With switches and breakers open.
   e. With switches and breakers closed.
   f. Control wiring except that connected to solid state components.
   g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

2. Overpotential Tests:
   a. Applied ac or dc voltage and test procedure in accordance with: IEEE C37.20.1, C37.20.2, C37.20.3 and NEMA PB 2. Or Alternatively use NETA ATS, Table 100.2.
   b. Each phase of each bus section. Phase-to-phase and phase-to-ground for 1 minute.
   Test results evaluated on a pass/fail basis.

3. Current Injection Tests:
   a. For entire current circuit in each section.
   b. Secondary injection for current flow of 1 ampere.
   c. Test current at each device.

4. Control Wiring:
   a. Apply secondary voltage to control power and potential circuits.
   b. Check voltage levels at each point on terminal boards and each device terminal.

5. Operational Test:
   a. Initiate control devices.
   b. Check proper operation of control system in each section.

3.4 PANEL BOARDS

A. Visual and Mechanical Inspection: Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.

2. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer’s instruction manual.
3. Check panelboard mounting, area clearances, and alignment and fit of components.

4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer’s instructions for proper torque values.

5. Perform visual and mechanical inspection for overcurrent protective devices.

B. Electrical Tests: Include the following items performed in accordance with manufacturer’s instruction:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. With breakers open.
   e. With breakers closed.
   f. Control wiring except that connected to solid state components.
   g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

2. Ground continuity test ground bus to system ground.

3.5 DRY TYPE TRANSFORMERS

B. Visual and Mechanical Inspection:

1. Physical and insulator damage.

2. Proper winding connections.

3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.

4. Defective wiring.

5. Proper operation of fans, indicators, and auxiliary devices.

6. Removal of shipping brackets, fixtures, or bracing.

7. Free and properly installed resilient mounts.

8. Cleanliness and improper blockage of ventilation passages.

9. Verify tap-changer is set at correct ratio for rated output voltage under normal operating conditions.

10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.
C. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied 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.

2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.

3.6 LIQUID FILLED TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage.
2. Proper winding connections.
3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Effective core and equipment grounding.
7. Removal of shipping brackets, fixtures, or bracing.
8. Tank leaks and proper liquid level.
9. Integrity and contamination of bus insulation system.
10. Verify tap-changer is set at correct ratio for rated voltage under normal operating conditions.
11. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading. otherwise specified by manufacturer.
B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied 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.

2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.

3. 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.
   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.

3.7 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed power cable No. 6 and larger for:
   a. Physical damage.
   b. Proper connections in accordance with single-line diagram.
   c. Cable bends not in conformance with manufacturer’s minimum allowable bending radius where applicable.
   d. Color coding conformance with specification.
   e. Proper circuit identification.
2. Mechanical Connections for:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.

3. Shielded Instrumentation Cables for:
   a. Proper shield grounding.
   b. Proper terminations.
   c. Proper circuit identification.

4. Control Cables for:
   a. Proper termination.
   b. Proper circuit identification.

5. Cables Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 6 and Larger:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohmmeter for 600-volt insulated conductors.
   b. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
   c. Evaluate ohmic values by comparison with conductors of same length and type.
   d. Investigate values less than 50 megohms.

2. Continuity test by ohmmeter method to ensure proper cable connections

3.8 MEDIUM-VOLTAGE CABLES, 15 KV MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed cable for:
   a. Physical damage plus jacket and insulation condition.
   b. Proper connections in accordance with single-line diagram or the Authority approved Submittals.
   c. Proper shield grounding.
   d. Proper cable support.
   e. Proper cable termination.
   f. Cable bends not in conformance with manufacturer's minimum allowable bending radius.
   g. Proper arc and fireproofing in common cable areas.
   h. Proper circuit and phase identification.
2. Mechanical Connections:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Conductor Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturers.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 5,000-volt megohmmeter for 15 kV conductors.
   b. Test each cable individually with remaining cables and shields grounded.
   c. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
   d. Evaluate ohmic values by comparison with conductors of same length and type.
   e. Investigate values less than 50 megohms.

2. Shield Continuity Tests:
   a. By ohmmeter method on each section of conductor.
   b. Investigate values in excess of 10 ohms per 1,000 feet of conductors.

3. Acceptance Tests:
   b. Each conductor section tested with:
      1) Splices and terminations in place but disconnected from equipment.
      2) Remaining conductors and shields grounded in accordance with IEEE 400.
   c. Apply maximum test voltage per NETA ATS, Table 100.6, based on method (DC, AC, PD or VLF) used.
   d. Measure only leakage current associated with conductor.
   e. Utilize guard ring or field reduction sphere to suppress corona at disconnected terminations.
   f. Maximum test voltage shall not exceed limits for terminators specified in IEEE 48, IEEE 386, or manufacturer’s specifications.
   g. Apply test voltage in a minimum of five equal increments until maximum acceptable test voltage is reached.
      1) Increments not to exceed ac voltage rating of conductor.
      2) Record dc leakage current at each step after a constant stabilization time consistent with system charging current.
h. 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.

i. Immediately following test, ground conductor for adequate time period to drain insulation stored charge.

j. Test results evaluated on a pass/fail basis.

4. New Conductors Spliced to Existing Conductors:
   a. Prior to performing splices, high potential dc test new conductor sections.
   b. After splicing new conductors to existing conductors, disconnect existing conductors and perform the following tests:
      1) Shield continuity test.
      2) Insulation resistance test.
      3) High potential test with test voltage not to exceed 60 percent of applied acceptance dc test voltage.

3.9 SAFETY SWITCHES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:
   1. Proper blade pressure and alignment.
   2. Proper operation of switch operating handle.
   3. Adequate mechanical support for each fuse.
   4. Proper contact-to-contact tightness between fuse clip and fuse.
   5. Cable connection bolt torque level in accordance with NETA ATS, Table 100.12.
   6. Proper phase barrier material and installation.
   7. Verify fuse sizes and types correspond to one-line diagram or the
   8. Authority approved Submittals.
   9. Perform mechanical operational test and verify electrical and mechanical interlocking system operation and sequencing.

B. Electrical Tests:
   1. Insulation Resistance Tests:
      a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
      b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
      c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

   2. Contact Resistance Tests:
      a. Contact resistance in microhms across each switch blade and fuse holder.
      b. Investigatedeviationof50percentormorefrom adjacent poles or similar switches.
3.10 MEDIUM-VOLTAGE LINE SWITCHES

A. Visual and Mechanical Inspection:
   1. Proper blade pressure, alignment, and arch interrupter operation.
   2. Proper operation of operating mechanism.
   3. Proper contact condition.
   4. Adequate mechanical support for each fuse.
   5. Proper contact-to-contact tightness between fuse clip and fuse.
   7. Proper phase barrier material and installation.
   8. Proper operation of indicating devices.
   9. Proper motor operation.
  10. Perform mechanical operational test to verify electrical and mechanical interlocking system operation and sequencing.
  11. Perform phasing check on double-ended air switch arrangements to ensure proper bus phasing from each source.

B. Electrical Tests:
  1. Insulation Resistance Tests:
     a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
     b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
     c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
  2. Contact Resistance Tests:
     a. Contact resistance in microhms across each switch blade and fuse holder.
     b. Investigate values exceeding 500 microhms or deviation of 50 percent or more from adjacent poles or similar switches.
  3. Overpotential Tests:
     a. Applied ac or dc voltage in accordance with NETA ATS, Table 100.19.
     b. Phase-to-phase and phase-to-ground for 1 minute.
     c. Test results evaluated on pass/fail basis.
3.11 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 100 amperes and larger.

B. Visual and Mechanical Inspection:

1. Proper mounting.
2. Proper conductor size.
3. Feeder designation according to nameplate and one-line diagram.
4. Cracked casings.
5. Connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Operate breaker to verify smooth operation.
7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers 500-volt dc megohmmeter for 240-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.

2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.

3. Primary Current Injection Test to Verify:
   a. Long-time minimum pickup and delay.
   b. Short-time pickup and delay.
   c. Ground fault pickup and delay.
   d. Instantaneous pickup by run-up or pulse method.
e. Trip characteristics of adjustable trip breakers shall be within manufacturer’s published time-current characteristic tolerance band, including adjustment factors.

f. Trip times shall be within limits established by NEMA AB 4, Table 5-3. Alternatively, use NETA ATS, Table 100.7.

g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4. Alternatively, use NETA ATS, Table 100.8.

3.12 LOW VOLTAGE POWER CIRCUIT BREAKERS

A. Visual and Mechanical Inspection:
   1. Proper mounting, cell fit, and element alignment.
   2. Proper operation of racking interlocks.
   3. Check for damaged arc chutes.
   4. Proper contact condition.
   5. Bolt torque level in accordance with NETA ATS, Table 100.12.
   6. Perform mechanical operational and contact alignment tests in accordance with manufacturer’s instructions.
   7. Check operation of closing and tripping functions of trip devices by activating ground fault relays, undervoltage shunt relays, and other auxiliary protective devices.
   8. Verify primary and secondary contact wipe, gap setting, and other dimensions vital to breaker operation are correct.
   9. Check charging motor, motor brushes, associated mechanism, and limit switches for proper operation and condition.
  10. Check operation of electrically operated breakers in accordance with manufacturer’s instructions.
  11. Check for adequate lubrication on contact, moving, and sliding surfaces.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.

3. Primary Current Injection Test to Verify:
   a. Long-time minimum pickup and delay.
   b. Short-time pickup and delay.
   c. Ground fault pickup and delay.
   d. Instantaneous pickup by run-up or pulse method.
   e. Trip characteristic when adjusted to setting sheet. parameters shall be within manufacturer's published time-current tolerance band.

3.13 MEDIUM-VOLTAGE VACUUM LOAD INTERRUPTERS

A. Visual and Mechanical Inspection:

1. Proper alignment.
2. Proper operation of mechanism.
3. Proper contact condition.
4. Bolt torque level in accordance with NETA ATS, Table 100.12.
5. Perform mechanical operator and contact alignment tests on load interrupter and its operating mechanism in accordance with manufacturer’s instructions.
6. Verify primary and secondary contact wipe, gap setting, and other dimensions vital to load interrupter operations are correct.
7. Ensure maintenance devices are available for servicing and operating load interrupter.
8. Check for proper SF6 gas levels and operation in main tank.
9. Check for adequate lubrication on contact, moving, and sliding parts.
10. With interrupter in TEST position:
    a. Trip and close interrupter with control switch.
    b. Trip interrupter by manually operating each protective relay.
11. Perform interrupter travel and velocity analysis in accordance with manufacturer’s instructions; values shall be in accordance with manufacturer’s acceptable limits.
B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 2,500-volt dc megohmmeter for 15-kV interrupters.
   b. Pole-to-pole and pole-to-ground with contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.

2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.

3. Overpotential Tests:
   a. Maximum applied ac or dc voltage in accordance with NETA ATS, Table 100.19.
   b. Each pole-to-ground with other poles grounded and contacts closed for 1 minute.
   c. Test results evaluated on pass/fail basis.

4. Minimum pickup voltage tests on trip and close solenoids.

5. Control Wiring Tests: Insulation resistance test at 1,000 volts dc on control wiring except that connected to solid state components. Insulation resistance to be 1 megohm minimum.

6. Power factor test on each phase with interrupter in both OPEN and CLOSED positions. Compare power factor and arc chute watt loss with adjacent poles or manufacturer’s published data.

7. Power factor test on each bushing utilizing conductive straps and hot collar procedures if bushings are not equipped with power factor tap. Power factor and capacitance test results within nameplate rating of bushings.

3.14 MEDIUM-VOLTAGE SWITCHGEAR MODIFICATIONS (VACUUM CIRCUIT BREAKER)

A. Visual and Mechanical Inspection:

1. Check for proper element alignment.

2. Check for proper operation of cubicle shutters and racking mechanism.

3. Bolt torque level in accordance with NETA ATS, Table 100.12.

4. Perform mechanical operational tests on breaker and its operating mechanism in accordance with manufacturer’s instructions, plus check:
   a. Pull rod adjustment.
b. Trip latch clearance.
c. Overtravel stops.
d. Wipe and gap setting.

5. Perform breaker travel and velocity analysis in accordance with manufacturer’s instructions; values shall be in accordance with manufacturer’s acceptable limits.

6. Check contact erosion indicators in accordance with manufacturer’s instructions.

7. With breaker in TEST position:
   a. Trip and close breaker with control switch.
   b. Trip breaker by manually operating each protective relay.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 2,500-volt dc megohmmeter for 15-kV circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.

2. Contact Resistance Tests:
   a. Between the line and load stab of closed contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.

3. Overpotential Tests:
   a. Maximum applied ac or dc voltage in accordance with NETA ATS, Table 100.19.
   b. Each pole-to-ground with other poles grounded and contacts closed for 1 minute.
   c. Test results evaluated on pass/fail basis.

4. Minimum pickup voltage tests on trip and close coils.

5. Control Wiring Tests:
   a. Insulation resistance test at 1,000-volt dc on control wiring, except that connected to solid state components.
   b. Insulation resistance to be 1 megohm minimum.

6. Vacuum bottle overpotential integrity test across each vacuum bottle with breaker in OPEN position, in accordance with manufacturer’s instructions.
7. Power Factor Test (Each Phase):
   a. With breaker in both OPEN and CLOSED position.
   b. Compare power factor and arc chute watt loss with adjacent poles or manufacturer’s published data.

8. Power Factor Test (Each Bushing):
   a. Utilize conductive straps and hot collar procedures if bushings are not equipped with power factor tap.
   b. Power factor and capacitance test results within nameplate rating of bushings.

### 3.15 PROTECTIVE RELAYS

A. Visual and Mechanical Inspection:

1. Visually check each relay for:
   a. Proper mounting.
   b. Damaged faceplate and covers.
   c. Overall condition, wiring, and proper lug terminations.

2. Verify each relay:
   a. Complies with Contract Documents, the Authority approved Submittal, and application.
   b. Is set in accordance with recommended settings from Coordination Study and information provided by the Authority.

B. Electrical Tests:

1. Insulation resistance test on each circuit to frame, except for solid state devices.

2. Test on nominal recommended setting for:
   a. Pickup parameters on each operating element.
   b. Timing at three points on time-current curve.
   c. Pickup target and seal-in units.
   d. Special tests as required to check operation of restraint, directional, and other elements in accordance with manufacturer’s instruction manual.

3. Phase angle and magnitude contribution tests on differential and directional relays after energization to vectorially verify proper polarity and connections.

4. Current Injection Tests:
   a. For entire current circuit in each section.
   b. Secondary injection for current flow of 1 ampere.
   c. Test current at each device.
3.16 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Visually check current, potential, and control transformers for:
   a. Cracked insulation.
   b. Broken leads or defective wiring.
   c. Proper connections.
   d. Adequate clearances between primary and secondary circuit wiring.

2. Verify mechanically:
   a. Grounding and shorting connections have good contact.
   b. Withdrawal mechanism and grounding operation, when applicable, operate properly.

3. Verify proper primary and secondary fuse sizes for potential transformers.

B. Electrical Tests:

1. Current Transformer Tests:
   a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts dc for 30 seconds.
   b. Polarity test.
   c. Ratio and Accuracy Test

2. 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.
   c. Ratio and Accuracy test.

3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 100.5.

3.17 METERING

A. Visual and Mechanical Inspection:

1. Verify meter connections in accordance with appropriate diagrams.

2. Verify meter multipliers.

3. Verify meter types and scales conform to Contract Documents.

4. Check calibration of meters at cardinal points.
5. Check calibration of electrical transducers.

3.18 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in medium voltage switchgear, low voltage panelboard switchboard, and switchgear assemblies for proper connection and tightness.

2. Ground bus connections in medium voltage switchgear, low voltage panelboard switchboard, and switchgear assemblies for proper termination and tightness.

3. Effective transformer core and equipment grounding.

4. Accessible connections to grounding electrodes for proper fit and tightness.

5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:

1. Fall-of-Potential Test:
   a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system’s resistance.
   b. Main ground electrode system resistance to ground to be no greater than: 5 ohm(s).

2. Two-Point Direct Method Test:
   a. 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.
   b. Equipment ground resistance shall not exceed main ground system resistance by 0.50 ohm.

3. Neutral Bus Isolation:
   a. Test each neutral bus individually with neutral bonding jumper removed at service entrance or separately derived system.
   b. Evaluate ohmic values by measuring resistance between ground bus and neutral bus.
   c. Investigate values less than 50 megohms.
3.19 GROUND FAULT SYSTEMS

A. Inspection and testing limited to:

1. Zero sequence grounding systems.
2. Residual ground fault systems.

B. Visual and Manual Inspection:

1. Neutral main bonding connection to ensure:
   a. Zero sequence sensing system is grounded ahead of neutral disconnect link.
   b. Ground strap sensing system is grounded through sensing device.
   c. Neutral ground conductor is solidly grounded.

2. Verify control power has adequate capacity for system.

3. Manually operate monitor panels for:
   a. Trip test.
   b. No trip test.
   c. Nonautomatic rest.

4. Zero sequence system for symmetrical alignment of core balance transformers about current carrying conductors.

5. Relay check for pickup and time under simulated ground fault conditions.

6. Verify nameplate identification by device operation.

C. Electrical Tests:

1. Test system neutral insulation resistance with neutral ground link removed; minimum 1 megohm.

2. Determine relay pickup by primary current injection at the sensor. Relay pickup current within plus or minus 10 percent of device dial or fixed setting.

3. Test relay timing by injecting 300 percent of pick-up current or as specified by manufacturer. Relay operating time in accordance with manufacturer’s time-current characteristic curves.

4. Test system operation at 55 percent rated control voltage, if applicable.

5. Test zone interlock system by simultaneous sensor current injection and monitoring zone blocking functions.
3.20 AUTOMATIC TRANSFER SWITCHES

A. Visual and Mechanical Inspection:

1. Check doors and panels for proper interlocking.

2. Check connections for high resistance by low-resistance ohmmeter.

3. Check positive mechanical and electrical interlock between normal and alternate sources.

4. Check for proper operation:
   b. Generator under load and non-load conditions.
   c. Auto-exerciser of generator under load and no-load conditions.

5. Verify settings and operation of control devices.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1, for each phase with switch CLOSED in both source positions.
   b. Phase-to-phase and phase-to-ground for 1 minute.
   c. Test values in accordance with manufacturer’s published data.

2. Contact Resistance Test:
   a. Contact resistance in microhms across each switch blade for both source positions.
   b. Investigate values exceeding 500 micro-ohms.
   c. Investigate values deviating from adjacent pole by more than 50 percent.

3. Set and calibrate in accordance with Specifications, manufacturer’s recommendations, and Coordination Study or information provided by the Authority.
   a. Voltage and frequency sensing relays.
   b. Time delay relays.
   c. Engine start and shutdown relays.

4. Perform automatic transfer tests by:
   a. Simulating loss of normal power.
   b. Return to normal power.
   c. Simulating loss of alternate power.
   d. Simulating single-phase conditions for normal and alternate sources.
5. Monitor and verify operation and timing of:
   a. Normal and alternate voltage sensing relays.
   b. Engine-start sequence.
   c. Timing delay upon transfer and retransfer.
   d. Engine cool down and shutdown.
   e. Interlocks and limit switch functions.
   f. Engine cool down and shutdown feature.

3.21 BATTERY SYSTEM

A. Visual and Mechanical Inspection:
   1. Physical damage and electrolyte leakage.
   2. Evidence of corrosion.
   3. Intercell bus link integrity.
   4. Battery cable insulation damage and contaminated surfaces.
   5. Operating conditions of ventilating equipment.
   6. Visual check of electrolyte level.

B. Electrical Tests:
   1. Measure:
      a. Bank charging voltage.
      b. Individual cell voltage.
      c. Electrolyte specific gravity in each cell.
      d. Measured test values to be in accordance with manufacturer’s published data.
   2. Verify during recharge mode:
      a. Charging rates from charger.
      b. Individual cell acceptance of charge.
   3. Load tests for integrity and capacity; test values in accordance with IEEE 450.
3.22  LOW VOLTAGE SURGE ARRESTORS

A.  Visual and Mechanical Inspection:

1.  Adequate clearances between arrestors and enclosures.
2.  Ground connections to ground bus.

B.  Electrical Tests:

1.  Varistor Type Arrestors:
   a.  Clamping voltage test.
   b.  Rated RMS voltage test.
   c.  Rated dc voltage test.
   d.  Varistor arrestor test values in accordance with IEEE C62.33, Section 4.4 and Section 4.9.

3.23  MEDIUM-VOLTAGE SURGE ARRESTORS AND SURGE CAPACITORS

A.  Visual Inspection:

1.  Ground connections to ground bus.
2.  Shortest practical jumper connections to line.

B.  Electrical Tests:

1.  Grounding electrode resistance test in accordance with IEEE 81, Section 8.2.1.5 using three-point fall-of-potential method.
2.  Insulation power factor.
3.  Insulation resistance.
4.  RF noise test using Stoddart noise test set with applied voltage of 1.18 times maximum continuous operating voltage.
5.  Insulation power factor leakage current, watts loss, and insulation resistance test in accordance with manufacturer’s test values. RIV value not to exceed 10 microvolts above background noise.
6.  Leakage current and watts loss tests.

3.24  POWER FACTOR CORRECTION CAPACITORS

A.  Visual and Mechanical Inspection:

1.  Verify capacitors are connected in proper configuration.
2.  For units switched with motors, verify capacitor rating does not exceed motor nameplate maximum allowable value.
B. Electrical Tests:

1. Insulation resistance, each pole-to-case and pole-to-ground; values in accordance with manufacturer’s recommendation.

2. Capacitance for pole-to-pole combinations; ratings differing more than plus 15 percent, minus 0 percent from manufacturer’s values shall be replaced.

3. Resistance of internal discharge arrestors with analog volt-ohmmeter; resistance to be in excess of 2 megohms.

3.25 THERMOGRAPHIC SURVEY

A. Provide thermographic survey per NETA ATS Table 100.18 of connections associated with incoming service conductors, cable and conductor terminations, bus work and branch circuit conductors No. 4 and larger at each:

1. Medium and low voltage switchgear.

2. Switchboards.

3. Unit substation.

4. Panelboard.

5. All splice points.

B. Provide thermographic survey of feeder conductors No. 4 and larger terminating at:

1. Transformers; dry-type or liquid filled.

2. Medium and low voltage disconnect switches.

3. Transfer switches.

4. Medium and Low Voltage Switchgear.

5. Switchboards.

6. Capacitor Banks.

C. Remove necessary enclosure metal panels and covers prior to performing survey.

D. Perform with equipment energized during periods of maximum possible loading per NFPA 70B, Section 20.17.
E. Do not perform survey on equipment operating at less than 20 percent of rated load. If plant load is insufficient, perform test with supplemental load bank producing rated load on item being measured.

F. Utilize thermographic equipment capable of:
   1. Detecting emitted radiation.
   2. Converting detected radiation to visual signal.
   3. Detecting 1 degree C temperature difference between subject area and reference point of 30 degrees C.

G. Temperature Gradients:
   1. 3 degrees C to 7 degrees C indicates possible deficiency that warrants investigation.
   2. 7 degrees C to 15 degrees C indicates deficiency that is to be corrected as time permits.
   3. 16 degrees C and above indicates deficiency that is to be corrected immediately.

H. Provide written report of:
   1. Areas surveyed and the resultant temperature gradients.
   2. Locations of areas having temperature gradients of 3 degrees C or greater.
   3. Cause of heat rise and actions taken to correct cause of heat rise.
   4. Detected phase unbalance.

I. Thermographic windows shall be added to all, transformer, panelboards and switchboards. They shall be added so as to view:
   1. All connection points.

END OF SECTION 26 08 00
PART 1  GENERAL

1.1  SUMMARY

A. This section covers existing elements of the 12KV control system and requirements for additions to the San Diego International Airport (SDIA) Power Measurement and Control, is included for reference, and is in addition to General Requirements of Section 26 09 14, Power System Supervisory Control and Data Acquisition (SCADA).

B. Overview:

1. Provide all work in accordance with the California Electrical Code (CEC): Material and equipment shall be labeled or listed by a nationally recognized testing laboratory or another testing agency acceptable to the Authority, in order to provide a basis for approval under the CEC.

2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. and or another The Authority Approved Testing Agency shall conform to those standards and shall have an applied listing mark or label.

1.2  REFERENCES

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


2. Institute for Electrical and Electronics Engineers, Inc. (IEEE):
   c. C57.13, Standard Requirements for Instrument Transformers.
   c. 60688, Electrical Measuring Transducers for Converting a.c. Electrical Quantities to Analogue or Digital Signals.
   e. 61850, Communication Network and Systems in Substations.


1.3 DEFINITIONS

A. ATO: Automatic Throw-over.

B. CT: Current Transformer.

C. CPCR: Capacitor Protection and Control Relay.


E. LCD: Liquid Crystal Display.

F. LED: Light Emitting Diode.

G. MMFR: Main Management and Feeder Relay.

H. MPR: Motor Protection Relay.

I. PACR: Protection Automation and Bay Control System Relay.

J. PT: Potential Transformer.

K. RTD: Resistance Temperature Detectors.

L. RTAC: Real-time Automation Controller.

M. UCA: Utility Communications Architecture.

N. VT: Voltage Transformer.

O. Reference Section 26 09 14, Power System Supervisory Control and Data Acquisition (SCADA), for additional abbreviations and definitions.
1.4 SUBMITTALS

A. Action Submittals, submit to the Authority per contract:
   1. Instruction manuals for each type of device.
   2. Special features, licensed programming software.
   3. Potential and current transformer schematic diagrams, certified factory test report and performance curve(s).
   4. Control and metering schematic diagrams.
   5. Interconnection wiring diagrams.
   6. Installation and mounting requirements.
   7. Complete descriptive literature and renewal parts data.
   8. Application software (device programming) in accordance with Section 26 09 14, Power System Supervisory Control and Data Acquisition (SCADA), and Section 26 09 16, Power System Application Software.

B. Informational Submittals, submit to the Authority per contract: Operation and Maintenance Data as specified in Section 1D – Special Conditions, Article 1D-51 Project Closeout.

PART 2 PRODUCTS

2.1 SOURCE QUALITY CONTROL

A. Reference Section 26 09 14, Power System Supervisory Control and Data Acquisition (SCADA).

2.2 MAIN MANAGEMENT AND FEEDER RELAY (MMFR)

A. General: Existing 12kV Main Switchgear in Vault and Terminal 2 West Electrical Room incorporate main management, differential, and feeder management relaying consisting of mains – SEL-751A, GE-MIB, and SEL-735 relays control and test switches, jumpers, CTs, PTs and Feeder Power Quality Metering GE PQM II.
2.3 PROTECTION, AUTOMATION AND BAY CONTROL SYSTEM RELAY (PACR)

A. General: Rack mounted complete monitoring, bay control, reclosing, and breaker input failure protection, multiple operating devices (ATO line switches, ATO load interrupters, vacuum breakers, and ancillary discrete and analog inputs) for medium-voltage pad mounted switchgear (ATO) motorized line switches and load interrupters, and PV solar power applications. Required salient features are listed in Paragraphs B through L herein.

B. Protection features shall include:

1. High-Impedance Fault Detection (HIF): The relay shall include high-impedance fault detection algorithms capable of detecting HIF signatures without being affected by loads and other system operation conditions. The relay shall make high-impedance fault summary and history information available in ASCII format and up to 40 minutes of fault data shall be stored in COMTRADE format.

2. Voltage Protection (27/59): The relay shall provide over- and under voltage protection elements with selectable phase-, positive-, negative-, and zero-sequence voltage operating quantities.

3. Time-Overcurrent Fault Protection (51): The relay shall incorporate selectable operating quantity time-overcurrent elements. Torque control capability (internal and external) shall be provided.

4. Instantaneous Overcurrent (50): The relay shall provide instantaneous overcurrent elements with torque control and definite-time delay.

5. Directional Overcurrent Protection (67): The relay shall provide phase-, negative-sequence, and ground directional overcurrent elements with Best Choice Ground Directional Element® polarizing capabilities.

6. Breaker Failure Logic (50BF): The relay shall incorporate dual breaker failure logic for three-pole tripping and reclosing. Retrip and transfer trip initiate contacts shall be provided. Dropout time of the current detection circuit shall be less than one cycle, even in cases with residual dc current in the CT secondary.

7. Auto reclosing (79): The relay shall incorporate three-pole reclosing with four separately set open time intervals for reclosing. Separately set reset times from reclose cycle and from lockout shall be available. Reclosing shall be selectable for one or two breakers.
8. Synchronism Check (25): The relay shall include two synchronism check elements with separate maximum angle settings. The synchronism check function shall incorporate slip frequency, close angle settings, and allow different sources of synchronizing voltage (VA, VB, VC, VAB, VBC, and VCA).

9. Transformer Inrush Detection: The relay shall provide 2nd, 4th, and 5th harmonic detection elements for detecting transformer energization inrush conditions.

10. Integral and Independent Trip/Close Pushbuttons: The relay shall include integral and independently operated breaker trip/close switches and indicating lamps. The switches and breaker status lamps shall be functional regardless of the relay status.

C. Automation features shall include:

1. Programmable Logic: includes programmable logic functions for a wide range of user-configurable protection, monitoring, and control schemes. Logic shall have the ability to use bay elements, math functions, comparison functions, and Boolean logic functions.

2. Automation: The relay shall include 32 local control switches, 32 remote control switches, 32 latching switches, and programmable display messages in conjunction with a local display panel in the relay. The relay shall be capable of displaying custom messages. Input signals to the bay shall have settable assertion levels.

3. Alias Naming: The relay shall support the capability of providing unique name settings (aliases) for up to 200 different relay Boolean and analog quantities.

D. Communication and Integration features shall include:

1. Serial Communications: The relay shall include four independent EIA-232 serial ports for external communication.

2. Ethernet Communications: The relay shall include Ethernet communication capabilities, with failover, fixed and switched port modes.

3. Digital Relay-to-Relay Communications: The relay shall have send and receive logic elements, and analog and virtual terminal elements in each of two serial communications ports for dedicated relay-to-relay communication.

4. IEC 61850: The relay shall be capable of IEC 61850-compliant communication over Ethernet. The IEC 61850 capability shall include GOOSE messaging and defined logical node data points.
5. Distributed Network Protocol (DNP): The relay shall incorporate certified DNP3 Level 2 Outstation protocol and Ethernet DNP3 LAN/WAN communications capability.

6. Synchrophasors: The relay shall include operation as a phasor measurement unit (PMU) following the IEEE C37.118-2005 Standard for Synchrophasors for Power Systems.

7. IRIG-B Time Input: The relay shall include an interface port for either a standard or high-accuracy demodulated IRIG-B time-synchronization input signal.

8. High-Accuracy Timing: The relay shall time-tag event reports to an absolute accuracy of 10 µs. Relays at different system locations shall have the same absolute timing accuracy.

9. Web Server: The relay shall allow inspection of settings, metering reports, self-test reports, and configuration via a guaranteed read-only integrated web server.

10. Simple Network Time Protocol (SNTP): The relay shall be capable of synchronizing the internal timekeeping to a network time source.

11. Synchrophasors: The relay shall provide high-accuracy synchrophasor data that is compliant with the IEEE C37.118 synchrophasor data standard. The IEEE C37.118 synchrophasor data shall be supported on serial and Ethernet ports of the relay. The relay shall provide the capability to produce up to five PMU data configurations.

12. Password Protection: The relay shall have multilevel passwords to safeguard bay control, protection, and automation settings.

13. Parallel Redundancy Protocol (PRP): This protocol shall be used to provide seamless recovery from any single Ethernet network failure, in accordance with IEC 62439-3. The Ethernet network and all traffic shall be fully duplicated with both copies operating in parallel.

E. Operator interface features shall include:

1. HMI Display: The relay shall include custom configurable display information to display status, analog quantities with units, user-defined labels, and alarm information.

2. Bay Display: The bay control shall have the ability to display one-line bay diagrams on the front-panel display. The bay display shall be interactive to view the status and control of breakers and disconnect switches.
3. Operator Controls: The relay shall include operator control pushbuttons on the relay front panel. Each pushbutton shall be programmable and accessible in the bay control logic.

F. Monitoring and Reporting features shall include:

1. Fault Locator: The relay shall include a fault-locating algorithm to provide an accurate estimate of fault location without communications channels or special instrument transformers.

2. Event Reporting and Sequential Events Recorder (SER): The relay shall automatically record disturbance events of up to 3 seconds at 8 kHz sampling rate and 24 seconds at 1 kHz sampling rate. Events shall be stored in nonvolatile memory. The relay shall also include an SER that stores the latest 1000 entries.

3. Dual Circuit Breaker Monitor: The relay shall include a breaker wear monitor function for two circuit breakers with a programmable breaker monitor curve. Electrical and mechanical operating times, with comparison between last and average times, shall be monitored and reported.

4. Dual Battery Monitor: The relay shall measure and report the substation battery voltages both at steady-state and conditions during trip operations. Two sets of selectable threshold parameters shall be provided for alarm and control purposes at each battery voltage. DC ground detection for two systems shall be included.

5. Voltage Sag, Swell, and Interruption Reporting (VSSI): The relay shall support VSSI reporting. Fast (1/4 cycle), medium (1 cycle), slow (64 cycles) and daily recording rates shall be supported with 4 cycles of pre- and post-recording data. Settings shall be provided for VSSI trigger conditions.

G. Relay shall operate with wye-connected four wire) potential transformers, and three-phase, four-wire connected current transformers.

H. Control shall include high speed breaker failure detection for two (2) protective devices, manual close control, cold load pickup control, programmable logic inputs, two breaker control relay outputs, internal failure relay output, programmable relay outputs, solid state trip output, analog transducer input, and analog transducer outputs.
I. Relay shall provide complete monitoring and metering functions which shall include:

2. Voltage: Phase A-N (A-B) voltage, Phase B-N (B-C) voltage, Phase C-N (C-A) voltage.
3. Frequency.
4. Symmetrical components.
5. Three-phase power factor.
6. Three-phase real power.
7. Three-phase reactive power.
8. Three-phase apparent power.
9. Watt-hours.
10. Demand Measurement: Rolling demand, time interval, programmed to minutes. A fault locator with a record of last 10 faults.
11. Event Recorder: Record 1000 entries of data, time tagged.
12. Waveform Capture: Relay shall store up to 5 cycles of data, captured for the analog current and voltage inputs as well as digital data for output relays and input contact states. Amount of data to capture and trigger point shall be user configurable.
14. Latest Trip Report: Containing date and time, cause, phase, ground, sensitive ground, and neutral currents, line-line and line-ground voltages, neutral voltage, frequency, and analog Input.
15. Relay shall include an operation counter and accumulated interrupted currents per phase.
16. Relay shall have coil (trip/close) monitoring inputs for the detection of a failed circuit regardless of the breaker state.
J. Hardware Specifications:

1. AC Voltage Inputs: six (6) total 300V (L-N) continuous, 600Vac for 10 seconds.

2. AC Current Inputs: six (6) total 5 A nominal, 20 amps continuous, 500 amps for 1 second, 100 A symmetrical, 1250 amps for 1 cycle.


4. Expanded IO: 3 high interrupt outputs, 2 standard-speed Form A outputs, 3 standard-speed Form C outputs, and 7-settable assertion level inputs.

K. Software Specifications: Schweitzer Engineering Laboratories Inc.; Graphical Logic Editor (GLE) using AcSELerator Quick Set SEL-5030 Software.

L. User interfaces shall include:

1. Large 40-character display, navigation keys, and a keypad.

2. Indicator LEDs on front panel which shall provide a quick visual indication of status.

3. Rear panel three (3) - RS232 serial port that shall provide easy computer access.

4. Front panel one (1) – RS485 serial port that shall provide easy computer access.

5. Rear panel IRIG-B communication port.

6. Rear panel discrete input contacts:

7. Rear panel discrete output contacts:

8. Rear panel six (6) analog voltage inputs.

9. Rear panel six (6) analog current inputs.

10. Rear panel one (1) RJ45 Ethernet port to support Ethernet connectivity to local or wide area networks using IEC 61850 and DPN3 protocols and File Transfer Protocol (FTP) for high-speed data collection.

11. Relay shall be capable of being set by Windows-based, easy to use setup graphical terminal interface.
M. Manufacturers and Products: (Basis of Present system)


2. Or the Authority approved equal, (no known equal).

2.4 CAPACITOR PROTECTION AND CONTROL SYSTEM RELAY (CPCR)

A. General: Rack mounted complete monitoring, control and failure protection for medium voltage pad mounted capacitor bank applications. Required salient features are listed in Paragraphs B. through L. herein.

B. Protection shall include:

1. Application-Based Settings: The relay shall provide application-based settings that automatically select the preferred protection elements for a given capacitor bank configuration.

2. Settings Assistance Software: Settings assistance software shall be provided as an extension of the relay settings software. The settings assistance software shall automatically calculate voltage unbalance settings based upon capacitor bank configuration and nameplate ratings.

3. Faulted Phase and Section Identification: The relay shall provide the capability of identifying the phase and relative location (top/bottom, left/right) of faulty capacitor units in grounded and ungrounded capacitor bank applications.

4. Voltage Differential Protection: The relay shall provide three phase-voltage differential protection with null compensation. Null compensation is used to nullify any small voltage differential levels caused by measurement tolerances and/or slight variances in element capacitance due to manufacturing variances or environmental conditions. The voltage differential protection shall provide three levels of settings for alarm, trip, and catastrophic failure conditions.

5. Neutral-Voltage Differential Protection: The relay shall provide neutral-voltage differential protection with null compensation. The neutral-voltage differential element shall calculate zero-sequence voltage from three phase-voltage inputs to the relay, and measure differential voltage with respect to a neutral-voltage input. The neutral-voltage differential protection shall provide three levels of settings for alarm, trip, and catastrophic failure conditions.

6. Phase-Current Unbalance Protection: The relay shall provide phase-current unbalance protection with null compensation. The phase-current unbalance protection shall be capable of detecting as little as 20 mA of current unbalance on a 1 A CT secondary input. The phase-current unbalance protection shall provide three levels of settings for
7. Neutral-Current Unbalance Protection: The relay shall provide neutral-current unbalance protection with null compensation. The neutral-current unbalance protection shall be capable of detecting as little as 20 mA of current unbalance on a 1 A CT secondary input. The phase-current unbalance protection shall provide three levels of settings for alarm, trip, and catastrophic failure conditions.

8. Instantaneous Overcurrent Fault Protection: The relay shall provide overcurrent elements for phase, negative-sequence, and zero-sequence currents. The relay offers three levels of phase, negative-sequence, and zero-sequence overcurrent protection for the Terminal W current inputs. Torque control is provided for each element.

9. Time-Overcurrent Fault Protection: The relay shall incorporate selectable operating quantity time-overcurrent elements. Positive-sequence, negative-sequence, and zero-sequence currents shall be supported. Fundamental and rms shall be supported. Torque control capability (internal and external) shall be provided.

10. Voltage Protection Elements: The relay shall provide six over voltages and six under voltage elements with two level settings per element. Level 1 settings shall have definite-time delay capabilities. Input voltages to the elements shall be selectable from phase, zero-sequence, positive-sequence, negative-sequence, and maximum quantities. RMS and fundamental voltages shall be supported.

11. Frequency Protection Elements: The relay shall have six independent frequency elements with definite-time delay. The frequency elements shall have under voltage supervision inputs.

12. Breaker Failure Elements: The relay shall have breaker failure protection with flashover detection. Breaker failure protection shall operate using subsidence detection logic to minimize coordination time requirements of downstream devices.

13. Automatic Control: The relay shall be capable of providing three independent dead-band controllers. Each control shall be capable of either voltage, power factor, or VAR control. Each control function shall include instability (hunting) detection logic.

14. Time-of-Day Control: The Relay shall be capable of providing time of day/day of week control. The control shall allow on/off control logic for any day of the week, hour of the day, and minute of the hour.

15. Mimic Control. The mimic control shall have the ability to provide status and control for as many as eight disconnects and a single breaker.
16. Mimic Control Logic. The relay shall include programmable logic functions for a wide range of user-configurable protection, monitoring, and control schemes. Logic shall have the ability to use bay elements, math functions, comparison functions, and Boolean logic functions.

17. Independent Trip/Close Pushbuttons: The relay shall include independently operated breaker trip/close switches and indicating lamps. The switches and breaker status lamps shall be functional regardless of the relay status.

18. Real-Time Control with Synchrophasor Data: The relay shall be capable of providing real-time control using IEEE C37.118 synchrophasor data. This data shall be represented as analog quantities within the relay, available for use within SELOGIC equations.


C. Automation features shall include:

1. Automation: The relay shall include 32 local control switches, 32 remote control switches, 32 latching switches, and programmable display messages in conjunction with a local display panel in the relay. The relay shall be capable of displaying custom messages. Input signals to the bay shall have settable assertion levels.

D. Communication and Integration features shall include:

1. High-Accuracy Timing: The relay shall time-tag event reports to an absolute accuracy of 10 µs. Relays at different system locations shall have the same absolute timing accuracy.

2. Password Protection: The relay shall have multilevel passwords to safeguard relay, protection, and automation settings.

3. Digital Relay-to-Relay Communications: The relay shall have send and receive logic elements, and analog and virtual terminal elements in each of two communications ports for dedicated relay-to-relay communications.

4. IRIG-B Time Input: The relay shall include an interface port for either a standard or high-accuracy demodulated IRIG-B time-synchronization input signal.

5. Communications: The relay shall include four independent EIA-232 serial ports for external communications.
6. Synchrophasors: The relay shall include operation as a phasor measurement unit (PMU) following the IEEE C37.118-2005 Standard for Synchrophasors for Power Systems. The relay shall be capable of storing up to 120 seconds of IEEE C37.118 2005 binary data in nonvolatile memory.

7. IEC 61850: The relay shall provide IEC 61850-compliant communications. The IEC 61850 capability shall include GOOSE messaging and defined logical node data points.


E. Operator interface features shall include:

1. Configurable Labels: The relay shall include configurable labels to customize the targets and operator control pushbuttons.

2. Operator Controls. The relay shall include operator control pushbuttons on the relay front panel. Each pushbutton shall be programmable and accessible in the relay logic.

3. HMI Display: The relay shall include custom configurable display information to display status, analog quantities with units, user-defined labels, and alarm information.

F. Monitoring and Reporting features shall include:

1. Voltage Sag, Swell, Interruption Reporting (VSSI). VSSI reporting shall be supported. Fast (1/4 cycle), medium (1 cycle), slow (64 cycles) and daily recording rates shall be supported with 4 cycles of pre- and post-recording data. Settings shall be provided for VSSI trigger conditions.

2. Event Reporting and Sequential Events Recorder: The relay shall automatically record disturbance events of up to 3 seconds at 8 kHz sampling rate and 24 seconds at 1 kHz sampling rate. Events shall be stored in nonvolatile memory. The relay shall store at least five event reports at the maximum report length setting. The relay shall also include an SER that stores the latest 1000 entries.

3. Circuit Breaker Monitor: The relay shall include a breaker wear monitor function with a programmable breaker monitor curve. Electrical and mechanical operating times, with comparison between last and average times, shall be monitored and reported.
4. Battery Monitor: The relay shall measure and report the substation battery voltages both at steady-state conditions and during trip operations. Selectable threshold parameters shall be provided for alarm and control purposes. DC ground detection shall be included.

G. Relay shall operate with either wye-connected (four wire) or open-delta-connected (three-wire) potential transformers, and three-phase, four-wire connected current transformers.

H. Control shall include high speed breaker failure detection for protective devices, manual close control, cold load pickup control, programmable logic inputs, two breaker control relay outputs, internal failure relay output, programmable relay outputs, solid state trip output, analog transducer input, and analog transducer outputs.

I. Relay shall provide complete monitoring and metering functions which shall include:


2. Voltage: Phase A-N (A-B) voltage, Phase B-N (B-C) voltage, Phase C-N (C-A) voltage.

3. Frequency.

4. Symmetrical components.

5. Three-phase power factor.

6. Three-phase real power.

7. Three-phase reactive power.

8. Three-phase apparent power.

9. Demand Measurement: Rolling demand, time interval, programmed to minutes. A fault locator with a record of last 10 faults.

10. Event Recorder: Record 1000 entries of data and time tagged.

11. Waveform Capture: Relay shall store up to 5 cycles of data, captured for the analog current and voltage inputs as well as digital data for output relays and input contact states. Amount of data to capture and trigger point shall be user configurable.

12. Data logger.
13. Latest Trip Report: Containing date and time, cause, phase, ground, sensitive ground, and neutral currents, line-line and line-ground voltages, neutral voltage, frequency, and analog input.

14. Relay shall include an operation counter and accumulated interrupted currents per phase.

15. Relay shall have coil (trip/close) monitoring inputs for the detection of a failed circuit regardless of the breaker state.

J. Hardware Specifications:

1. AC Voltage Inputs: six (6) total 300V (L-N) continuous, 600Vac for 10 seconds.

2. AC Current Inputs: six (6) total 5 A nominal, 20 amps continuous, 500 amps for 1 second, 100 A symmetrical, 1250 amps for 1 cycle.


4. Expanded IO: 3 high interrupt outputs, 2 standard-speed Form A outputs, 3 standard-speed Form C outputs, and 7-settable assertion level inputs.

K. Software Specifications: Schweitzer Engineering Laboratories Inc.; Graphical Logic Editor (GLE) using AcSELerator Quick Set SEL-5030 Software.

L. User interfaces shall include:

1. Large 40-character display, navigation keys, and a keypad.

2. Indicator LEDs on front panel which shall provide a quick visual indication of status.

3. Rear panel three (3) - RS232 serial port that shall provide easy computer access.

4. Front panel one (1) – RS485 serial port that shall provide easy computer access.

5. Rear panel IRIG-B communication port.

6. Rear panel discrete input contacts.

7. Rear panel discrete output contacts.

8. Rear panel six (6) analog voltage inputs.

9. Rear panel six (6) analog current inputs.
10. Rear panel one (1) RJ45 Ethernet port to support Ethernet connectivity to local or wide area networks using IEC 61850 and DPN3 protocols and File Transfer Protocol (FTP) for high-speed data collection.

11. Relay shall be capable of being set by Windows-based, easy to use setup graphical terminal interface.

M. Manufacturers and Products: (Basis of Present System)


2. Schweitzer Engineering Laboratories Inc.; Model SEL-451 - Control Or equal, (no known equal).

2.5 REMOTE INPUT-OUTPUT MODULE (RIO)

A. General: Programmable assembly used for equipment monitoring and control by emulating functions of conventional panel mounted equipment such as relays, timers, counters, current switches, calculation modules, loop controllers, functional operators, stepping switches, and drum programmers.

B. Type: Microprocessor based programmable device supporting Advanced IEC 61131-3 languages.

C. Parts: Central processing unit (CPU), power supply, local and remote input/output modules, local and remote base controllers, I/O bases, communication modules, and factory assembled interconnecting cables.

D. Protection Relay Expansion Input-Output Module.

E. Stand-Alone Remote Input-Output Module.

F. Communications:

1. Ethernet.

2. SEL ASCII.

3. SEL Mirror Bits.

4. Peer-to-Peer IEC 61850 GOOSE Messaging.

5. DNP3 Serial and DNP3 LAN/WAN.
6. Modbus RTU.

7. Time-Coded Input and Output Demodulated IRIG-B.

G. Hardware Specifications:

1. Module Chassis:
   a. Rack or surface mounted.
   b. Ten (10) module slot chassis.

2. Power Supply:
   a. Rated Supply Voltage: 120 / 240 Vac, 50 / 60 Hz.

3. Central Processor Unit:
   a. Processor Speed: 533 MHz.
   b. Memory: 512 MB DDR2 ECC RAM.
   c. Storage: 4 GB (2 GB reserved).

4. Analog Input Module:
   a. From SEL.

5. Digital Input Module:
   a. Opto-isolated 24 digital input.
   b. Voltage ranges: 24V DC /24VAC; 48V DC /48VAC; 110V DC /110VAC; 125V DC /125VAC.

6. Digital Output Module:
   a. Eight (8) Form A and Eight (8) Form B Electromechanical Outputs.
   b. Sixteen (16) Form A Electromechanical Outputs.
   c. Sixteen (16) Form B Electromechanical Outputs.
   d. Current: 6 amps
   e. Voltage ranges: 24V DC /24VAC; 48V DC /48VAC; 110V DC /110VAC; 125V DC /125VAC.

7. Protective Relay Expansion Input-Output Module:
   a. Eight (8) digital inputs.
   b. Eight (8) Form A and Eight (8) Form B Electromechanical Outputs.
   c. Voltage ranges: 24V DC /24VAC; 48V DC /48VAC; 110V DC /110VAC; 125V DC /125VAC.

8. Stand-alone Remote Input-Output Module:
   a. Eight (8) digital inputs.
   b. Eight (8) Form A and Eight (8) Form B Electromechanical Outputs.
   c. Voltage ranges: 24V DC /24VAC; 48V DC /48VAC; 110V DC /110VAC; 125V DC /125VAC.
H. User interfaces:

1. Power Coupler:
   a. Two (2) Ethernet RJ-45 ports: 10 or 100 Mbps.
   b. Power Connections.
   c. Operating Status LEDs.

2. Central Processor Unit:
   b. Time Code Input (IRIG-B).
   c. Time Code Output (IRIG-B).
   d. Two (2) Ethernet RJ-45 ports: 10 or 100 Mbps.
   e. One (1) USB Port: Type B.
   f. Power Connections.
   g. Operating Status LEDs.

3. Protective Relay Expansion and Stand-alone Remote Input-Output Module:
   a. Two (2) Fiber-Optic ports: ST Connectors.
   b. Power Connections.
   c. Operating Status LEDs.

I. Ratings:

1. Operating Temperature: –40 degrees to +85 degrees C (–40 degrees to +185 degrees F).

2. Relative Humidity: 5–95 percent, noncondensing.

J. Software Specifications: Graphical Logic Editor (GLE) using AcSELerator SEL-5030 and RTAC SEL-5033 Software.

K. Basis of Design:


2. Schweitzer Engineering Laboratories Inc.; Model SEL-2241 RTAC.


2.6 CONTROL SWITCHES

A. General: Reference Article Analog Meter and Instrument in this Section for additional information.

B. Type: Pushbutton, Rotary, cam-operated, with two contacts per stage.

C. Configuration: Integrally mounted with protective relaying and or externally mounted as noted.

D. Hardware Specifications:

1. Lockout Relay Series 24 (Main-Tie-Main applications only):
   a. Lock-Out, Trip, and Reset switch.
   b. LOR Class 1E Utility.
   d. N.C. contacts, Manual Reset.
   e. Oval Handle.

2. Instrument and Control Switches Series 24:
   a. Local-Remote selector switch, current phase, and potential phase selector switch.
   c. Pistol Grip Handle.

3. Control Switch Module:
   a. Open-Close pushbutton and indication.
   b. Arc-suppressed contacts.

4. Contact Arc Suppressors:
   a. Voltage: 160 VDC and 280VDC.
   b. Let-Through Current at DC: 2000, and 100 micro-seconds.
   c. Leakage Current: < 150 micro-amperes @ 125V DC.

E. Manufacturer and Products:

1. Schweitzer Engineering Laboratories Inc.; Model SEL-9510 Control Switch Modules.

2. Schweitzer Engineering Laboratories Inc.; Model SEL9501, SEL- 9502 Contact Arc Suppressors.


5. ABB Flexitest Switches; FT-1, FT-1F, FT-1X, and FT-14.

6. Or equal.
2.7 POWER QUALITY METER (PQM)

A. General:
1. Solid state device with LED displays.
2. Direct voltage input up to 600V ac.
3. Current input via current transformer with 5-ampere secondary.
4. Programmable current and potential transformer ratios.
5. Programmable limits to activate up to four alarms.
6. Selectable Voltage Measurements: Line-to-line or line-to-neutral and wye or delta.
7. IRIG/B, DNP3, and Ethernet capable.
8. Memory: 128 MB.
9. Accuracy: exceed class 0.2 accuracy, guaranteed 0.06 revenue accuracy.

B. Displays:
1. Volts, three-phase.
2. Amperes, three-phase.
4. Kilowatt hours.
5. Power factor.
6. Frequency.
7. kW Demand with programmable period intervals.
8. kVA.
9. kVAR.
10. kVARh.
11. Harmonic THD through the 63rd order.
12. Voltage Rating: 95V ac to 135V ac.
C. Software:

1. Schweitzer Engineering Laboratories Inc.; AcSELerator Quick Set SEL-5030.
2. Schweitzer Engineering Laboratories Inc.; AcSELerator Team SEL-5045.
3. No substitutions.

D. Manufacturers and Products: (Basis of Present System)

2. No substitutions.

2.8 ANALOG METERS AND INSTRUMENTS

A. General:

1. Semi-flush mounted switchboard type.
2. Suitable for mounting on hinged steel panels.
3. Case: Dust-tight, enclosed, with dull black finish.
4. Shape: Square or rectangular.
5. Complete with resistors, reactors, and necessary auxiliaries.
6. 1 percent accuracy.
7. Antiparallax scales with convex clear glass shadow-proof covers for indicating meters and relays.
8. White dials with black points and markings.

B. Instrument and Control Switches:

1. Type: Rotary, cam-operated, with two contacts per stage.
2. Silver contacts and maintained positive contact position.
3. Wiping action closing contacts.
4. Adjacent contacts separated by barriers.
5. Contact assembly enclosed in removable cover.


7. Marked escutcheon plates.

8. Operating Handles:
   c. Voltmeter Switches: Four-position, phase-to-phase voltage, and OFF.
   d. Ammeter Switches: Four-position, three-phase currents, and OFF.
   e. Transfer and Auxiliary Switches: Oval type with arrow.

9. Circuit Breaker Switches:
   a. Momentary contact, spring-return type.
   b. Operation indicator to show last operation.
   c. Indicating Lights:
      1) Red to indicate closing.
      2) Green to indicate open.
      3) White to indicate tripped.
      4) Switchboard type with series resistors.
   d. Mechanical key interlock for locking in OFF position.

10. Test Switches for Instrument and Current Sources:
    a. Back connected with clear plastic covers.
    b. Test jacks in phases for current test switches.
    c. Four-pole units for both current and voltage.

C. Indicating Instruments and Meters:

1. Register Size: 6.9-inch scale length, 250-degree arc.

2. ac Voltmeters:
   a. Full-scale rating 150-volt movement calibrated for 15,000 volts, 60-Hz.
   b. Taut-suspension type.

3. ac Ammeters:
   a. Full-scale rating 5-ampere movement.
   b. Taut-suspension type.
4. Watt meters and Varmeters:
   a. Rated 5 amperes at 120 volts.
   b. Taut-suspension type with built-in watt and var transducer.
   c. Register: Clock.
   d. Elements: Two.

D. Metering Transducers:

1. In accordance with IEC 60688.

2. Inputs: 115 volts nominal, 5 amperes, 60-Hz.

3. Output: 4 mA to 20 mA dc into variable loads as established by manufacturer.

4. Withstand:
   a. IEEE C37.90.1 surge capability tests.
   b. Minimum of 1,500-volt rms between input, output, and case.

5. Maximum Ripple: 1 percent dc peak-to-peak output.


7. Operating Temperature Range: Minus 20 to plus 60 degrees C.

8. Circuitry: Solid state, with calibration and zero adjustment.


10. Screw type barrier terminal blocks plus enclosure grounding terminal.

11. Transducers: Voltage current watt var and frequency.

2.9 INSTRUMENT TRANSFORMERS

A. Current Transformer (CT), 600V and Below:

1. Type: Molded bar or donut.

2. Accuracy: 0.3 at burden imposed by meters and instruments.

3. Shorting type terminal boards for current transformer leads.
B. Potential Transformer (PT), 600V and Below:

1. Type: Molded.

2. Accuracy Classification: 0.3 at burden imposed by meters and instruments, including future.


C. Current Transformer (CT), Over 600 Volts:

1. Type:
   a. Insulated dry indoor.
   b. Window type for relaying and ground sensing.
   c. Wound type for metering.

2. Transformer accuracy in accordance with IEEE C57.13.

3. Class C20 or greater for relaying.

4. Class 1.2 maximum for imposed burden for metering.

5. Rating: As indicated. Install in separate compartment if rated greater than 3kVA.


7. Thermal Rating: 100 times normal, 1 second.

8. Size to operate continuously at rated primary current without insulation damage.

9. Identify polarity with standard mark or symbol.

10. Secondary Wiring: Install in conduit, PVC tubing or wiring trough.

11. Isolate from adjacent components and circuits by removable insulating or metal barriers.

12. Window type CTs accessible for replacement without removing high voltage insulated connections.
D. Potential Transformer (PT), Over 600 Volts:

1. Type: Insulated dry, indoor, two bushing, UL Recognized.
2. Rating: 12,000/120-volt, single-phase with 110 kV BIL rating, 60 Hz.
3. Three transformers connected phase-to-phase.
6. Accuracy classification in accordance with IEEE C57.13 for connected burden.
7. Primary Protection: Two, integral mounted current-limiting fuses, 0.5 amp.
9. Identify polarity with standard marking or symbols.

E. Manufacturer:

1. GE, PTW5-2-110-123FF (008-0120). (Match existing in Switchgear)
2. ABB, PTS - 15
3. Or written, the Authority approved equal.

2.10 SUBMETERING

A. Overall System Accuracy Plus or minus 1.0 percent or better accuracy from 2 percent to 100 percent of current sensor rating in accordance with NEMA C12.1 metering accuracy standards.

B. Current Sensors:

1. In accordance with display manufacturer’s instructions.
2. Current Ratio: As indicated on Drawings or as suitable for circuit under measurement.
3. Split core or donut type.
4. Current-to-current (traditional current transformer) or current-to-voltage (for example, Hall-effect type) conversion device, compatible with display.

5. Provide current transformers with shorting terminal blocks.

C. Display:

1. Solid state device with LED or backlit LCD display.

2. Direct voltage input, suitable for monitoring systems indicated on Drawings.

3. Operating Temperature Range: 0 to plus 50 degrees C.


5. True Reading Display: Parameter readings shall reflect actual measurements without multipliers or conversion factors.

6. Parameters to be Displayed:
   a. kWh.
   b. kW.
   c. Current in all phases.
   d. Line-to-line and line-neutral voltages for all phases.
   e. Power factor.

D. Display Enclosure:

1. NEMA 250 Type 12.

2. Suitable for installation of 4 display units. Provide covers plates for unused openings.

E. Display Communications: For connecting metering display or multiple displays to remote monitoring system.

1. Modbus RS-485 with Ethernet gateway for connection of multiple display devices to local area network (LAN).

F. Software:

1. Provide, from manufacturer of display devices, Microsoft Windows-based software suitable for number of devices monitored.
2. Capable of the following:
   a. Interval logging of metering data every 15 minutes.
   b. Error detection and diagnostics for metering device status.
   c. Automatic retrieval of data from display device memory.
   d. Reporting of kW, kWh, and Peak Demand.
   e. Assignment of individual information, such as names, to display devices.

3. Production of Reports:
   a. Load profile by day, week, and month.
   b. Annual summary of data.
   c. Export of up to 1 year of data to Microsoft Excel.

G. Manufacturer and Products:

1. E-Mon/D-Mon; Match existing models, direct connectors, configuration, and seamless integration into existing network, Class 3000.

2. Above units shall be manufactured by E-Mon/D-Mon. This brand name manufacturer is designed to match and function with the existing system and no alternative product or substitution will be permitted.

2.11 INDICATOR, DIGITAL PANEL:

A. General:

1. Function: Digital indication of resistance and analog signals.

2. Type: 3.5-digit LED display.

B. Performance:

1. Accuracy: Plus or minus 0.05 percent of full scale plus or minus one count.

2. Display Update Rate: 2.5 second minimum.

3. Operating Temperature Range: 0 degree C to 60 degrees C.

4. Relative Humidity: 0 percent to 90 percent noncondensing

C. Features:

1. Display:
   a. LED.
   b. At least 3.5-digits.
   c. 0.56-inch height.
2. Overrange indication.

3. Input Impedance: 100 ohms maximum.

D. Enclosure:

1. 1/8 DIN, high impact plastic.

2. Nominal Maximum Dimensions: 2.5 inches high by 4.7 inches wide by 4 inches deep.

3. Nominal Cutout Dimensions: 1.8 inches high by 3.6 inches wide.

4. Suitable for panel mounting.

5. Maintains NEMA 4X Panel Rating: If noted.
   a. Furnish accessories as required.

E. Power: 115V ac, unless otherwise noted.

F. Signal Interfaces:

1. Process Inputs:
   a. Thermocouple resistance input.
   b. 4-20mA DC output.
   c. Loop Power Supply: If noted.
      1) 24V dc, at least 25 mA.

G. Manufacturer and Products:

1. Newport Electronics, Santa Ana, CA; Model 202A-P.

2. Precision Digital, Natick, MA; Model Trident Model PD765.

3. Or written, FMD approved equal.

2.12 TEMPERATURE ELEMENT AND TRANSMITTER, THERMOCOUPLE:

A. General:

1. Function: Measure temperature of cable environment and send signal proportional to temperature.

2. Type: Thermocouple.

3. Parts: Element and transmitter.
B. Service:

1. Ambient: Air.

2. Process Temperature Range: 32 Degree F to 120 Degree F.

C. Element:

1. Type:
   a. Single-element, unless otherwise noted.
   b. Iron-constantan, Type J, ungrounded, unless otherwise noted.

2. Performance:
   a. Accuracy: Plus or minus 4 degrees F or plus or minus 0.75 percent of reading, whichever is greater.

3. Features:
   a. Dimensions (Bare Element): 1/4-inch diameter.
   b. Length to accommodate thermowell insertion and extension length.
   c. Spring-loaded element when well is used.
   d. Sheath:
      1) Type 316 stainless steel, unless otherwise noted.

4. Process Operating Temperature:
   a. Range: Minus 320 degrees F to 1600 degrees F, unless otherwise noted.

5. Terminal Connection Head:

6. General purpose, NEMA 4 weatherproof, unless otherwise noted.

7. Maximum Temperature: 220 degrees F, unless otherwise noted.

D. Transmitter:

1. Ambient Operation Conditions:
   a. Temperature: Minus 20 degrees F to 158 degrees F, with display.
   b. Relative Humidity: 0 percent to 100 percent, noncondensing.

2. Type: Two-wire, powered by a remote power supply.

3. Performance:
   a. Digital Accuracy: Greater of plus or minus 0.07 degree F or plus or minus 0.01 percent of span.
   b. Response Time: 1.2 second 90 percent response time for 80 percent input step, with minimum damping.
4. Electrical Safety: Standard unless otherwise noted.

5. Features:
   a. Indicator: Three-line LCD, unless otherwise noted.
   c. Failsafe Mode:
      1) User configurable ON, unless otherwise noted.
   d. Downscale, unless otherwise noted.
      1) Electric Damping: 1.2 seconds.
   e. Signal Interface: 4 mA to 20 mA dc.


7. Enclosure:
   a. Materials: Epoxy-coated, low-copper aluminum, unless otherwise noted.
   b. Type: NEMA 4X.
   c. Mounting: As noted.

E. Manufacturers and Products:

1. Invensys/Foxboro; RTT20 Series Transmitter with MINOX MT Series Thermocouple.

2. Rosemount; Series 183 Thermocouple and Model 644H Transmitter.

3. Or equal.

1.13 INTRUSION SWITCH, DOOR

A. General:

1. Function: Monitor intrusion of standard enclosure or cabinet door.

2. Type: Mechanical; indoor/outdoor use.

3. Parts: Level arm, rocker, plunger, switch, mounting bracket.

4. NEMA 250 Type 12, 4 ratings.

B. Signal Interface:

1. Switch: SPDT, normally open, normally closed contacts

2. Contact Rating: 20 amp continuous rating.
C. Manufacturer and Products:
   3. Or equal.

PART 3 EXECUTION

3.1 INSTALLATION

A. In accordance with manufacturer’s written instructions.

B. As defined in Section 26 08 00, Acceptance Testing of Electrical Systems.

C. As defined in Section 26 09 14, Power System Supervisory Control and Data Acquisition (SCADA).

END OF SECTION 26 09 13
PART 1   GENERAL

1.1 SUMMARY

A. This section covers existing elements of the 12KV control system and requirements for the San Diego County International Airport (SDIA) Power System SCADA (PSS). This section is included in these specifications to provide reference information when additions to the system are planned as part of a new project. The following specification subsection expands on requirements of this section as it relates to changes or additions to the 12KV electrical system and its SCADA system:

1. Section 26 05 70, Electrical System Analysis.

B. The project Developer/Contractor shall be required to provide proposed electrical load and structure information to the Authority, who will forward to its third party Integrator, in order to implement Power System SCADA modifications and system electrical coordination, as necessary, based upon the scope and impact of the developer/contractor’s project. Work within this section shall be provided by the Authority Approved Power System SCADA (PSS) Integrator; identified as the PSS Integrator in this section and subsections. The Authority is the contact for information regarding the PSS SCADA and will be identified as the contact point for all information regarding modifications to the PSS SCADA.

1. PSS Integrator maintains a physical office in San Diego County, CA or Orange County, CA with SEL trained and qualified staff.

C. The Authority PSS Integrator: Schweitzer Engineering Laboratories, Inc. (SEL) Engineering Services; location 3210 El Camino Real #150 Irvine, CA 92612, phone (509) 332-1890.

D. Contractor will provide materials and information required, per the design of their project that is necessary for the full integration of their project into the PSS SCADA system. In addition, any equipment intended to be supplied that is not the Basis of Design, First Named, listed in Section 26 09 13 shall have full documentation submitted with the Bid.

E. The PSS Integrator shall be responsible for the coordination, integration, factory witness and field testing, training, commissioning, and documentation of Power System SCADA modifications. Reference Article Quality Assurance within this Section for additional requirements.
F. Overview: PSS Integrator has provided engineering, personnel, tools, labor, hardware, software, application software (programming), documentation, testing and training of the Authority personnel to meet system requirements as specified. The following is an overview of the scope of the original PSS Integrator project:

1. Provide Power System SCADA (PSS) to control and monitor the operation of the 12kV Power Distribution System within the San Diego County International Airport (SDIA). SDIA 12kV Power Distribution System consists of SDG&E Preferred and Alternate 12kV Sources of power, primary distribution metal-clad switchgear with main and feeder vacuum circuit breakers, 12kV pad mounted switchgear with line switches and load interrupters, medium voltage-low voltage pad mounted transformers, power factor correction capacitors, protective relaying, intelligent electronic devices (IEDs), battery systems, power meters, substation transformers, alternative power generation systems (PV Solar), 15kV class primary system cables, ancillary, and environmental conditions within equipment cabinets and designated rooms.

2. Provide Power System SCADA architecture, incorporating programmable controllers, remote input/output modules, protocol converters, satellite time clock and synchronization hardware, protective relaying, intelligent electronic devices (IED), network switches, human-machine interface (HMI) Servers, iHistorian, Domain Controller, Client, and Terminal Services (Webserver) computers, and printers operating over Ethernet and IED specific communication networks.

3. Provide all work in accordance CEC. Where required by the Authority, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or another testing agency acceptable to The Authority, in order to provide a basis for approval under the CEC.

4. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. and or another the Authority Approved Testing Agency shall conform to those standards and shall have an applied listing mark or label.

5. Provide personnel and labor to participate and support the Authority, 3rd Party Commissioning.

6. Modify controls for existing 12kV main switchgear protective relays and power monitoring. Reference Section 26 05 02 Basic Electrical Requirements, Article Description of Work.
G. PSS Functionality: Power System SCADA has the following minimum functionality:

1. Monitor and Control the 12kV Power Distribution System including:
   b. Display Power Data (up to 30 unique locations simultaneously).
   c. Operator access to Power Device and Equipment control operations (open/close) and control and alarm set-points.
   d. Perform Power Device and Equipment Control (open/close, reset).
   e. Collect Data and Display Power Trends (kW, kV, kVAR, kVA Power Factor, Magnitude, Vector Angles, Phase Rotation, Load Flow Ampsand Harmonics where noted).
   f. Display and Print Critical Alarms.
   g. Trend, Display, and Print Critical Synchronized Sequence of Events and Synchrophasor Reports.
   h. Display and Print Power Data Reports.
   i. Historize: collect and backup data.

2. Establish and control load shedding based upon predetermined operating schemes.

3. Establish and control system recovery in the event of a preferred or alternate power source failure, equipment failure, differential current fault and faulted cable condition based upon initial load conditions and predetermined operating schemes.

4. Support synchronized sequence-of-event (SOE) and synchrophasor data collection and reporting.

5. Transmit Data from PSS with selected CMMS and Asset Management.

6. Transmit Data from PSS with selected Mass Notification System.

7. Coordinate the management of data and information exchange with internal stakeholders (BMS).

8. Coordinate Data and Information Exchange with SDG&E.

9. Implement communication between programmable IEDs, automatic controllers, control and view Nodes, servers, clocks, and printers over the Power System LAN.

10. Implement secured communication between PSS LAN and Airport Facility Network.

11. PSS Integrator to provide scalability supporting system expansions.
H. Major Work Items: Includes but is not limited to engineering, furnishing, installing, calibrating, adjusting, testing, documenting, starting up, and training of the Authority operations personnel for a complete PSS:

1. Power measurement and control protective relaying, IEDs, and power instrumentation including: controllers, primary elements, transmitters, control devices, interface devices, ac and dc power supplies, and control panels with environmental controls.


3. Programmable real-time automation controllers and automating computers.


5. Specialty communication cables and connectors: serial, coax, IRIG-B, fiber-optic and copper jumpers, patch cabling, and patch panels.


7. Application Software: Provided under this Section for all PSS programmable real-time automation controllers and automating computers, protective relaying, IEDs, networks, HMI client and server computers, Web-Servers, Historians, and printers.

I. The Authority will provide the following Work:

1. Configuration of SDIA Mass notification system.

2. Configuration of SDIA CMMS.

3. Configuration of SDIA Asset Management.

4. Configuration of SDIA BMS.

1.2 REFERENCES

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

2. ASTM International (ASTM):

3. Deutsche Industrie-Norm (DIN): VDE 0611, Specification for modular terminal blocks for connection of copper conductors up to 1,000V ac and up to 1,200V dc.


5. International Society of Automation (ISA):
   a. RP12.06.01, Recommended Practice for Wiring Methods for Hazardous (Classified) Locations Instrumentation Part 1: Intrinsic Safety.
   b. S5.1, Instrumentation Symbols and Identification.
   c. S5.4, Instrument Loop Diagrams.
   d. S50.1, Compatibility of Analog Signals for Electronic Industrial Process Instruments.
   e. TR20.00.01, Specification Forms for Process Measurement and Control Instruments, Part 1: General.


8. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. ICS 1, Industrial Control and Systems General Requirements.

1.3 DEFINITIONS

A. Abbreviations:

1. Communication GOOSE: Generic Object Oriented Substation Event, an IEC 61850 Messaging System supporting communication and messaging between IEDs and SCADA Applications.

2. Communication DNP3: Distributed Network Protocol as defined by IEEE 1815-2012 Standard supporting communication between IEDs, SCADA and Remote Terminal Unit (RTU) Applications.

3. Communication Mirror Bits: Peer-to-peer communication between IEDs and RTAC normally applied to main-tie-main protective relaying topologies and applications.


5. Communication Fast Ethernet: Ethernet data network based on a transmission speed of 100 Mbit/Sec.

6. Communication Gigabit Ethernet: Ethernet data network based on a transmission speed of 1000 Mbit/Sec.

7. Communication Network-Ring: Redundant communications based on the construction of ring-shaped network structure. In the case of an interruption in the ring structure, the redundancy manager restructures message routing such that communication is not interrupted.

8. CMMS: Computerized Maintenance Management System.


10. CPT: Control Power Transformer.

11. CPCR: Capacitor Protection and Control Relay.

12. CT: Current Transformer.

13. DCU: Distributed Control Unit.


17. HVAC: Heating, Ventilating, and Air Conditioning.
19. IRIG-B: GPS time synchronization time codes and communication protocol.
20. IO: Input and Output.
22. MMFR: Main Management and Feeder Relay.
24. PACR: Protection, Automation and Bay Control System Relay.
25. PSS: Power System SCADA.
27. PC: Personal Computer.
29. PT: Potential Transformer.
30. RTU: Remote Terminal Unit.
31. RTAC: Real-time automation controllers (SEL 3530).
32. SEL: Schweitzer Engineering Laboratories Inc.
33. SEL: SEL Serial Communications Protocol.
34. SSC: Synchronized-Satellite Clocks (SEL-2407).
35. SSCP: Secure SCADA Communications Protocol (SSCP).
36. Synchrophasor: Synchronized data consisting of real-time values for phase voltages, currents, and angles or Synchronized real-time vector data for phase voltage and currents.
37. SCADA: Supervisory Control and Data Acquisition.
38. VLAN: Virtual local area networks that are logically configured independently of their physical topology.
39. WAN: Wide Area Network.

40. WLAN: Wireless data transmission in local area networks.

41. 100Base-FX: 100 Mbit/Sec Ethernet transmission rate on multi-mode fiber optic cables.

42. 100Base-TX: 100 Mbit/Sec Ethernet transmission rate on twisted pair cables.

43. 1000Base-SX: 1000 Mbit/Sec Ethernet transmission rate on single-mode fiber-optic cables.

B. Enclosure: Control panel, console, cabinet, or instrument housing.

C. Instructor Day: Eight hours of actual instruction time.

D. Standard Software: Software packages that are independent of Project on which they are used. Standard software includes system software, supervisory control, and data acquisition (SCADA) software.

1. System Software: Application independent (non-project specific) software developed by digital equipment manufacturers and software companies. Includes, but is not limited to, operating systems; network support, programming languages (C, C++, Visual C++, BASIC, Visual Basic, etc.); Office Suites (word processor, spreadsheet, database, etc.); e-mail; security (firewall, antivirus; spam, spyware, etc.) debugging aids; and diagnostics.

2. SCADA Software: Software packages independent of specific process control project on which they are used. Includes, but is not limited to, providing configuring and run-time capability for, data acquisition (IO driver, OPC servers, etc.), monitoring, alarming, human-machine interface, supervisory control, data collection, data retrieval, trending, report generation, control, and diagnostics.

3. Controller Programming Software: Software packages for the configuring of IED, Protective Relaying, RTACs, and fieldbus devices.

E. Application Software: Software to provide functions unique to this Project and that are not provided by standard software alone, including but not limited to:

1. Configuring databases, tables, displays, historians, reports, parameter lists, controller logic, function blocks, and control strategies as required implementing functions that are unique to this Project.

2. Programming in any programming or scripting language.
F. Rising/Falling: Define action of discrete devices about their setpoint.

1. Rising: Contacts close when an increasing process variable rises through setpoint.

2. Falling: Contacts close when a decreasing process variable falls through setpoint.

G. Signal Types:

1. Analog Signal, Current Type:
   a. 4 to 20 mA dc signals conforming to ISA S50.1.
   b. Unless otherwise indicated for specific PSS subsection components, use the following ISA S50.1 options.
      1) Transmitter Type: Number 2, two-wire.
      2) Transmitter Load Resistance Capacity: Class L.
      3) Fully isolated transmitters and receivers.

2. Analog Signal, Voltage Type: 1 to 5 volts dc within panel where common high precision dropping resistor is used.

3. Discrete signals, two-state logic signals using dc or 120V ac sources as indicated.

4. Pulse Frequency Signals:
   a. Direct-current pulses whose repetition rate is linearly proportional to process variable.
   b. Pulses generated by contact closures or solid state switches.
   c. Power source less than 30V dc.

5. Special Signals: Other types of signals used to transmit analog and digital information between field elements, transmitters, receivers, controllers, and digital devices.

1.4 SYSTEM DESCRIPTION

A. Design requirements for modifications to PSS:

1. Complete detailed design revision of PSS components and PSS Drawings required by the new project.

2. Ensure consistent hardware and software functions for PSS. For example, ensure functions in control logic, sequence controls, and display layouts are depicted in the same manner.
3. PSS design as shown and specified includes:
   a. Functional requirements, performance requirements, and component specifications.
   b. Point IO Drawings, block diagrams, and network diagrams.

4. Typical Drawings include installation details, control panel layouts, control panel schedules, RTAC, IED, Protective Relaying, IO module wiring, panel power, and control diagrams.

B. Coordinate with the Authority the following work:

1. The Authority to review PSS Equipment and Ancillaries:
   a. Completed detail design.
   b. Submittals (diagrams, Drawings, instruments documents, Shop Drawings, workshops, meetings, standards, testing forms, equipment delivery, and etc.).
   c. Equipment, enclosures, and ancillaries.
   d. Instructions, details, and recommendations to, and coordination with Contractor for Certificate of Proper Installation.
   e. Verify readiness for operation.
   f. Verify correctness of final power and signal connections (lugging and connecting), that is completed by others.
   g. Adjusting and calibrating.
   h. Starting up.
   i. Testing and coordination of testing.
   j. Training on modifications.

2. The Authority to Verify work not by PSS Integrator but integral to PSS is provided and properly coordinated:
   a. Verify correct type, size, and number of signal wires with their raceways.
   b. Verify correct electrical power circuits and raceways.
   c. Verify correct size, type, materials, and connections of electrical connections for primary equipment and elements (CTs, CCVTs, CPTs, and PTs).
   d. Verify re-wiring and re-programming of existing protective relaying.
   e. Verify correct count and actions for input and output signals.

3. Contractor provided Non-PSS Equipment Directly Connected to PSS Equipment:
   a. The Authority to supply to PSS Integrator manufacturers’ information on installation, interface, function, and adjustment.
   b. Contractor to follow requirements to interface and operate with PSS.
c. PSS Integrator to confirm operation and control, verify installations, interfacing signal terminations, and adjustments have been completed in accordance with manufacturer’s recommendations.

d. PSS Integrator to demonstrate required interface and operation with PSS.

e. Examples of items in this category, but not limited to the following:
   1) ATO Line switch and ATO load interrupter operators, position switches, and controls.
   2) Vacuum breaker operators, position switches, and controls.
   3) Switchgear, switchboards, manual and automatic transfer switches.
   4) PV Solar alternative source power systems.
   5) Capacitor bank systems.
   6) Sub-metering.
   7) Transformer auxiliary alarm contacts.

f. Examples of items not in this category:
   1) Internal portions of equipment provided under Division 26, Electrical, that are not directly connected to PSS equipment.
   2) Internal portions of instrumentation and controls that are not directly connected to PSS equipment.

1.5 SUBMITTALS

A. General, submit to the Authority:

1. Submit proposed Submittal breakdown consisting of sequencing and packaging of information in accordance with Project Schedule.

2. Partial Submittals not in accordance with Project Schedule will not be accepted.

3. Reference Section 1D-Special Conditions, Article 1D-11A Submittals for additional requirements.

4. Submittal Format:
   a. Hard Copy: Required for all submittals.
   b. Electronic Copies: Required, unless otherwise noted for specific items.
      1) Manufacturers’ Standard Documents: Adobe Acrobat PDF.
2) Documents created specifically for Project:
   a) Text and Graphics: Microsoft Word.
   b) Lists: Microsoft Excel, unless otherwise noted for specific items.
   c) Drawings: AutoCAD.

5. Identify proposed items, options, installed spares, and other provisions for future work (for example, reserved panel space, unused components, wiring, and terminals).

6. Legends and Abbreviation Lists:
   a. Definition of symbols and abbreviations used; for example, engineering units, flow streams, instruments, structures, and other process items used in nameplates, legends, data sheets, point descriptions, HMI displays, alarm/status logs, and reports.
   b. Use identical abbreviations in PSS subsections.
   c. Submit updated versions as they occur.

7. Activity Completion:
   a. Action Submittals: Completed when reviewed and approved.
   b. Informational Submittals: Completed when reviewed and found to meet conditions of the Contract.

B. Action Submittals, submit to The Authority per contract:

   a. Group equipment items by enclosure and field, and within an enclosure, as follows:
      1) PSS Components: By component identification code.
      2) Other Equipment: By equipment type.
   b. Data Included:
      1) Equipment tag number.
      2) Description.
      3) Manufacturer, complete model number and all options not defined by model number.
      4) Quantity supplied.
      5) Component identification code where applicable.
      6) For panels, include panel reference number and name plate inscription.
   c. Formats: Hard copy and Microsoft Excel.

2. Catalog Cuts: PSS components, electrical devices, and mechanical devices:
   a. Catalog information, marked to identify proposed items and options.
   a. Descriptive literature.
   b. External power and signal connections.
   c. Scaled Drawings showing exterior dimensions and locations of electrical and mechanical interfaces.
3. **Warranties:** Contractor to Provide warranty information on supplied PSS hardware identifying warranty applications, duration, coverage, scope of services, roles and responsibilities for all parties (PSS Integrators, the Authority, and Suppliers), and contact information. The intent of this submittal is to confirm that proper coordination has taken place between PSS Integrator and hardware suppliers.

4. **Contractor provided information for Sizing and Selection Calculations:**
   a. **Primary Elements:**
      1) Nominal voltage, current, and load burden and equipment to be connected to PSS system.
   b. **Electronic Copies:** Microsoft Excel, one file for each group of components with identical sizing calculations.

5. **Panel Construction Drawings:**
   a. **Scale Drawings:** Show dimensions and locations of panel-mounted devices, doors, and louvers, subpanels, internal and external.
   b. **Panel Legend (Bill of Material):** List front of panel devices by tag numbers, nameplate inscriptions, service legends, and annunciator inscriptions.
   c. **Bill of Materials:** List devices mounted within panel that are not listed in panel legend. Include tag number, description, manufacturer, and model number.
   d. **Construction Details:** NEMA rating, materials, material thickness, structural stiffeners and brackets, lifting lugs, mounting brackets and tabs, door hinges and latches, and welding and other connection callouts and details.
   e. **Construction Notes:** Finishes, wire color schemes, wire ratings, wire, terminal block numbering, and labeling scheme.
   f. Submit electronic copies of Drawings.

6. **Detailed Wiring Diagrams:**
   a. **Refer to Drawings for Schematic Wiring Diagrams including:**
      1) Panel Wiring Diagrams for discrete control and power circuits.
      2) Loop Wiring Diagrams showing individual wiring diagram for each analog or pulse frequency loop.
      3) Interconnecting Wiring Diagrams showing electrical connections between equipment, consoles, panels, terminal junction boxes, and field-mounted components.
   b. **Prepare as-built redline markup of detailed wiring diagrams.** Show terminal numbers on switch blocks, relays, and internal components.
   c. **Submit electronic copies of Drawings.**
7. Panel Wiring Diagrams:
   a. Cover wiring within a panel including, but not limited to, instrumentation, control, power, and communications, and digital networks.
   b. Objectives: For use in wiring panels, making panel connections, and future panel trouble shooting.
   c. Diagram Type:
      1) Ladder diagrams where applicable in a format similar to those shown on Drawings. Include devices that are mounted in or on the panel that require electrical connections. Show unique rung numbers on left side of each rung.
      2) Schematic Drawings for wiring of circuits that cannot be well represented by ladder diagrams.
   d. Item Identification: Identify each item with attributes listed.
      1) Wires: Wire number and color. Cable number if part of multi-conductor cable.
      2) Terminals: Location (enclosure number, terminal junction box number, or MCC number), terminal strip number, and terminal block number.
      3) Components:
         a) Tag number, terminal numbers, and location (“FIELD”, enclosure number, or MCC number).
   e. Show each circuit individually. No “typical” diagrams or “typical” wire lists will be allowed.
   f. Ground wires, surge protectors, and connections.
   g. Wire and Cable Names: Show names and wire color corresponding to Circuit and Raceway Schedule for circuits entering and leaving a panel. Refer to Division 26, Electrical.

8. Power Schematic and Loop Wiring Diagrams: Individual, end-to-end wiring diagram for each power control, analog and discrete or equipment loop.
   a. Conform to the minimum requirements of ISA S5.4.
   b. Under Paragraph 5.3 of ISA S5.4, include the information listed under Subparagraphs 2 and 6.
   c. Show loop components within a panel and identify each component, component terminals, and panel terminals.
   d. If a loop connects to panels or devices not provided under this section and its subsections, such as control valves, motor control centers, package system panels, variable speed drives, include the following information:
      1) Show the first component connected to within the panel or device that is not provided under this section and its subsections.
      2) Identify the component by tag and description.
      3) Identify panel and component terminal numbers.
e. Drawing Size: Individual 11-inch by 17-inch sheet for each loop.

f. Divide each loop diagram into areas for panel face, back-of-panel, field and PROTECTIVE RELAY, IED, IO MODULE, AND RTAC.

g. One Drawing Per Loop: Show each loop individually. No “typical” loop diagrams will be allowed.

h. Show:
   1) Terminal numbers, location of dc power supply, and location of common dropping resistors.
   2) Switching contacts in analog loops and output contacts of analog devices. Reference specific control diagrams where functions of these contacts are shown.
   3) Tabular summary on each analog loop diagram:
      a) Transmitting Instruments: Output capability.
      b) Receiving Instruments: Input impedance.
      c) Loop Wiring Impedance: Estimate based on wire sizes and lengths shown.
      d) Total loop impedance.
      e) Reserve output capacity.
   4) Circuit and raceway schedule names.

9. Communications and Digital Networks Diagrams:
   a. Scope: Includes connections to Ethernet network, remote IO, and fieldbus (for example, DNP3, GOOSE, IRIG-B, Modbus RTU, and etc.).
   b. Format: Network schematic diagrams for each different type of network.
   c. Show:
      1) Interconnected devices, both passive and active.
      2) Device names and numbers.
      3) Terminal numbers.
      4) Communication Media: Type of cable.
      5) Connection Type: Type of connector.
      6) Node and device address numbers.
      7) Wire and cable numbers and colors.

10. Panel Power Requirements and Heat Dissipation: For control panels tabulate and summarize:
    a. Required voltages, currents, and phases(s).
    b. Maximum heat dissipations Btu per hour.
    c. Calculations.
    d. Steady State Temperature Calculations: For nonventilated panels, provide heat load calculations showing the panel estimated internal steady state temperature for ambient air temperatures of 100 degrees F in direct sunlight.
11. Installation Details: Include modifications or further details required and define installation of PSS components.

12. Spares, expendables, and test equipment.


14. IO List:
   a. Managed by PSS Integrator:
      1) During construction PSS Integrator will maintain IO List and give electronic Microsoft Excel copies to the Authority.
      2) PSS Integrator will assign IO points to specific chassis, slot, and point addresses.
   b. IO List Changes: Changes to RTAC, IED, Protective Relaying, IO List reflecting actual equipment and instrumentation provided.
      1) Mark up electronic file of latest IO List with The Authority Highlight changed cells with yellow, new rows with red, and rows to be deleted with green.
      2) Submit marked up copies of changes at 30-day intervals.

15. IO List: Submit IO assignment.

16. Shop Drawings for Changes Impacting Programming:
   a. Submit details of changes required to PROTECTIVE RELAY, IED, IO MODULE, AND RTAC monitoring and control resulting from installation of alternative or upgraded process equipment and instrumentation, and other causes.
   b. Submit changes at 30-day intervals.

17. Color schedule for control panels.

18. Application Software Documentation: For equipment for which PSS Integrator provides application software:
   a. Complete configuration documentation for microprocessor based programmable devices.
   b. For each device, include program listings and function block diagrams, as appropriate, showing:
      1) Functional blocks or modules used.
      2) Configuration, calibration, and tuning parameters.
      3) Descriptive annotations.
   c. Refer to PSS subsections for additional requirements.
D. Informational Submittals:

1. Statements of Qualification:
   a. PSS Integrator.
   b. PSS Integrator’s site representative.
   c. Resume for each PSS Integrator’s onsite startup and testing team member (Engineers, technicians, and software/configuring personnel).

2. Operation and Maintenance Data: In accordance with Section 1D – Special Conditions, Article 1D-51 Project Closeout, and the following requirements:
   a. General:
      1) Provide sufficient detail to allow operation, removal, installation, adjustment, calibration, maintenance and purchasing replacements for PSS components.
      2) Submittal Format: Both hard copy and electronic copies for all submittals. Refer to Article Submittals, heading Submittal Format.
   b. Final versions of Legend and Abbreviation Lists.
   c. Process and Instrumentation Diagrams: Marked up copy of revised P&ID to reflect as-built PSS design.
   d. Provide the following items as defined under heading Action Submittals:
      1) Bill of materials.
      2) Catalog cuts.
      3) Instrument list.
      4) Component data sheets.
         a) Panel wiring diagrams.
         b) Loop diagrams.
         c) Interconnecting wiring diagrams.
         d) Application software documentation.
   e. Manufacturer’s O&M manuals for components, electrical devices, and mechanical devices:
      1) Content for Each O&M Manual:
         a) Table of Contents.
         b) Operations procedures.
         c) Installation requirements and procedures.
         d) Maintenance requirements and procedures.
         e) Troubleshooting procedures.
         f) Calibration procedures.
         g) Internal schematic and wiring diagrams.
         h) Component and IO Module Calibration Sheets from field quality controls calibrations.
2) Provide PDF file linked index to all manuals.

f. List of spares, expendables, test equipment and tools provided.

g. List of additional recommended spares, expendables, test equipment, and tools. Include quantities, unit prices, and total costs.

h. Copies of UL 508 Equipment Label to be applied to control cabinets. Copy of NEC Section 409 compliant Equipment Label to be applied to control cabinets.

3. Provide Manufacturer’s Certificate of Proper Installation where specified.

4. Testing Related Submittals:
   a. Factory Demonstration Test:
      1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
      2) Final Test Procedures:
         a) Proposed test procedures, forms, and checklists.
         b) Capacity, Timing, and Simulation:
            Describe simulation and monitoring methods used to demonstrate compliance with capacity and timing requirements.
      3) Test Documentation: Copy of signed test results.

   b. Software Demonstration Test:
      1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
      2) Final Test Procedures: Proposed test procedures, forms, and checklists.
      3) Test Documentation: Copy of signed test results when tests are completed.

   c. Functional Test:
      1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
      2) Final Test Procedures: Proposed test procedures, forms, and checklists.
      3) Test Documentation:
         a) Copy of signed test results.
         b) Completed component calibration sheets.

   d. Performance Test:
      1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
      2) Final Test Procedures: Proposed test procedures, forms, and checklists.
      3) Test Documentation: Copy of signed test results.
5. The Authority Training Plan: In accordance with Section 01910, Commissioning.

6. Maintenance Service Agreement: Prior to Substantial Completion, submit service agreements signed by the Authority and maintenance provider for work required under Article Maintenance Service.

1.6 QUALITY ASSURANCE

A. Qualifications:

1. PSS Integrator: The Authority approved Engineering Services Organization with a minimum of 10 years’ experience providing, integrating, installing, and starting up similar systems as required for this Project.

2. PSS Integrator’s Site Representative: Minimum of 5 years’ experience installing systems similar to PSS required for this Project.

B. PSS Coordination Meetings and Workshops:

1. General: Refer to Section 1D – Special Conditions, Article 1D-14 Contractor Coordination with Others, and requirements within this Section for PSS coordination meetings.

2. Summary of PSS Workshops:
   a. One (1) Overall Submittal Kick Off Workshop – discusses the ground rules and submittal scope of work for the project.
   b. One (1) PSS Application Software Kick Off Workshop - discusses the ground rules and software scope of work for the project.
   c. Three (3) PSS Application Software Control Description Application Software Workshops (Draft Schematic, Draft Design, and Draft Final).
   d. Three (3) PSS Application Software HMI Application and Standards Workshops (Draft Schematic, Draft Design, and Draft Final).
   e. Three (3) PSS Application Software RTAC Application and Standards Workshops (Draft Schematic, Draft Design, and Draft Final).
   f. Three (3) PSS Application Software Protective Relaying and IED Standards Workshops (Draft Schematic, Draft Design, and Draft Final).
   g. Three (3) PSS Application Software Reporting Standards Workshops (Draft Schematic, Draft Design, and Draft Final).
   h. One (1) minimum Pre-Site Testing Workshop: In accordance with the Section 1D – Special Conditions, Article 1D-14 Contractor Coordination with Others, Section 01010 Summary of
3. **PSS Pre-Submittal Kick-Off Workshop:** Reference Section 26 09 16 Power System Application Software.

4. **PSS Schedule Coordination Meeting:**
   a. **Timing:** Following Engineer review of PSS Schedule.
   b. **Purpose:** Discuss Engineer’s comments and resolve scheduling issues.

5. **PSS Application Software Workshops:** Reference Section 26 09 16 Power System Application Software.

6. **PSS Pre-Site Testing Workshop:** In accordance with the Section 1D–Special Conditions, Article 1D-14 Contractor Coordination with Others, and Section 01010 Summary of Work.

7. **Training Coordination Meeting:**
   a. **Timing:** Following Engineer review of preliminary training plan.
   b. **Purpose:**
      1) Resolve required changes to proposed training plan.
      2) Identify specific the Authority personnel to attend training.

1.7 **DELIVERY, STORAGE, AND HANDLING**

   A. In accordance with Section 1D – Special Conditions, Article 1D- 15 Contractor Equipment Storage and Stock Pile Areas.

   B. Prior to shipment, include corrosive inhibitive vapor capsules in shipping containers, and related equipment as recommended by capsule manufacturer.

   C. Prior to installation, store items in dry indoor locations. Provide heating in storage areas for items subject to corrosion under damp conditions.

   D. Cover panels and other elements that are exposed to dusty construction environments.

1.8 **SEQUENCING AND SCHEDULING**

   A. Refer to Section 1D – Special Conditions, Article 1D-14 Contractor Coordination with Others and Section 01010 Summary of Work, for Contractor’s scheduling requirements for sequencing and scheduling.

   B. Note: Field Quality Control Activities may need to be completed in separate stages depending upon metering cutover sequence of activities, backup power availability, assigned priority, and The Authority coordination with SDIA Tenants. For example:


C. Prerequisite Activities and Lead Times: Do not start following key Project activities until prerequisite activities and lead times listed below have been completed and satisfied:

1. Power System SCADA Workshops:
   a. Prerequisite: Notice to Proceed and Qualification Submittal Approval and Complete.

2. Power System SCADA Shop Drawing Reviews by Engineer:
   a. Prerequisite: Engineer acceptance of Schedule of Values and Progress Schedule.
   b. Workshops: Corresponding workshops in progress.
   c. Schedule: In accordance with completed schedule of Shop Drawing and Sample submittals specified in Section 1D – Special Conditions, Article 1D-11A Submittals.

3. PSS Test Prerequisite: Associated test procedures Submittals completed.

4. PSS Training Prerequisite: Associated training plan Submittal completed.

5. PSS Training Sessions Prerequisite: Action Submittals and Shop Drawings approved.

6. PSS Hardware Assembly and Application Software by PSS Integrator at PSS Integrator’s Office.
   a. Prerequisite: Action Submittals and workshops completed.
   b. Duration: 6 Months

7. PSS Hardware and Software Unwitnessed, and Witnessed (SDT, and FDT) by PSS Integrator at PSS Integrator’s Office.
   a. Prerequisite: Action and Informational Submittals and workshops completed; SDT and FDT Test Procedure Submittals completed.
   b. Application software completed.
   c. Required power system equipment Shop Drawings approved, equipment assembled and delivered to SDT and FDT facility for testing.
   d. Duration: 1 Month: 25 Days Unwitnessed Testing (programming, testing, de-bug, corrective actions prior to Witnessed Testing) and 5 Days Witnessed Testing.
8. Shipment of PSS Hardware and Software to Project Site:
   a. General Prerequisites:
      1) Approval of PSS Shop Drawings and preliminary operation and maintenance data.
      2) Unwitnessed, Witnessed (SDT and FDT) completed.

9. Functional Test Part 1 Prerequisite: PSS Hardware and Software complete; pad mounted switchgear, protective relaying, controls panels, power system modifications, raceway, cables, fiber-optic cables, power, and all terminations are complete and labeled.

10. Functional Test Part 2 Prerequisite: Functional Test Part 1 completed.

11. Performance Test Prerequisite: Functional Test Part 2 completed and facility started up.

1.9 MAINTENANCE

A. Maintenance Service Agreement:
   1. Duration of 3 years unless otherwise noted in PSS subsections.
   2. Start on date of Substantial Completion.
   3. Performed by factory-trained and certified service Engineers with experience on PSS systems to be maintained and employed by PSS.
   4. PSS Systems Covered: PSS components, RTAC, IED, Protective Relaying HMI Hardware and Software, and Application Software.
   5. Materials and labor for preventive maintenance and bi-monthly Site visits.
   6. Materials and labor for demand maintenance with coverage 24 hours per day, 7 days per week.
   7. Response Time: Service Engineer shall be onsite within 4 hours of request by the Authority.
   8. Spare Parts: If not stocked onsite, delivered to Site within 24 hours from time of request.
   9. Repair or replace components or software found to be faulty.
   10. Update PSS application and vendor operating system software on PSS hardware with latest upgrades and revisions.
   11. Manage GE Global Care Premium 2 Years and Global Care Complete 3 Years as specified in PSS subsections.
12. Replace and restock within 1 month onsite spare parts and expendables used for maintenance. Provide list of items used and replaced.

13. Submit records of inspection, maintenance, calibration, repair, and replacement within 2 weeks after each Site visit.

B. Telephone Support: As specified in PSS subsections.

C. Software Subscription: Provide subscriptions supporting licenses, updates, and revisions to programming for three years and as specified in PSS subsections.

1.10 SPARES AND EXTRA MATERIALS

A. Provide spares as Listed Below and as specified in PSS subsections:

1. Spare Qty (1) Real-time Automation Controller SEL-3530 (each type used).

2. Spare Qty (1) Protective Relay SEL-451 (each type used).

3. Spare Qty (1) Protective Relay SEL-487V (each type used).

4. Spare Qty (1) Communication Modules SEL-ICON (each module type used: Fiber Backbone Interface, IRIG, DNP3, Ethernet, RS-485, and etc).

5. Spare Qty (1) Remote Input-Output Modules SEL-2240 (each module type used: DI, DO, AI, AO, and etc).

6. Spare Qty (1) Remote Input-Output Modules SEL-2250 (each type used).

7. Spare Qty (1) Rack Mounted DC Power Supply and Charger (each type used).

8. Spare Qty (1) Instrument AC-DC Power Supply (each type used).

9. Spare Qty (1) Power Meter E-Mon/D-Mon (each type used)

10. Spare Qty (3) Low Voltage Current Transformers (each type used).

11. Spare Qty (3) Low Voltage Potential Transformers (each type used).

12. Spare Qty (3) Low Voltage Control Power Transformers (each type used).
13. Spare Qty (5%) Control Switches (each type used Open- Close, Trip, Lock-Out, Local-Remote, Test).

14. Spare Qty (5%) Terminal Devices (each type used).

15. Spare Qty (5%) Fiber-Optic Interface Modules (each type used).

16. Spare Qty (5%) Intrusion Door Switches (each type used).

17. Spare Qty (5%) Low Voltage Surge Arrestors (each type used).

18. Spare Qty (10%) Low Voltage Control Circuits Fuses and Protectors (each type used).

B. In computing spare parts quantities based on specified percentages, round up to nearest whole number.

C. Expendables: For following items provide manufacturer’s recommended 2-year supply, unless otherwise noted.


2. Spray pump filter adhesive; Hoffman Model A-FLTAD. One pint per panel with air filters.

PART 2 PRODUCTS

2.1 GENERAL

A. Provide PSS functions shown on Drawings and required in PSS subsections for each system and control description. Furnish equipment items required in PSS subsections. Furnish materials, equipment, and software, whether indicated or not, necessary to effect required system and control performance.

B. First Named Manufacturer: PSS design is based on first named manufacturers of equipment, materials, and software.

1. If an item is proposed from other than first named manufacturer, obtain approval from Engineer for such changes in accordance with the Section 1D-Special Conditions, Article 1D-11A Submittals.

2. If proposed item requires, but not limited to, different installation, wiring, raceway, enclosures, intrinsically safe barriers, and accessories, provide such equipment and work at no additional cost to the Authority.
C. **Like Equipment Items:**

1. Use products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer’s services.

2. Implement same or similar functions in same or similar manner. For example: control logic, sequence controls, and display layouts.

### 2.2 COMPONENTS, INSTRUMENTS, AND PANELS

A. **Specifications:** Refer to Section 26 09 13, Power Measurement and Control for specifications on PSS components.

B. **Components:** Major components for each PSS application are listed in Instrument List, referenced in Article Supplements. Furnish equipment that is necessary to achieve required control performance.

C. **Control Panels:** Reference this Section and Control Panel Schedule in Article Supplements.

### 2.3 NETWORK AND HMI HARDWARE AND SOFTWARE COMPONENTS

A. **Reference Section 26 09 15, Power System Digital Network and Computer Equipment.**

### 2.4 SERVICE CONDITIONS

A. **Standard Service Conditions:** The following defines certain types of environments. PSS subsections refer to these definitions by name to specify the service conditions for individual equipment units. Design equipment for continuous operation in these environments:

1. **Computer Room, Air Conditioned:**
   a. **Temperature:** 60 degrees F to 80 degrees F.
   b. **Relative Humidity:** 40 percent to 60 percent.
   c. **CEC Classification:** Nonhazardous.

2. **Inside, Air Conditioned:**
   a. **Temperature:**
      1) **Normal:** 60 degrees F to 80 degrees F.
      2) **With Up to 4-Hour HVAC System Interruptions:** 40 degrees F to 100 degrees F.
   b. **Relative Humidity:**
      1) **Normal:** 10 percent (winter) to 70 percent (summer).
      2) **With Up to 4-Hour HVAC System Interruption:** 10 percent to 100 percent.
   c. **CEC Classification:** Nonhazardous.
3. Inside:
   a. Temperature: degrees F to 100 degrees F.
   b. Relative Humidity: 10 percent to 95 percent noncondensing.
   c. CEC Classification: Nonhazardous.

4. Outside, Corrosive:
   a. Temperature: 20 degrees F to 100 degrees F.
   b. Relative Humidity: 0 to 100 percent rain, fog.
   c. Corrosive Environment: Marine air.
   d. CEC Classification: Nonhazardous.

B. Standard Service Conditions for Panels and Consoles: Unless otherwise noted, in Instrument List Control Panel Schedule located in Article Supplements at End of Section, design equipment for continuous operation in these environments:

1. Freestanding Panel and Consoles:
   b. Inside: NEMA 12.
   c. Outside: NEMA 4X.

2. Smaller Panels and Assemblies (that are not freestanding):
   a. Inside, Air Conditioned: NEMA 12.
   b. All Other Locations: NEMA 4X.

3. Field Elements: Outside NEMA 4X.

2.5 NAMEPLATES AND TAGS

A. Panel Nameplates: Enclosure identification located on enclosure face.
   1. Location and Inscription: Refer to Schedules and Drawings.
   2. Materials: Laminated plastic attached to panel with stainless steel screws.
   3. Letters: 1/2-inch-high, white on black background, unless otherwise noted.

B. Component Nameplates, Panel Face: Component identification located on panel face under or near component.
   1. Location and Inscription: As shown on panel Drawing.
   3. Letters: 3/16-inch-high, white on black background, unless otherwise noted.
C. Component Nameplates, Back of Panel: Component identification located on or near component inside of enclosure.
   1. Inscription: Component tag number.
   3. Letters: 3/16-inch-high, white on black background, unless otherwise noted.

D. Legend Plates for Panel Mounted Pushbuttons, Lights, and Switches.
   1. Inscription:
      a. Refer to table under Paragraph Standard Pushbutton Colors and Inscriptions.
      b. Refer to table under Paragraph Standard Light Colors and Inscriptions.
      c. Refer to Point IO Drawings.
   2. Materials: Stainless steel, keyed legend plates. Secured to panel by mounting nut for pushbutton, light, or switch.
   3. Letters: Black on gray or white background.

E. Service Legends: Component identification nameplate located on face of component.
   1. Inscription: As shown on panel Drawing.
   3. Letters: 3/16-inch-high, white on black background, unless otherwise noted.

F. Nametags: Component identification for field devices.
   1. Inscription: Component tag number.
   4. Mounting: Affix to component with 16-guage or 18-gauge stainless steel wire or stainless steel screws.
2.6 FUNCTIONAL REQUIREMENTS FOR CONTROL DESCRIPTIONS

A. Shown on Electrical One-Line Drawings, Point IO Drawings, Panel and Electrical Protective Relay Control Diagrams. Supplemented by Control Descriptions specifying control requirements not obvious on Electrical One-Lines, Point IO Drawings and protective relaying diagrams.

B. Supplemented by standard functional requirements in PSS subsections.

2.7 CONTROL DESCRIPTIONS

A. See Article Supplements located at End of Section.

B. Organization: By primary selective loop and Point IO Diagrams.

C. Control Description Subheadings:

1. Hardwired Special Functions: Clarifies functional performance of loop, including abstract of complex interlocks for hard wired logic, for example in ATOs, Switchgear, and control panels.

2. RTAC, IED, and Protective Relaying Special Functions: Specifies standard and nonstandard functions. When required for clarification, additional definition is shown by logic diagrams or sequence diagrams on Drawings.

3. HMI Special Functions: Specifies standard and nonstandard HMI functions.

2.8 ELECTRICAL REQUIREMENTS

A. Electrical Raceways: As specified in Section 26 05 33, Raceway and Boxes.

B. Wiring External to PSS Equipment:

1. Special Control and Communications Cable: Provided by PSS Integrator as noted in Component Specifications and PSS subsections.

2. Other Wiring and Cable: As specified in Section 26 05 05, Conductors.

C. PSS and electrical components, terminals, wires, and enclosures UL recognized or UL listed.

D. Wires within Enclosures:

1. ac Circuits:
   a. Type: 600-volt, Type MTW stranded copper.
   b. Size: For current to be carried, but not less than No. 18 AWG.
2. Analog Signal Circuits:
   a. Type: 600-volt stranded copper, twisted shielded pairs or triad with a 100 percent, aluminum-polyester shield, rated 60 degrees C.
   b. Panels with Circuits Less Than 600 volts: Rated at 600 volts. Belden No. 18 AWG Type 9341, Triad Beldon No. 1121A.
   c. Size: No. 18 AWG, minimum.

3. Other dc Circuits.
   a. Type: 600-volt, Type SIS or MTW stranded copper.
   b. Size: For current carried, but not less than No. 18 AWG.

4. Special Signal Circuits: Use manufacturer’s standard cables.

5. Wire Identification: Numbered and tagged at each termination.
   a. Wire Tags: Machine printed, heat shrink.
   b. Manufacturers:
      1) Brady Perma Sleeve.
      2) Tyco Electronics.
      3) Or equal.

E. Terminate and identify wires entering or leaving enclosures as follows:

1. Analog and discrete signal, terminate at numbered terminal blocks.

2. Special signals terminated using manufacturer’s standard connectors.

3. Identify wiring in accordance with requirements in Section 26 05 05, Conductors.

4. Identify and terminate wiring from IO to field terminal devices as required to support present, future, and spare interface. For example if Drawing shows future component (i.e. solar, power load) terminate IO accordingly to support future connections.

F. Terminal Blocks for Enclosures:

1. Quantity:
   a. Accommodate present, future, and spare indicated needs.
   b. Wire present, future, and spare IO points to terminal blocks.
   c. One wire per terminal for field wires entering enclosures.
   d. Maximum of two wires per terminal for No. 18 AWG wire for internal enclosure wiring.
   e. Spare Terminals: 20 percent of connected terminals, but not less than 5 per terminal block, unless otherwise shown on Drawings.
2. Terminal Blocks:
   a. General:
      1) Connection Type: Screw compression clamp.
      2) Compression Clamp:
      3) Complies with DIN-VDE 0611.
      4) Hardened steel clamp with transversal grooves that penetrate wire strands providing a vibration-proof connection.
      5) Guides strands of wire into terminal.
      1) Current Bar: Copper or treated brass.
      2) Insulation:
         3) Thermoplastic rated for minus 55 degrees C to plus 110 degrees C.
         4) Two funneled shaped inputs to facilitate wire entry.
   c. Mounting:
      1) Standard DIN rail.
      2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
      3) End Stops: Minimum of one at each end of rail.
   d. Wire Preparation: Stripping only permitted.
   e. Jumpers: Allow jumper installation without loss of space on terminal or rail.
   f. Marking System:
      1) Terminal number shown on both sides of terminal block.
      2) Allow use of preprinted and field marked tags.
      3) Terminal strip numbers shown on end stops.
      4) Mark terminal block and terminal strip numbers as shown on panel control diagrams and loop diagrams.
      5) Fuse Marking for Fused Terminal Blocks: Fuse voltage and amperage rating shown on top of terminal block.

3. Terminal Block, General Purpose:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 30 amps.
   c. Wire Size: 24 AWG to 10 AWG.
   d. Rated Wire Size: 10 AWG.
   e. Color: Gray body.
   f. Spacing: 0.25 inch, maximum.
   g. Manufacturers and Products:
      1) Phoenix Contact; Type UT4/UT4-TWIN.
      2) Entrelec; Type M4/6.T.
      3) Or equal.

4. Terminal Block, Ground:
   a. Wire Size: 24 AWG to 10 AWG.
   b. Rated Wire Size: 10 AWG.
   c. Color: Green and yellow body.
   d. Spacing: 0.25 inch, maximum.
   e. Grounding: Electrically grounded to mounting rail.
5. Manufacturers and Products:
   a. Phoenix Contact; Type UT4-PE-UT4-TWIN-PE.
   b. Entrelec; M4/6.P.
   c. Or equal.

6. Terminal Block, Blade Disconnect Switch:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 10 amps.
   c. Wire Size: 22 AWG to 10 AWG.
   d. Rated Wire Size: 10 AWG.
   e. Color: Gray body, orange switch.
   f. Spacing: 0.25 inch, maximum.
   g. Manufacturers and Products:
      1) Phoenix Contact; Type UT4-PE-UT4-TWIN-PE.
      2) Entrelec; M4/6.SNT.
      3) Or equal.

7. Terminal Block, Isolating Terminal:
   a. Rated Voltage: 125VDC.
   b. Rated Current: 10 amps.
   c. Wire Size: 22 AWG to 10 AWG.
   d. Rated Wire Size: 10 AWG.
   e. Color: Gray body, orange switch.
   f. Spacing: 0.25 inch, maximum.
   g. Manufacturers and Products:
      1) Phoenix Contact.
      2) Entrelec.
      3) Or equal.

8. Terminal Block Diode:
   a. Rated Voltage: 24V dc.
   b. Rated Current: 30 mA.
   c. Wire Size: 16 AWG.
   d. Manufacturers and Products:
      1) Phoenix Contact, Type ST-IN.
      2) Entrelec.
      3) Or equal.

9. Terminal Block, Fused, 24V dc:
   a. Rated Voltage: 600V dc.
   b. Rated Current: 25 amps.
   c. Wire Size: 22 AWG to 10 AWG.
   d. Rated Wire Size: 10 AWG.
   e. Color: Gray body.
   f. Fuse: 0.25 inch by 1.25 inches.
   g. Indication: LED diode 24V dc.
   h. Spacing: 0.512 inch, maximum.
i. Manufacturers and Products:
   1) Schneider Electric/Square D;
   2) Phoenix Contact; Type UT6-HESILED (24)
   3) Entrelec; Type ML10/13/SFD.
   4) Or equal.

10. Terminal Block, Fused, 125V dc:
   b. Rated Current: 6 amps.
   c. Wire Size: 22 AWG to 10 AWG.
   d. Rated Wire Size: 10 AWG.
   e. Color: Black body.
   f. Fuse: 0.25 inch by 1.25 inches.
   g. Leakage Current: 1.8 mA, maximum.
   h. Spacing: 0.512 inch, maximum.
   i. Manufacturers and Products:
      1) Schneider Electric/Square D.
      2) Phoenix Contact; Type UT4-HESI.
      3) Entrelec.
      4) Or equal.

11. Terminal Block, Fused, 120V ac, High Current:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 35 amps.
   c. Wire Size: 18 AWG to 8 AWG.
   d. Rated Wire Size: 8 AWG.
   e. Color: Gray.
   f. Fuse: 13/32 inch by 1.5 inches.
   g. Spacing: 0.95 inch, maximum.
   h. Manufacturers and Products:
      1) Schneider Electric/Square D.
      2) Phoenix Contact; Type UK10.3-HESILED
      3) Entrelec; MB10/24.SF
      4) Or equal.

G. Relays:

1. General:
   b. Relay Enclosure: Furnish dust cover.
   c. Socket Type: Screw terminal interface with wiring.
   d. Socket Mounting: Rail.
   e. Provide hold-down clips.

2. Signal Switching Relay:
   a. Type: Dry circuit.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 5 amps at 28V dc or 120V ac.
   d. Contact Material: Gold or silver.
   e. Coil Voltage: As noted or shown.
f. Coil Power: 0.9 watt (dc), 1.2VA (ac).
g. Expected Mechanical Life: 10,000,000 operations.
h. Expected Electrical Life at Rated Load: 100,000 operations.
i. Indication Type: Neon or LED indicator lamp.
j. Seal Type: Hermetically sealed case.
k. Manufacturers and Products:
   1) Potter and Brumfield; Series KH/KHA.
   2) IDEC; Series RR.
   3) Or equal.

3. Type: Compact general purpose plug-in.
   a. Contact Arrangement: 3 Form C contacts.
   b. Contact Rating: 20A at 28V dc or 120V ac, and 6.6A at 240V ac.
   c. Contact Material: Silver cadmium oxide alloy.
   d. Coil Voltage: As noted or shown.
   e. Coil Power: 1.8 watts (dc), 2.7VA (ac).
   f. Expected Mechanical Life: 10,000,000 operations.
   g. Expected Electrical Life at Rated Load: 100,000 operations.
   h. Indication Type: Neon or LED indicator lamp.
   i. Push-to-test button.
   j. Manufacturers and Products:
      1) Potter and Brumfield; Series KUP.
      2) IDEC; Series RR.
      3) Or equal.

4. Type: Compact general purpose plug-in.
   a. Contact Arrangement: 2 Form C contacts.
   b. Contact Rating: 20 amps 125Vdc.
   c. Contact Material: Silver cadmium oxide alloy.
   d. Coil Voltage: 125V dc.
   e. Coil Power: 1.5 Watts.
   f. Expected Mechanical Life: 10,000,000 operations.
   g. Expected Electrical Life at Rated Load: 100,000 operations.
   h. Indication Type: Neon or LED indicator lamp.
   i. Push-to-test button.
   j. Manufacturers and Products:
      1) Potter and Brumfield; Series KUH, KRP.
      2) IDEC; Series RR.
      3) Or equal.

5. Control Circuit Switching Relay, Latching:
   a. Type: Dual coil mechanical latching relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 28V dc or 120V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 2.7 watts (dc), 5.3VA (ac).
   g. Expected Mechanical Life: 500,000 operations.
   h. Expected Electrical Life at Rated Load: 50,000 operations.
i. Manufacturers and Products:
   1) Potter and Brumfield; Series KB/KBP.
   2) IDEC; Series RR2KP.
   3) Or equal.

6. Control Circuit Switching Relay, Time Delay:
   a. Type: Adjustable time delay relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 30V dc or 277V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Operating Temperature: Minus 10 degrees C to 55 degrees.
   g. Repeatability: Plus or minus 2 percent.
   h. Delay Time Range: Select range such that time delay setpoint falls between 20 percent and 80 percent of range.
   i. Time Delay Setpoint: As noted or shown.
   j. Mode of Operation: As noted or shown.
   k. Adjustment Type: Integral potentiometer with knob external to dust cover.
   i. Manufacturers and Products:
      1) Potter and Brumfield; Series CB for 0.1-second to 100-minute delay time ranges, Series CK for 0.1- second to 120-second delay time ranges.
      2) IDEC; Series RTE/GT3.
      3) Or equal.

H. Instrument DC Power Supplies:

1. Furnish as required, to power instruments requiring external dc power, including two-wire transmitters and dc relays. Provide dual power supplies with diode auctioneered outputs.

2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.

3. Convert dc to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.

4. Provide output over voltage and over current protective devices to:

5. Protect instruments from damage due to power supply failure.

6. Protect power supply from damage due to external failure.

8. Mount such that dissipated heat does not adversely affect other components.

9. Fuses: For each dc supply line to each individual two-wire transmitter.

10. Type: Indicating.

11. Mount so fuses can be easily seen and replaced.

12. Manufacturer and Product:
   a. Power-One; O-Din, W-Din Series.
   b. Phoenix Contact; Quint-PS.
   c. Sola; Son Series.
   d. Or equal.

I. Grounding of Enclosures:

1. Furnish isolated copper grounding bus for signal and shield ground connections (isolated not mounted to enclosure and bonded to enclosure grounding bus with single bonding conductor).

2. Ground this ground bus at a common signal ground point in accordance with National Electrical Code requirements.

3. Single Point Ground for Each Analog Loop:
   a. Locate signal ground at dc power supply for loop.
   b. Use to ground wire shields for loop.
   c. Group and ground wire shields in following locations: Power source (power supplies).

4. Ground terminal block rails to ground bus.

J. Analog Signal Isolators:

1. Furnish signal isolation for analog signals that are sent from one enclosure to another.

2. Do not wire in series instruments on different panels, cabinets, or enclosures.

K. Intrinsic Safety System Installation:


2. Install intrinsically safe circuits in a separate wire way that:
   a. Is separated from non-intrinsically safe circuits as specified by CEC.
   b. Is colored light blue and has message “Intrinsically Safe Circuits Only” on raceway cover every 6 inches.
L. Wiring Interface: Terminate and identify wiring entering or leaving enclosures.

1. Analog and Discrete Signal Wires: Terminate at numbered terminal blocks as shown on the wiring diagrams.

2. Wiring for Special Signals: Terminate communications, digital data, and multiplexed signals using manufacturer’s standard connectors for the device to which the signals terminate.

M. Electrical Transient Protection:

1. General:
   a. Function: Protect elements of PSS against damage due to electrical transients induced in interconnecting lines by lightning and nearby electrical systems.
   b. Surge suppressors are not shown for external analog transmitters. Determine quantity and location, and show in Shop Drawings. Refer to example wiring in installation details in Drawings.
   c. Provide, install, coordinate, and inspect grounding of surge suppressors at:
      1) Connection of ac power to PSS equipment including panels, consoles assembles, and field-mounted analog transmitters and receivers.
      2) At the field and panel, console, or assembly connection of signal circuits that have portions of the circuit extending outside of a protective building.

N. Surge Suppressor Types:

1. General:
   a. Construction: First-stage high-energy metal varistor and oxide second-stage bipolar silicon avalanche device separated by Series impedance; includes grounding wire, stud, or terminal.
   b. Response: 5 nanoseconds maximum.
   d. Temperature Range: Minus 20 degrees C to plus 85 degrees

2. Suppressors on 120V ac Power Supply Connections:
   a. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE C62.41 Category B test waveform.
   b. First-Stage Clamping Voltage: 350 volts or less.
   c. Second-Stage Clamping Voltage: 210 volts or less.
   d. Continuous Operation: Power supplies for one four- wire transmitter or receiver: 5 amps minimum at 130V ac. All other applications: 30 amps minimum at 130V ac.
3. Suppressors on Analog Signal Lines:
   a. Test Waveform: Linear 8 microsecond rise in current form 0 amps to a peak current value followed by an exponential decay of current reaching one-half the peak value in 20 microseconds.
   b. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
   c. dc Clamping Voltage: 20 percent to 40 percent above operating voltage for circuit.
   d. dc Clamping Voltage Tolerance: Less than plus or minus 10 percent.
   e. Maximum Loop Resistance: 18 ohms per conductor.

4. Physical Characteristics:
   a. Mounted in Enclosures: Encapsulated in flame retardant epoxy.
   b. For Analog and DC Discrete Signals Lines:
      1) EDCO PC-642 or SRA-6 Series.
   c. Phoenix Contact; Plugtrab PT or TT Series.
   d. For 120V ac Discrete Lines:
      1) EDCO HSP-121.
      2) Phoenix Contact; Plugtrab PT or TT Series.
      3) Or equal.
   e. Field Mounted at Two-Wire Instruments: Encapsulated in stainless steel pipe nipples.
      1) EDCO SS64 Series.
      2) Phoenix Contact; SPD Series.
      3) Or equal.

5. Field Mounted at Four-Wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistors on signal lines, all in enclosure.
   a. Enclosure:
   b. NEMA 4X fiberglass or Type 316 stainless steel with door.
   c. Maximum Size: 12 inches by 12 inches by 8 inches deep.
   d. Manufacturers and Products:
      1) EDCO; SLAC Series.
      2) Transector; ACP Series.
      3) Phoenix Contact; BXT Series.
      4) Innovative Technologies.
      5) Or equal.

6. Installation and Grounding of Suppressors:
   a. As shown. See Surge Suppressor Installation Details.
   b. Grounding equipment, installation of grounding equipment, and terminations for field mounted devices are provided under Division 26, Electrical.
2.9 PANEL FABRICATION

A. General:

1. Nominal Panel Dimensions: Refer to Control Panel Schedule in Article Supplements for maximum external dimensions allowed for individual control panels.

2. Instrument Arrangements: Refer to Drawings Typical Local Control Panel Layout and Typical Local Control Panel Schedule Drawings.

3. Panel Construction and Interior Wiring: In accordance with the California Electrical Code (CEC), state and local codes, and applicable sections of NEMA, ANSI, UL, and ICECA.

4. Fabricate panels, install instruments and wire, and plumb at PSS Integrator’s facility. No fabrication other than correction of minor defects or minor transit damage permitted onsite.

5. UL Listing Mark for Enclosures: Mark stating “Listed Enclosed Industrial Control Panel” per UL 508A.

6. Electrical Work: In accordance with the applicable requirements of Division 26, Electrical and CEC Article 409.

B. Temperature Control:

1. Freestanding Panels:
   a. Nonventilated Panels: Size to adequately dissipate heat from equipment mounted inside panel and on panel.
   b. Ventilated Panels:
      1) Furnish with louvers and forced ventilation as required to prevent temperature buildup from equipment mounted inside panel and on panel.
      2) For panels with backs against wall, furnish louvers on top and bottom of panel sides.
      3) For panels without backs against wall, furnish louvers on top and bottom of panel back.
      4) Louver Construction: Stamped sheet metal.
      5) Ventilation Fans:
         a) Furnish where required to provide adequate cooling.
         b) Create positive internal pressure within panel.
         c) Fan Motor Power: 120V ac, 60-Hz, thermostatically controlled.
6) Air Filters: Washable aluminum, Hoffman Series A-FLT.
   a) Refrigerated System: Furnish where heat dissipation cannot be adequately accomplished with natural convection or forced ventilation.

2. Smaller Panels (that are not freestanding): Size to adequately dissipate heat from equipment mounted inside panel and on panel face.

3. Space Heaters:
   a. Thermostatically controlled to maintain internal panel temperatures above dew point.
   b. Refer to Control Panel Schedule in Article Supplements.

C. Outdoor SCADA Cabinets:

1. Materials:
   a. Aluminum, sheet steel, as noted in Control Panel Schedule in Article Supplements.
   b. Minimum Thickness: 10-gauge, unless otherwise noted.

2. General: NEMA 250 Type 4X Free standing indoor/outdoor enclosure supporting the rack mounting of data communication equipment including: protective relaying, fiber optic and copper patch panels, network switches, power supply, batteries, power supplies, environmental controls, and other ancillary data communication equipment.

3. Hardware Specifications:
   a. Solid Frame: 0.125 inches, gauge alumiflex enclosure with alumishield top cover and stainless steel handles, screws, fasteners, and gasketed doors and covers.
   b. Enclosure standard 19-inch EIA rack structure, 42U front, 42U back.
   c. Front and rear access doors with 3-point, 316-stainless steel locking handles.
   d. Enclosure Fan Kit and space heater with T-stat, 120V ac.
   e. Grounding bar.
   f. Power strips, NEMA 20R 120V, 20 amps power outlets.
   g. Dimensions: 84 inches high by 25 inches wide by 34 inches.


5. Manufacturer:
   a. DDB Unlimited.
   b. Schweitzer Engineering Laboratories, Inc
   c. California Chassis.
   d. Pentair.
   e. Or equal.
D. Freestanding Panel Construction:

1. Materials:
   a. Aluminum, sheet steel, as noted in Control Panel Schedule in Article Supplements.
   b. Minimum Thickness: 10-gauge, unless otherwise noted.

2. Panel Front:
   a. Fabricated from a single piece of sheet steel, unless otherwise shown on Drawings.
   b. No seams or bolt head visible when viewed from front.
   c. Panel Cutouts: Smoothly finished with rounded edges.
   d. Stiffeners: Steel angle or plate stiffeners or both on back of panel face to prevent panel deflection under instrument loading or operation.

3. Internal Framework:
   a. Structural steel for instrument support and panel bracing.
   b. Permit panel lifting without racking or distortion.

4. Lifting rings to allow simple, safe rigging and lifting of panel during installation.

5. Adjacent Panels: Securely bolted together so front faces are parallel.

6. Internal Rails: 19” EIA standard as shown.

7. Door:
   a. Full height, fully gasketed access door where shown on Drawings.
   b. Latch: Three-point, Southco Type 44.
   c. Handle: “D” ring, foldable type.
   d. Hinges: Full-length, continuous, piano-type, steel hinges with stainless steel pins.
   e. Rear Access: Extend no further than 24 inches beyond panel when opened to 90-degree position.
   f. Front and Side Access Doors: As shown on Drawings.

E. Non-freestanding Panel Construction:

1. Based on environmental design requirements and referenced in Article Environmental Requirements, provide the following unless otherwise noted in Control Panel Schedule in Article Supplements:
   a. Panels listed as inside, air conditioned:
      1) Enclosure Type: NEMA 1.
      2) Materials: Steel.
   b. Other Panels:
      1) Enclosure Type: NEMA 4X.
      2) Materials: Aluminum or Type 316 stainless steel as shown.

3. Doors:
   a. Rubber-gasketed with continuous hinge.
   b. Stainless steel lockable quick-release clamps.

4. Manufacturers:
   a. Schweitzer Engineering Laboratories, Inc.
   b. DDB Unlimited.
   d. H. F. Cox.
   e. Or equal.

F. Breather and Drains: Furnish with NEMA 250, Type 4 and 4X panels:
   1. Manufacturer and Product:
      a. Cooper Crouse-Hinds; ECD Type 4X Drain and Breather; b. Drain Model ECD1-N4D, Breather Model ECD1-N4B
      b. O-Z/Gedney.
      c. Or equal.

G. Control Panel Electrical:
   1. Power Distribution within Panels:
      a. Feeder Circuits:
         1) One or more 120V ac, 60-Hz, and 1250V dc feeder circuits as shown on Drawings.
         2) Make provisions for feeder circuit conduit entry.
         3) Furnish terminal block for termination of wires.
      b. Power Panel: Furnish main circuit breaker and circuit breaker on each individual branch circuit distributed from power panel.
         1) Locate to provide clear view of and access to breakers when door is open.
         2) Breaker Sizes: Coordinate such that fault in branch circuit will blow only branch breaker, but not trip main breaker.
            a) Branch Circuit Breakers: 15 amps at 250V ac.
            b) Branch Circuit Breakers: 15 amps at 125V dc.
            c) Breaker Manufacturers and Products: Refer to Division 26.
      c. Circuit Wiring: Point IO Drawings and Control Diagrams on Drawings show general wiring diagrams that use the following rules for circuit wiring:
         1) Devices on Single Circuit: 20, maximum.
         2) Multiple Units Performing Parallel Operations: To prevent failure of any single branch circuit from shutting down entire operation, do not group all units on same branch circuit.
         3) Branch Circuit Loading: 12 amperes continuous, maximum.
4) Panel Lighting and Service Outlets: Put on separate 15 amp, 120V ac branch circuit.
5) Provide 120V ac plug mold for panel components with line cords.

2. Signal Distribution:
   a. Signal Wiring: Separate analog signal cables from power and control within a panel and cross at right angles where necessary.
   b. Within Panels: 4 to 20 mA dc signals may be distributed as 1V dc to 5V dc.
   c. Outside Panels: Isolated 4 to 20 mA dc only.
   d. Signal Wiring: Twisted and shielded cables for all signal applications: pairs, triads, multi-twisted pairs, Cat5E, IRIG-B coax and etc.
   e. RTD and Thermocouple Extension Cable:
      1) Continuous field to panel with no intermediate junction boxes or terminations.
      2) Terminate thermocouple extension wire directly to loop instrument.

3. Signal Switching:
   a. Use dry circuit type relays or switches.
   b. No interruption of 4 to 20 mA loops during switching.
   c. Switching Transients in Associated Signal Circuit:
      1) 4 to 20 mA dc Signals: 0.2 mA, maximum.
      2) 1V dc to 5V dc Signals: 0.05V, maximum.

4. Push-to-Test Circuitry: For each push-to-test indicating light, provide a fused push-to-test circuit.

5. Internal Panel Lights for Freestanding Panels:
   a. Type: Switched LED lighting package.
   b. Quantity: One light for every 4 feet of panel width.
   c. Mounting: Inside and in the top of back-of-panel area.
   d. Protective metal shield for lights.

6. Service Outlets for Freestanding Panels:
   b. Quantity:
      1) Panels 4 Feet Wide and Smaller: One.
      2) Panels Larger than 4 Feet Wide: One for every 4 feet of panel width, two minimum per panel.
   c. Mounting: Evenly spaced along back-of-panel area.
7. Internal Panel Lights and Service Outlets for Smaller Panels:
   b. Service Outlet: Breaker protected 120-volt, 15-amp, GFCI duplex receptacle:
   c. Required for panels. Refer to Control Panel Schedule in Article Supplements.

8. Standard Pushbutton Colors and Inscriptions:
   a. Use following unless otherwise noted Instrument List:
   b. Lettering Color:
      1) Black on white and yellow buttons.
      2) White on black, red, and green buttons.

9. Standard Light Colors and Inscriptions:
   a. Use following color code and inscriptions for service legends and lens colors for indicating lights, unless otherwise noted in Instrument List:
   b. Lettering Color:
      1) Black on white and amber lenses.
      2) White on red and green lenses.

H. PSS Enclosure Internal Wiring:

1. Restrain by plastic ties or ducts or metal raceways.

2. Hinge Wiring: Secure at each end so bending or twisting will be around longitudinal axis of wire. Protect bend area with sleeve.

3. Arrange wiring neatly, cut to proper length, and remove surplus wire.

4. Provide abrasion protection for wire bundles that pass through holes or across edges of sheet metal.

5. Connections to Screw Type Terminals:
   a. Locking-fork-tongue or ring-tongue lugs.
   b. Use manufacturer’s recommended tool with required sized anvil to make crimp lug terminations.
   c. Wires terminated in a crimp lug, maximum of one.
   d. Lugs installed on a screw terminal, maximum of two.

6. Connections to Compression Clamp Type Terminals:
   a. Strip, prepare, and install wires in accordance with terminal manufacturer’s recommendations.
   b. Wires installed in a compression screw and clamp, maximum of one for field wires entering enclosure, otherwise maximum of two.

7. Splicing and tapping of wires, allowed only at device terminals or terminal blocks.
8. Terminate 24V dc and analog signal circuits on separate terminal block from ac circuit terminal blocks.

9. Separate analog and dc circuits by at least 6 inches from ac power and control wiring, except at unavoidable crossover points and at device terminations.

10. Arrange wiring to allow access for testing, removal, and maintenance of circuits and components.


12. Conductors Carrying Foreign Voltages within a Panel:
   a. Route foreign voltage conductors into panel and land on a circuit blade disconnect type terminal block.
   b. Use wire with pink insulation to identify foreign voltage circuits within panel from terminal block on. Do not use wires with pink insulation for any other purpose.

13. Harness Wiring:
   a. 120V ac: No. 14 AWG, MTW.
   b. 24V dc: No. 16 AWG, MTW where individual conductors are used and Type TC shielded tray cable where shielded wire is used.

14. Panel work:
   a. No exposed connections.
   b. Allow adjustments to equipment to be made without exposing these terminals.
   c. For power and control wiring operating above 80V ac or dc use covered channels or EMT raceways separate from low voltage signal circuits.

15. Plastic Wire Ducts Color:
   a. 120V ac: White.
   b. 125V dc: Gray.
   c. 24V dc: Gray.
   d. Communications Cables and Fiber Optic Jumpers: Orange.

16. Provide a communications plastic wire duct for communications cables and fiber optic cables between the communications devices in control panel and communications raceways. Design plastic wire duct design to take into account the minimum bending radius of the communications cable.

17. Make plastic wire ducts the same depth.

18. Provide a minimum of 1-1/2 inches between plastic wire ducts and terminal blocks.
I. Control Relay Arrangement: Install control relays associated with specific loops in same panel section as corresponding terminal blocks or side panels. Provide 20 percent space for future relays. Locate spare space in same sections as spare terminal blocks.

J. Factory Finishing:

1. Furnish materials and equipment with manufacturer’s standard finish system.

2. Use specific color as indicated. All outdoor mounted enclosures not specifically chosen by the Authority shall be painted Munsell Green. All color samples shall be submitted to The Authority for Review and Approval.


5. Steel Panels:
   a. Sand panel and remove mill scale, rust, grease, and oil.
   b. Fill imperfections and sand smooth.
   c. Paint panel interior and exterior with one coat of epoxy coating metal primer, two finish coats of two-component type epoxy enamel.
   d. Sand surfaces lightly between coats.
   e. Dry Film Thickness: 3 mils, minimum.

2.10 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsules:

1. Areas Where Required: Refer to Part 3, Article Protection.

2. Manufacturers and Products:
   a. Northern Instruments; Model Zerust VC.
   b. Hoffmann Engineering; Model A-HCI.
   c. Or equal.

2.11 TEST EQUIPMENT AND TOOLS

A. Digital Multimeter:

1. Type: Industrial True RMS Digital Multimeter, CAT IV 600V protection with test leads, removable test probes, long reach alligator clips, magnetic hanger, temperature probe, and carrying case.

2. Quantity: 2.
3. Manufacturers and Products:
   a. Fluke; Model 87V/E Industrial Electrician Combo Kit.
   b. Greenlee; Model DM-860.
   c. Extech; Model EX530.
   d. Or equal.

B. Clamp-on Ammeter:

1. Type: True RMS Digital Clamp-on meter with 3-1/2-digit display and protective case.

2. Quantity: 1.

3. Manufacturers and Products:
   a. TES; Model 3040.
   b. Fluke; Model 337E.
   c. Greenlee; Model CMI-100.
   d. Extech; Model EX830.
   e. Or equal.

C. DC Digital Process Signal Calibrator:

1. Type: Portable, two-channel, with test leads, rechargeable batteries, charger, and carrying case.

2. Quantity: 2.

3. Manufacturers and Products:
   a. Transmation; Model 1045-01.
   b. Fluke; Model 789.
   c. Extech; Model CMM17.
   d. Or equal.

D. Datalogger:

1. Type: Portable Handheld Multichannel Datalogger, USB communications, Graphical Display, with Analysis Software.

2. Quantity: 1.

3. Manufacturers and Products:

4. Graphtec; Model GL200A.

5. Omega; Model OM-DAQPRO-5300.

6. Or equal.
E. Mirror Bits Tester:

1. Type: Portable Handheld, cable, communications, Graphical Display, with Analysis Software.

2. Quantity: 1.

3. Manufacturers and Products:

4. Schweitzer Engineering Laboratory Inc.; SEL-4388.

5. Or equal, (no known equal).

2.12 SOURCE QUALITY CONTROL

A. General:

1. Engineer will actively participate in many of the tests.

2. Engineer reserves right to test or retest specified functions.

3. Engineer’s decision will be final regarding acceptability and completeness of testing.

4. Contractor and PSS Integrator shall coordinate and supply on-hand all personnel and testing equipment to support all Source Quality Control activities.

5. Procedures, Forms, and Checklists:
   a. Except for Unwitnessed Factory Test, conduct tests in accordance with, and documented on, Engineer accepted procedures, forms, and checklists.
   b. Describe each test item to be performed.
   c. Have space after each test item description for sign off by appropriate party after satisfactory completion.

6. Required Test Documentation: Test procedures, forms, and checklists signed by the Authority, Engineer, and Contractor.

7. Conducting Tests:
   a. Provide special testing materials and equipment.
   b. Wherever possible, perform tests using actual process variables, equipment, and data.
   c. If not practical to test with real process variables, equipment, and data provide suitable means of simulation.
   d. Define simulation techniques in test procedures.
e. Test Format: Cause and effect.
   1) Person conducting test initiates an input (cause).
   2) Specific test requirement is satisfied if correct result (effect), occurs.

B. Unwitnessed Factory Tests:

1. Scope: Inspect and test PSS to ensure it is operational, ready for Witnessed SDT and FDT.

2. Location: PSS Integrator’s facility.

3. Integrated Test:
   a. Interconnect and test PSS, except for primary elements and smaller panels.
   b. Exercise and test functions.
   c. Provide stand-alone testing of all hardware, software, computers, communications, power equipment, and panels as assembled to demonstrate a complete SDT and FDT.
   d. Simulate inputs and outputs for primary elements, final control elements, and panels excluded from test.

C. Witnessed Software Demonstration Test (SDT) and Factory Demonstration Test (FDT):

1. Contractor shall coordinate and schedule factory tests with PSS Integrator, Hardware and Software Manufacturer Representatives, and Engineer.

2. Contractor shall be present with PSS Integrator, Hardware and Software Manufacturer Representatives, and Engineer for Witnessed SDT and FDT.

3. Contractor shall include costs to send and retrieve (2) pad mounted switchgear. Reference Specification Section 26 13 16.02 Pad-Mounted Switchgear for additional requirements. Equipment shall not be released back to supplier until all testing is completed.

4. Test reports shall indicate test procedures and instrumentation used to measure and record data.

5. Test reports shall be certified by testing personnel and stamped and signed by a PSS Integrator Professional Engineer Licensed in the State of California.

6. Contractor and PSS Integrator shall supply on-hand all personnel and testing equipment to support SDT and FDT activities.
7. Notify Engineer of test schedule 5 weeks prior to start of test.

8. Scope:
   a. Test entire PSS, with exception of primary elements, final control elements, and certain smaller panels, to demonstrate it is operational.
   b. Refer to Control Panel Schedule in Article Supplements for list of panels for which FDT is required.
   c. Refer to Specification Section 26 13 16.02 Pad-Mounted Switchgear for additional information on shipment of two (2) Pad- Mounted Switchgear to support unwitnessed and witnessed and factory demonstration testing. Provide, personnel, hardware, software, tools, and support personnel to receive, set-up, wire, test, document, pad mounted switchgear. When testing is complete, support the retrieval of pad mounted switchgear.

9. Location: PSS Integrator’s facility.

10. Correctness of wiring from panel field terminals to RTAC, IED, Protective Relaying, system input/output points and to panel components.
    a. Simulate each discrete signal at terminal strip.
    b. Simulate correctness of each analog signal using current source.

11. Operation of communications between RTAC, IED, Protective Relaying, remote IO and HMI.

12. Loop-Specific Functions: Demonstrate functions shown on Point IO Drawings, control diagrams, loop specifications and agreed upon decisions stemming from Workshops as identified within Specification Section 26 09 16, Power System Application Software:
    a. All required and shown functions for 100 percent of loops including but not limited to: manual and automatic controls, HMI displays, operator interface commands, data collection, trending, alarming, reporting, and data synchronization.

13. Non-loop-Specific Functions:
    a. Capacity: Demonstrate that PSS systems have required spare capacity for expansion. Include tests for both storage capacity and processing capacity.
    b. Timing: Include tests for timing requirements.
    c. Diagnostics: Demonstrate online and offline diagnostic tests and procedures.

14. Correct deficiencies found and complete prior to shipment to Site.
15. Failed Tests:
   a. Repeat and witnessed by Engineer.
   b. With approval of Engineer, certain tests may be conducted by PSS Integrator and witnessed by Engineer as part of Functional Test.

16. Make following documentation available to Engineer at test site both before and during SDT and FDT:
   b. Master copy of SDT and FDT procedures.
   c. List of equipment to be tested including make, model, and serial number.
   d. Written Authority Approved Hardware Shop Drawings for equipment being tested.
   e. Written Authority Approved preliminary software documentation Submittal.

17. Daily Schedule for SDT and FDT:
   a. Begin each day with meeting to review day’s test schedule.
   b. End each day with each meeting to review day’s test results and to review or revise next day’s test schedule.

PART 3 EXECUTION

3.1 EXAMINATION

A. For equipment not provided by PSS Integrator, but that directly interfaces with PSS, verify the following conditions:
   1. Proper installation.
   2. Rating and calibration of instruments (voltage sensors, current transformers, potential transformers, position switches, temperature transmitters).
   3. Rating and calibration of SDG&E and The Authority operated IEDs and protective relaying.
   4. Correct control actions.
   5. Switch settings and dead bands.
   6. Opening and closing speeds and travel stops.
   7. Input and output signals.
   8. Labels, identifications, tags, and documentation.
3.2 INSTALLATION

A. Material and Equipment Installation: Follow manufacturers’ installation instructions, unless otherwise indicated or directed by Engineer.

B. Wiring connected to PSS components and assemblies, including control, fiber-optic, and power wiring in accordance with requirements in Section 26 05 05, Conductors.

C. Electrical Raceways: As specified in Section 26 05 33, Raceway and Boxes.

D. Mechanical Systems:

Enclosure Lifting Rings: Remove rings following installation and plug holes.

E. Field Finishing: Manufacturer’s instructions. Outdoor enclosures shall be Munsell 7GY3.29/1.5, olive green. The following SCADA Enclosures shall require a custom color:

1. SCP – FBO-520.
2. SCP – RCC – 530.

F. All color samples shall be submitted to the Authority for Review and Approval.

3.3 FIELD QUALITY CONTROL

A. General:

1. Coordinate PSS testing with The Authority, Engineer, and affected SUB-Contractors.

2. Notify the Authority and Engineer of Functional and Performance Test schedule 4 weeks prior to start of test.

3. The Authority and Engineer may actively participate in tests.

4. The Authority and Engineer reserves right to test or retest specified functions.

5. Engineer’s decision will be final regarding acceptability and completeness of testing.

6. Field Quality Control may need to be completed in various stages depending upon metering cutover sequence of activities, backup power availability, assigned priority, and the Authority coordination with SDIA Tenants. For example:


B. Onsite Supervision:

1. Require PSS Integrator to observe PSS equipment installation to extent required in order to provide Certificates of Proper Installation.

2. Require PSS site representative to supervise and coordinate onsite PSS activities.

3. Require PSS site representative to be onsite while onsite work covered by this section and PSS subsystems is in progress.

C. Current and Power Tests: In preparation of Functional Test Part 1, conduct power tests in accordance with Section.

D. Testing Sequence:

1. Provide Functional Tests and Performance Tests for facilities as required to support staged construction and startup of plant.

2. Refer to article Order of Work under Section 1D – Special Conditions, Article 1D-14 Contractor Coordination with Others, and Section 01010 Summary of Work, for a definition of project milestones.

3. Refer to Section 01910, Commissioning.

4. Completion: When tests (except Functional Test) have been completed and required test documentation has been accepted.

E. Testing:

1. Prior to Facility Startup and Performance Evaluation period for each facility, inspect, test, and document that associated PSS equipment is ready for operation. Divide Functional Test into two parts.

2. Functional Test Part 1: Performed by Contractor and PSS Integrator to test and document PSS, is ready for operation.
   a. Loop/Component Inspections and Tests:
      1) These inspections and tests will be spot checked by the Authority and Engineer.
      2) Check PSS for proper installation, calibration, and adjustment on loop-by-loop and component-by-component basis.
      3) Provide space on forms for signoff by PSS Integrator.
4) Use loop status report to organize and track inspection, adjustment, and calibration of each loop and include the following:
   a) Project name.
   b) Loop number.
   c) Tag number for each component.
   d) Checkoffs/Signoffs for Each Component:
      (1) Tag/identification.
      (2) Installation.
      (3) Termination wiring.
      (4) Calibration/adjustment.
   e) Checkoffs/Signoffs for the Loop:
      (1) Panel interface terminations.
      (2) IO interface terminations with RTAC, IED, and Protective Relaying.
   f) IO Signals for RTAC, IED, Protective Relaying, IO and IO MODULES are Operational: Received/sent, processed, and adjusted.
   g) Total loop operational.
   h) Space for comments.

5) Component calibration sheet for each active PSS component (except simple hand switches, lights, gauges, and similar items) and each RTAC, IED, Protective Relaying IO module and include the following:
   Project name.
   Loop number.
   c) Component tag number or IO module number.
   d) Component code number for PSS elements.
   e) Manufacturer for PSS elements.
   f) Model number/serial number for PSS elements.
   g) Summary of Functional Requirements;
      For Example:
      1) Indicators and recorders, scale and chart ranges.
      2) Transmitters/converters, input and output ranges.
      3) Computing elements' function.
      4) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual).
   h) IO Modules: Input or output.
      1) Calibrations, for example, but not limited to: Analog Devices: Actual inputs and outputs at 0, 10, 50, and 100 percent of span, rising and falling.
      2) Discrete Devices: Actual trip points and reset points.
3) IO Modules: Actual inputs or outputs of 0, 10, 50, and 100 percent of span, rising and falling.

4) Space for comments.

b. Maintain loop status reports and component calibration sheets at Site, and make them available to Engineer at all times.

c. Engineer reviews loop status sheets and component calibration sheets and spot-check their entries periodically, and upon completion of Preparation for Testing. Correct deficiencies found.

d. SDT and FDT Repeat:
   1) Repeat SDT and FDT onsite with installed PSS equipment and software.
   2) As listed in PSS subsections, certain portions of SDT and FDT may not require retesting.
   3) Use SDT and FDT test procedures as basis for this test.
   4) In general, this test shall not require witnessing. However, portions of this test, as identified by Engineer during original SDT and FDT shall be witnessed.

e. Forms: See Loop Status Report, Instrument Calibration Sheet, and PSS Adjustment Sheet referenced in Article Supplements.

3. Functional Test Part 2: Combined effort between Contractor, PSS Integrator, the Authority, and Engineer to confirm PSS hardware, software, and all application software are functioning.
   a. Prerequisite: Completion of Functional Test Part 1. Completed when Functional Test has been conducted and
   b. Engineer has spot-checked associated test forms and checklists in field.

4. Required Test Documentation: Test procedures, forms, and checklists. Signed by Engineer and Contractor except for Functional Test items signed only by Contractor.

F. Performance Test During and After Facility Startup:

1. Once a facility’s Functional Test has been completed and that facility has been started up, perform a witnessed Performance Test on associated PSS equipment to demonstrate that it is operating as required by Contract Documents. Demonstrate each required function on a paragraph-by-paragraph, loop-by-loop, and site-by-site basis.

2. Loop-specific and nonloop-specific tests same as required for FDT except that entire installed PSS tested using actual process variables and functions demonstrated.

3. Perform local and manual tests for each loop before proceeding to remote and automatic modes.
4. Where possible, verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by others, as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.

5. Make updated versions of documentation required for Performance Test available to Engineer at Site, both before and during tests.

6. Make O&M data available to Engineer at Site both before and during testing.

7. Follow daily schedule required for SDT and FDT.

8. Determination of Ready for Operation: When Functional Test has been successfully completed.

9. Refer to examples of Performance Test procedures and forms in Article Supplements.

G. Commissioning: Reference Section 01910, Commissioning.

3.4 MANUFACTURER’S SERVICES

A. Manufacturer’s Representative: As required by each PSS subsection.

B. Specialty Equipment: For certain components or systems provided under this section, but not manufactured by PSS Integrator, provide services of qualified manufacturer’s representative during installation, startup, demonstration testing, and training. Provide original equipment manufacturer services for three (3) years.

C. See Section 01 43 33, Manufacturer’s Field Services.

3.5 TRAINING

A. General:

1. Provide an integrated training program for the Authority personnel.

2. Perform training to meet specific needs of the Authority’s personnel.

3. Include training sessions, classroom and field, for managers, Engineers, operators, and maintenance personnel.

4. Provide instruction on two working shift(s) as needed to accommodate the Authority’s personnel schedule.
5. The Authority reserves the right to reuse videotapes of training sessions.

B. Vendor Training RTAC:

1. Length: 2 days.

2. Location: Vendor’s facility.

3. Objective: Provide the Authority with the ability to identify major parts, panel indicators, communication ports; understanding of hardware functionality and capability, communication protocols, perform basic programming, login-in and security features, set-up and configurations; access hardware using programming laptop and software for the purpose of viewing programs, communication status, perform basic program searches, review logic, tables, configurations, messages, error codes, and generate reports.

4. Attended by the Authority operations: 6 attendees.

5. Primary Topics:
   b. RTAC Initial Setup and Security.
   c. acScLerator RTAC® SEL-5033 Software Overview.
   d. RTAC Client/SEL-351S Server and DNP/IP.
   e. RTAC Client/SEL-351S Server and SEL Protocols.
   f. RTAC Client/SEL-351S Server and Modbus® TCP.
   g. Mirrored Bits® Communications and IEC 61131-3.
   h. RTAC Client/SEL-351S Server and IEEE C37.118.
   i. RTAC DNP/IP Server.
   j. RTAC Logging and ODBC.

C. Vendor Training Power System and Protective Relaying:

1. Length: 4 days.

2. Location: Vendor’s facility.

3. Objective: Provide the Authority with a detailed re-presentation on power system fundamentals including: power equations and calculations, circuit protection, various protective relaying applications, fault analysis, power system planning, reporting, and standards.

4. Attended by the Authority operations: 6 attendees.
5. Primary Topics:
   a. Power system basics including per-unit and three-phase power concepts.
   b. Symmetrical component concepts and fault analysis.
   c. Relaying fundamentals.
   d. Applications of overcurrent, directional, distance, and differential relays to protect distribution lines, transmission lines, buses, and transformers.
   e. Distribution system protective devices and their coordination.
   f. Distance and pilot protection schemes used for transmission line protection.
   g. System aspects of protection.
   h. Event reporting and analysis.
   i. Power System Basics, including PV Solar generation interface.
   j. Electrical Equipment Damage.
   k. Power System Balanced Faults.
   l. Introduction to Symmetrical Components (includes a class exercise).
   m. Power System Unbalanced Faults.
   n. Relaying Fundamentals.
   o. Instrument Transformers: CTs and VTs (includes a class exercise).
   p. Protective Relay Design.
   q. Introduction to Line Overcurrent Protection.
   r. Coordination of Overcurrent Protection in Radial Systems.
   s. Line Directional Overcurrent Protection.
   t. Transformer Overcurrent and Mechanical Protection.
   u. Transformer Differential Protection (includes a class exercise).
   v. Bus Protection (includes a class exercise).
   w. Transmission Line Distance Protection Concepts.
   x. Transmission Line Distance Protection Issues.
   y. Line Pilot Protection.
   z. System Aspects of Protection.

D. Vendor Training HMI:

1. Length: 1 Week.

2. Location: Vendor’s facility.

3. Objective: Provide THE AUTHORITY Operations with the ability to identify and understand various software applications, understanding software functionality and capability and hardware requirements, login and security features, set-up and load software, access and import software revisions, import/export and print software functions for displays, databases, scripts, and controls; configure, edit, and add to databases, displays, trends, alarms, scripts, menus, pop-ups, and various controls.
4. Attended by the Authority operations: 6 attendees.

5. Primary Topics Session 1:
   a. Understand communication between HMI Servers and Client nodes.
   b. Configure HMI nodes using the System Configuration Utility.
   c. Configure IO Drivers to communicate with HMI.
   d. Create and modify standard Process Database tags.
   e. Create graphic screens (pictures) using a wide variety of object types and animations.
   f. Design and build a picture navigation strategy.
   g. Create basic scripts using Visual Basic for Applications (VBA).
   h. Configure alarming and create screens to monitor and acknowledge alarms.
   i. Use trending to monitor both real-time and historical data.
   j. Design and build a system-wide security strategy.
   k. Use a variety of HMI Utilities and Operating System administrative options to troubleshoot project or system process faults.

6. Primary Topics Session 2:
   a. Integrate HMI with OPC servers and Clients.
   b. Advanced configuration with Database Blocks.
   c. Integrate HMI with Historian.
   d. Integrate HMI with Relational Databases (RDBs).
   e. Extend HMI Alarm systems to RDBs and Historian.
   f. Work with Charts and Chart Groups.
   g. Master Dynamic Object creation and maintenance.
   h. Work with ActiveX components.
   i. Develop schedules to automate workflows and processes.
   j. Drive reports with HMI.
   k. Configure Server Fail-over and Redundancy.
   l. Prepare HMI for use with Terminal Server.

E. Vendor Training Communications:

1. Length: 2 days.

2. Location: Vendor’s facility.

3. Objective: Provide the Authority personnel with a basic understanding of network hardware addressing, login-in and security features, communications protocols, data collision and recovery, layer 2/layer 3 functionality, SNMP and network management.

4. Attended by the Authority operations: 6 attendees.

5. Primary Topics:
b. Network Overview.
c. Network Management System Software.
e. Serial Channel Provisioning.
f. Provisioning an Ethernet Channel.
g. Managed, Unmanaged, Security Gateway, and ICON Testing and Maintenance.

F. Management Seminar:

1. Length: 2 days.

2. Location: the Authority’s facility.

3. Objective: Provide overview for non-operations and maintenance personnel for understanding the PSS.

4. Attended by the Authority Management, Engineers, and other non-operations and non-maintenance personnel.

5. Primary Topics:
   a. PSS Overview: How hardware and software are used for operation and control of facilities.
   b. Block Diagram Presentation of PSS: How and what information flows within system and what is done by each functional unit.
   c. HMI: Explanation and demonstration of how to use HMI to access displays, reports, and controls.
   d. Management-oriented explanation of data management displays and printouts.
   e. Walk-through of installed systems.

G. Operations and Maintenance Training:

1. General:
   a. Refer to specific requirements specified in PSS Subsections.
   b. Include review of O&M data and survey of spares, expendables, and test equipment.

2. Use equipment similar of that provided.

3. Unless otherwise specified in PSS subsections, provide training suitable for instrument technicians with at least a 2-year associate engineering or technical degree, or equivalent education and experience in electronics, instrumentation, or digital systems.

4. Operations Training: For the Authority’s operations personnel on operation of PSS components.
   a. Training Session Duration: 5 instructor days.
   b. Number of Training Sessions: Two.
   c. Location: Project Site.
d. Mechanism: Training of the Authority operations may be conducted as part of workshop, Application Software Development, SDT, FDT, and Functional Testing.
e. Course Objective: Develop skills needed to use PSS components and functions to monitor and control the system on a day-to-day basis. Provide standard format and initially create five (5) Standard Operating procedures (SOPs) to perform expected operations activities. Assist the Authority in completing these SOPs as their initial set of procedures that are coordinated with SCADA and the HMI.

Content: Conduct training on system by system and control loop by control loop basis (RTACs, IED, Protective Relaying, and HMI).

1) Functions: Understanding local and remote control functions and interlock for each component.
2) Operation: For example, adjusting process variable setpoints, HMI AUTO and MANUAL control, alarming and resetting of alarms.
3) Interfaces with PSS subsystems.

3. Maintenance Training:
a. Training Session Duration: 6 instructor days.
b. Number of Training Sessions: Two.
c. Location: Project Site.
d. Course Objective: Develop skills needed for routine maintenance of PSS. Provide standard format and initially create five (5) Standard Operating Procedures (SOPs) to perform expected maintenance activities. Assist the Authority in completing these SOPs as their initial set of procedures that are coordinated with SCADA and the HMI.
e. Content: Provide training for each type of component and function provided.
f. For protective relaying, provide the Authority Operations with the ability to:
   1) Identify major parts, panel indicators, communication ports.
   2) Understand hardware functionality.
   3) Understand communication protocols.
   4) Perform basic login-in, set-up, and configurations.
   5) Access hardware using programming laptop and software for the purpose of viewing programs, communication status, perform basic program searches, review logic, tables, configurations, messages, error codes, and generate reports.

g. For reporting: Provide the Authority Operations with the ability to:
   1) Identify and understand various software applications, and templates.
   2) Login-in and security features.
3) Set-up and load software, access and import software revisions.
4) Import/export and print reports, databases, scripts, controls.
5) Configure and edit databases and add new reports.


5. Primary Topics:
   a. Historian and Data Collection.
   b. SQL and Open Database
   c. Synchrophasor and Time-Synchronized Measurement Overview Reports.
   d. Time-Synchronized Configuration.
   e. Phasor Measurement Unit Configuration.
   f. Phasor Data Concentrator Configuration.
   g. Wide-Area Monitoring and Control.
   h. System Visualization.

3.6 CLEANING

   A. Upon completion of Work, remove materials, scraps, and debris from interior and exterior of equipment.

3.7 PROTECTION

   A. Use corrosion-inhibiting vapor capsules in enclosures to protect electrical, instrumentation, and control devices, including spare parts, from corrosion.

   B. Periodically replace capsules based on capsule manufacturer’s recommendations.

3.8 SUPPLEMENTS

   A. Supplements listed below, follows “End of Section,” are part of this Specification.

      1. Control Descriptions.
      2. Instrument List
      3. Input/output List.
5. Preparation for Testing and Functional Test Forms:
a. Loop Status Report: Each sheet shows status of instruments on a loop. Also, gives functional description for loop.
b. Instrument Calibration Sheet: Shows details on each instrument (except simple hand switches, lights, and similar items).
c. Device Calibration Sheet.
d. Contractor to develop additional Forms as required for 5- & 6-Way ATOs.

6. Performance Test Sheet: Describe Performance Test for a given loop.
a. List requirements of the loop.
b. Briefly describe test.
c. Cite expected results.
d. Provide space for check off by witness.

END OF SECTION 26 09 14
SPECIAL PROVISIONS
DIVISION 26 – ELECTRICAL
SECTION 26 09 17
FIBER OPTIC COMMUNICATION SYSTEM

PART 1 GENERAL

1.1 SUMMARY

A. This section covers existing communication elements of the 12KV control system and requirements for the San Diego International Airport (SDIA) Power System SCADA (PSS). This section is included in these specifications in order to provide reference information when additions to the system are planned as part of a new project. The following specification sub-section expands on requirements of this section as it relates to changes or additions to the 12KV electrical system and its SCADA system:

1. Section 26 09 14 POWER SYSTEMS SCADA

B. Additional work under this section shall be based on information provided by the Authority and its Approved Power System SCADA (PSS) Integrator. The Authority is the contact for information regarding the PSS SCADA and will be identified as the contact point for all specific information regarding modifications to the PSS SCADA and its Fiber Optic Communication System.

1.2 REFERENCES

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


2. Institute of Electrical and Electronic Engineers, Inc. (IEEE): 802.3, Telecommunications and Information Exchange Between Systems—Local and Metropolitan Networks.

3. Insulated Cable Engineers Association (ICEA):
   a. S-83-596, Optical Fiber Premises Distribution Cable.
   b. S-87-640, Optical Fiber Outside Plant Communications Cable.
   c. S-104-696, Indoor-Outdoor Optical Fiber Cable.


8. Rural Development Utilities Programs (RDUP):
   a. 7 CFR 1755.902, Minimum Performance Specification for Fiber Optic Cables.
   b. 7 CFR 1755.903, Fiber Optic Service Entrance Cables.

9. Telecommunications Industry Association (TIA):
   b. 526-14, OFSTP-14 Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.
   c. 568-C.1, Commercial Building Telecommunications Cabling Standards.
   d. 568-C.3, Optical Fiber Cabling Components Standard.
   e. 598, Optical Fiber Cable Color Coding.
   f. 606, Administration Standard for Commercial Telecommunications Infrastructure.

10. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
   c. 492AAAA, Detail Specification for 62.5-Micrometer Core Diameter/125-Micrometer Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
   d. 492AAAB, Detail Specification for 50-Micrometer Core Diameter/125-Micrometer Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
   e. 492AAAC, Detail Specification for 850-nm Laser- Optimized, 50-um Core Diameter/125-um Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
   f. 492CAAA, Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers.
   g. 492CAAB, Detail Specification for Class IVa Dispersion- Unshifted Single-Mode Optical Fibers with Low Water Peak.
   h. 604-2, FOCIS-2 Fiber Optic Connector Intermateability Standard, Type ST.
   i. 604-3, FOCIS-3 Fiber Optic Connector Intermateability Standard, Type SC and SC-APC.
   j. 604-12, FOCIS-12 Fiber Optic Connector Intermateability Standard, Type MT-RJ.
k. 942, Telecommunications Infrastructure Standard for Data Centers.


### 1.3 DEFINITIONS

A. ATM: Asynchronous Transfer Mode.

B. AUI: Attachment Unit Interface.

C. dB: Decibel.

D. DNI: Desktop Network Interface.

E. EMB: Effective Modal Bandwidth.

F. ETL: Electrical Test Laboratories.

G. FDDI: Fiber Distributed Data Interface.

H. FIM: Facilities Information Management.

I. Flux Budget: Difference between transmitter output power and receiver input power required for signal discrimination when both are expressed in dBm.

J. FOCS: Fiber Optic Communication System.

K. FOIRL: Fiber Optic Inter Repeater Link.

L. Fusion Splice: Connecting ends of two fibers together by aligning fiber ends and applying electric arc to fuse ends together.

M. Hybrid Cable: Cable containing more than one type of fiber.

N. LAN: Local Area Network.

O. LIMS: Laboratory Information Management System.

P. m: Micrometer.

Q. Mbps: Megabits per Second.

R. Mechanical Splice: Connecting ends of two fibers together by means other than fusion.

S. Megahertz (MHz): One million cycles per second.
T. MHz: Megahertz.
U. micro: x 10-6.
V. Micron: Micrometer or one millionth meter.
W. MIS: Management Information System.
X. n, nano: x 10-9.
Y. N: Newton.
Z. nm: Nanometer—unit of measure equal to one billionth meter.
AA. OFL: Over-filled Launch.
BB. OFN: Nonconductive Optical Fiber Cable.
CC. OFNP: Nonconductive Optical Fiber Plenum Cable.
DD. OFNR: Nonconductive Optical Fiber Riser Cable.
EE. OLTS: Optical Loss Test Sets.
FF. OTDR: Optical Time Domain Reflectometer.
GG. OVD: Outside Vapor Deposit.
HH. PIC: Process Instrumentation and Control.
II. Plenum: Air return path of central air handling system, such as open space above suspended ceiling.
JJ. RLM: Restricted Mode Launch.
KK. ROL: Reverse Oscillation Lay.
LL. SPC: Super Physical Contact.
MM. UPC: Ultra Physical Contact.
PP. WAN: Wide Area Network.
1.3 SYSTEM DESCRIPTION

A. Function of FOCS is to transmit digital data between network nodes. Requirements listed identify minimum acceptable system performance.

B. Provide a FOCS based on referenced standards for use in the following local and wide area networks:

1. Power System SCADA Ethernet Communications (HMI and Field Level).

2. Power System SCADA IRIG-B Communications.

C. Network(s) will be used by HMI, RTAC, Protective Relays, IEDS, Remote IO Units and Power Metering to distribute data and coordinate THE AUTHORITY’s operations.

1.4 SUBMITTALS

A. Action Submittals, submit to The Authority per contract:

1. Site Layout Diagram Showing:
   a. Access holes, with identification.
   b. Abovegrade cable routings, with cable identification.
   c. Belowgrade conduit routings between access holes and buildings, with conduit counts and identification.
   d. Belowgrade innerduct routings through conduits, with innerduct counts and identification.
   e. Cable routings through innerducts to manholes, handholes, patch panels, fiber centers, splice centers, or network nodes, with cable and node identification.
   f. Color coding for cables, innerducts, patchchords, connectorization, repeaters, transceivers, housings, splice enclosures, and network switch connections. Coordinate color coding with the Authority.

2. Cable Schedule Showing:
   a. Cable identification.
   b. Cable slack and loops in access handholes, manholes, and large pull boxes as described under Article Execution.
   c. Fiber counts for each cable and identification of used fiber pairs.
   d. Cable length and attenuation, with connector pairs as shown and no planned number splice(s), based on TIA 568-C.3, Annex H.
3. Component Data:
   a. Manufacturer and model number.
   b. General data and description.
   c. Engineering specifications and data sheet.
   d. Scaled drawings and mounting arrangements.

4. Cable Pulling Calculations: Minimize the number of splices required. Ensure each cable pull is submitted and reviewed before cable installation with the following minimum information and parameters:
   a. Pulling point-to-point diagrams identifying manholes, cable, straight runs, vertical and horizontal bends. Maximum pull length shall be 2,500 feet, unless approved by the Engineer.
   b. Conduit characteristics and coefficients.
   c. Cable characteristics and coefficients.
   d. Conduit bends and radii.
   e. Equations, coefficients, characteristics, methods, and adjustment factors used in calculations.
   f. Conduit horizontal and vertical profiles.
   g. Maximum cable and conduit side wall and cable pulling tensions in and out of bends and sections.
   h. Cable pulling methods (single, dual, cradled, triangular).

B. Informational Submittals, submit to the Authority per contract:

1. Manufacturer’s statement that installer is certified to perform installation Work.

2. Subcontractor Qualifications:
   a. FOCS Subcontractor: Minimum of 5 years’ experience providing, integrating, installing, and commissioning of similar systems.
      1) Statement of Experience: List of at least three fiber optic data communications systems comparable to system specified which have been furnished and placed into operation. For each system, provide following information:
         a) Sub-contractor’s name, address, telephone number, and name of current operations supervisor or other contact.
         b) Description of system hardware configuration, including major equipment items, number of nodes, and communication standards implemented.
         c) System block diagram.
         d) Dates when contract was signed, equipment was delivered, and system was accepted by The Authority. Also, include originally scheduled completion date and if different from actual date, explain why.
e) Approximate value of listed FOCS provided in dollars.
f) Detailed horizontal and riser routing.
g) Distribution frame arrangements.
h) Fiber and termination identification, including spares.

b. FOCS Subcontractor’s Site Representative: Minimum of 5 years’ experience installing similar systems.

c. Qualification of Personnel:
1) Resumes identifying management and technical qualifications of supervisory, local service representative, and key personnel.
2) Qualification data of firm and persons to demonstrate capabilities and experience in the following areas:
   a) Fiber optic cable handling and placement techniques.
   b) Fiber optic splicing and installation of connections.
   c) Attenuation testing procedures.

d. The Authority acceptance of FOCS Subcontractor does not exempt FOCS Subcontractor or Contractor from meeting Contract Document requirements nor does it give prior acceptance of subsystems, equipment, materials, or services.

e. Sample of Network Test Report, minimum 10 pages, that Contractor generated in a previous project.

f. Testing and acceptance plan, 30 days prior to beginning of testing.

g. Fiber test results. Documentation covering fiber facility testing, not later than 2 days after testing, showing:
   1) Manufacturer’s tag of attenuation per fiber as recorded from OTDR reading before shipment.
   2) Attenuation of each fiber upon delivery to Site. Attenuation of each fiber plus connector after installation as recorded from OTDR with tracing.
   3) Flux Budget calculations with comparison to measured attenuation for each run verifying adequate optical signal strength.
   4) Flux Budget calculations with comparison to measured attenuation for each run verifying adequate optical signal strength.

h. For each maintenance organization, identify location of base of service and how required coverage will be achieved.

3. Manufacturer’s Certificate of Compliance, in accordance with Section 1D – Special Conditions, Article 1D-11 Submittal.

4. Manufacturer’s suggested installation practice.

5. Operation and Maintenance Data: As specified in Section 1D – Special Conditions, Article 1D-51 Project Closeout.
1.5 ENVIRONMENTAL REQUIREMENTS

A. Optical Fiber Cable:

1. Outside, Underground/Submerged: Minus 20 degrees C to 40 degrees C.

2. Outside, Aboveground in Conduit: Minus 20 degrees C to 80 degrees C.

3. Inside: 0 degree C to 40 degrees C.

B. Equipment:

1. Outside, Aboveground: Minus 20 degrees C to 80 degrees C.

2. Control Rooms, Equipment Rooms, and Telecommunications Closets: 30 percent to 55 percent relative humidity, 18 degrees C to 24 degrees C.

3. Other Interior Areas: 0 percent to 100 percent relative humidity, 5 degrees C to 35 degrees C.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Cable:
   a. ISO 9001 or QF TL 9000 registered, whichever applies to material.
   b. Minimum of 20 years in manufacturing optical fiber cable in to demonstrate reliable field performance.


3. Connector:
   a. ISO 9001 or QF TL 9000 registered.
   b. Minimum 10-year history of manufacturing and supporting connector technology that does not require epoxy or polishing in field.


B. Installer Qualifications:

1. Individuals with at least 3 years of experience with projects utilizing fiber optic cable in compliance with TIA 568-C.3.
2. Certified by fiber cable manufacturer.

C. Tester Qualifications: Individuals with at least 3 years of experience with projects utilizing fiber optic cable in compliance with TIA 568-C.3.

1. Technician: Successfully attended training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof. Certificate may have been issued by the following organizations or an equivalent organization:
   a. Manufacturer of fiber optic cable and fiber optic connectors.
   b. Manufacturer of test equipment used for field certification.
   c. Other independent training organizations acceptable to the Authority.
   d. Training certificate and manufacturer certifications dated within the last 3 years.

D. Provide connectors/coupling, splicing enclosures, mounting hardware, and miscellaneous accessories for fibers by same manufacturer.

1.7 SPECIAL GUARANTEE

A. Provide manufacturer’s extended guarantee or warranty, with the Authority named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at option of The Authority, removal and replacement of cable and work found defective during a period of 5 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be the responsibility of the Contractor.

PART 2 PRODUCTS

2.1 FIBER OPTIC CABLE

A. General: Single-Mode Fiber Optic Cable employed to establish SCADA fiber backbone and fiber rings throughout SDIA PSS SCADA System.

B. Single-Mode: 8.3/125/250-micron Class IVa dispersion-unshifted optical fibers for use in the backbone distribution system shall meet or exceed requirements of TIA 568-C.3, including the following specifications:

1. Fiber Quantity: 24 Fibers unless otherwise shown.

2. Chromatic Dispersion:
   a. Zero-Dispersion Wavelength: Between 1,302 nm and 1,322 nm.
   b. Maximum value of dispersion slope at zero dispersion wavelength shall be no greater than 0.093 ps per km-nm.

3. Mode Field Diameter: Nominal 8.7 microns to 10 microns, with a tolerance of plus or minus 0.5 micron at 1,300 nm.
4. Maximum Attenuation:
   a. Outside and Indoor-Outdoor Optical Fiber Cable:
      1) 0.5 dB per km at 1,310 nm.
      2) 0.5 dB per km at 1,550 nm.
   b. Inside Optical Fiber Cable:
      1) 1 dB per km at 1,310 nm.
      2) 1 dB per km at 1,550 nm.

5. Cutoff Wavelength of Cabled Fiber: Less than 1,260 nm.

6. TIA 492 CAAB (OS2) low water peak and complies with ITU T G.652 (A to D).

7. Distance Capacity per IEEE 802.3:
   a. 1 Gbit Ethernet, 1,300 nm Laser Minimum Distance: 5000 m.
   b. 10 Gbit Ethernet: 10 km at 850 nm and 40 km at 1,310 nm.

C. Type 8.3/250, Backbone for Underground Conduit and Building Entrance Installation:

2. Fiber Quantity: 24 Fibers unless otherwise shown.


3. Assembly:
   a. Nonmetallic, gel-free, dry water blocked, loose-tube fiber core with dielectric strength member enclosed by nonmetallic cross-ply sheath; requires buffer tubing.
   b. Cable: Comply with ICEA S-104-696.

4. CEC/UL Listing: OFNR.

5. Protective Covering: Black, flame and UV-resistant, thermoplastic jacket with rip-cord.

6. Minimum Short Term Pull Strength: 600 lbf.

7. Manufacturers and Products:
   a. Corning Cabling Systems; FREEDM cable.
   b. Mohawk; RiserLite loose-tube cable.
   c. Or approved equal.

8. Manufacturers and Products:
   a. Corning Cabling Systems; (MIC) cable.
   b. Mohawk; Distribution Riser cable.
   c. Or approved equal.
2.2 MULTIMODE FIBER OPTIC CABLE

A. General: Multi-Mode Fiber Optic Cable employed to create SCADA sub-communications with limited number of local IO devices (i.e. SEL-2505, SEL-3530).

B. 50/125/250-micron, graded-index for use in distribution subsystems, meets or exceeds the requirements of TIA 568-C.3, including the following specifications:

1. Fiber Quantity: 6 Fibers unless otherwise shown.

2. Maximum Mean Fiber Loss:
   a. 3.5 dB per km at 850 nm.
   b. 1.5 dB per km at 1,300 nm.

3. Minimum OFL Bandwidth:
   a. OM3-1500 MHz km minimum at 850 nm; TIA 492AAAC.
   b. 500 MHz km minimum at 1,300 nm.

4. Distance Capacity per IEEE 802.3:
   a. 100Mbit Ethernet: OM3 300m at 850 nm and 2000m at 1,310 nm.
   b. 1 Gbit Ethernet: OM3: 1000m at 850 nm and 600 at 1310 nm.
   c. 10 Gbit Ethernet—10km at 850 nm and 40km at 1310 nm: OM3: 300m at 850 nm and 300 at 1310 nm.

C. Type 50/250 OM3 Backbone for Underground Conduit and Building Installation: SCADA sub-communications with limited number of local IO devices (i.e. SEL-2505, SEL-3530).

1. Fiber Quantity: 6 Fibers unless otherwise shown.

2. Individual Fibers: 50/125/250 microns.

3. Assembly:
   a. Nonmetallic, gel-free, dry water blocked, loose-tube fiber core with dielectric strength member enclosed by nonmetallic cross-ply sheath; requires buffer tubing.
   b. Cable: Comply with ICEA S-104-696.

4. NEC/UL Listing: OFNR. Protective Covering: Black, flame and UV-resistant, thermoplastic jacket with rip-cord.

5. Minimum Short Term Pull Strength: 600 lbf.

6. Manufacturers and Products:
   a. Corning Cabling Systems; FREEDM cable.
   b. Mohawk; RiserLite loose-tube cable.
   c. Or approved equal.
2.3 INNERDUCT CONDUIT SYSTEM

A. Nonmetallic, designed for fiber optic cabling and telecommunications.

B. Flexible Fiber Innerduct:
   1. Function: Install within conduit system provided under Section 26 05 33 Raceway and Boxes, to provide smooth, low friction path through conduit, with only one cable per path to facilitate changing individual cables.
   2. Features:
      a. Size and Count:
         1) 2-inch 2 cell located within 2-inch diameter conduit unless otherwise noted.
         2) 3-inch 3 cell located within 3-inch and greater diameter conduit unless otherwise noted.
      b. Type: Fiber.
      d. Color Code: Orange, blue, green, brown, white, or grey as coordinated with the Authority.
      e. Strength: Minimum 2500-pound tensile strength, with no more than 5 percent ovalization at 600-pound tension.
      f. Lubrication: Prelubricated.
      g. Preloaded pull string.
   3. Manufacturers:
      b. CableGuide Fabric Innerduct.
      c. Or approved equal.

C. Corrugated Flexible Sleeves:
   1. Function: Exposed applications including cable trays, and fiber routing between communication handholes and pullboxes adjacent to, and associated with SCADA cabinets and to provide smooth, low friction path through conduit, with only one cable per path to facilitate changing individual cables.
   2. Features:
      a. Size and Count: Two (2) 1-inch sleeves routed within outer conduits. 1-inch sleeves routed within cable trays to support quantity of fiber-optic cable runs.
      b. Type: Corrugated Flexible and Fire Resistant.
      c. Material: HDPE.
      d. Color Code: Orange, blue, green, brown, white, or grey as coordinated with the Authority.
e. Strength: Minimum 600-pound tensile strength, with no more than 5 percent ovalization at 600-pound tension.

f. Lubrication: Prelubricated.

3. Manufacturers:
   a. Carlon Fire-Flex GP Duct.
   b. Carlon Fire-Flex Riser Duct.
   c. Future Path.
   d. Or approved equal.

2.4 ETHERNET FIBER OPTIC REPEATERS

A. Function: Extends Ethernet communications range beyond 1,000 meters.

B. Features:

1. In accordance with IEEE 802.3.

2. Attaches into Ethernet segment and repeats signals bi-directionally.
   a. Regeneration: Retimes packets, regenerates preamble, extends collision fragments, partitions problem segments, and reconnects non problem segments.
   b. Media: Support fiber optic type specified.
   c. Wavelength: 850 nm.
   d. Fiber Optic Connectors: ST unless shown otherwise.


4. Power: 120V ac.

C. Segments per Repeater, Maximum as shown on Drawings.

D. Fiber Signal: Minimum distance 14 km.

E. Manufacturers:

1. Black Box Corporation.

2. Hewlett-Packard.

3. Newbridge.


5. Or approved equal.
2.5 ETHERNET FIBER-TO-COPPER TRANSCEIVERS

A. Function: Convert half/full-duplex fiber optic Ethernet signal to copper Ethernet signal and vice versa.

B. Speed: Auto-negotiating 10/100/1000 Mbps.

C. Features:
   1. Support fiber optic type specified.
   2. Fiber Optic Connectors: ST unless shown otherwise.
   3. Copper Connector: RJ45 shielded, DB-9, or as shown
   4. Power:
      a. Powered by connecting instrument.
      b. External 120V ac power supply.
      c. As required.
   5. Mounting: Suitable for permanent mounting.
   6. Fiber Signal Distance: 4 km minimum.

D. Manufacturers:
   1. Schweitzer Engineering Laboratories.
   2. ATI Centre.
   3. Hewlett-Packard.
   4. Black Box Corporation.
   5. Or approved equal.

2.6 FIBER DISTRIBUTION FRAME

A. Function: Provides industry-standard rack mounting system for interface between fiber optic backbone and equipment cables.

B. Features:
   1. Used in either cross-connect or interconnect configuration.
   2. 23-inch (584-mm) rack for mounting 19-inch (483-mm) rack mount units.
      a. Accommodates up to 576 fiber terminations per frame.
      b. Accepts connector module housing within same rack.
      c. Fiber Optic Connectors: SC, ST or LC.
3. Fiber/Wire Management System:
   a. Vertical: 75-mm by 100-mm supports on 200-mm centers vertically on four sides (front LHS, back LHS, front RHS, back RHS).
   b. Horizontal: Supports on 100-mm centers horizontally above and below each termination frame front and back. Support may serve frames immediately above and below.

4. Mounting Hardware: Accepts standard 19-inch (483-mm) rack for integrated fiber optic system (for example, hubs, routers, patch panels).

C. Manufacturers:
   1. Black Box.
   2. Ortronics.
   4. Or approved equal.

2.7 FIBER CENTERS

A. Function: Provides secure place to terminate fiber optic cables.

B. Features:
   1. Compartments: Two; one for fiber optic cable, one for jumpers to individual equipment.
   2. Coil Former: Former to wind slack cable around, provides controlled long radius bends.
   3. Connectors: Minimum 24 SC, ST or LC connectors for entry and exit.
   4. Size: Maximum 450 mm by 300 mm by 100 mm.
   5. Construction: 1.5-mm steel with corrosion proof finish.
   6. Mountings: Suitable for permanent attachment as shown, or provide separate mountings that do not obscure covers and doors.
   7. Doors: Separate doors for cable and jumper terminations and lockable.
C. Manufacturers:

1. Black Box.
2. Ortronics.
3. AT&T.
4. Siecor.
5. Or approved equal.

2.8 HOUSINGS

A. Termination Housing:

1. Rack mountable connector housing.
2. Mountable in ECA 310-E compatible 465-mm or 592-mm rack.
3. Available in several sizes, including 1U, 2U, 3U, and 4U. One ECA rack space or panel height (denoted as U) is defined as being 44.45 mm in height.
4. In accordance with design requirements of TIA 568-C.3 and polymer compounds flammability requirements of UL 94.
5. Manufactured using 16-gauge aluminum or equivalent for structural integrity.
6. Finished with wrinkled black powder coat for durability.
7. Provide black installation fasteners.
8. Available sizes with their corresponding fiber capacities are noted below:

<table>
<thead>
<tr>
<th>Unit Size</th>
<th>Panel Capacity</th>
<th>Fiber Capacity with 6f Panes</th>
<th>Fiber Capacity with 12f Panels</th>
<th>Fiber Capacity with 24f Panels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1U</td>
<td>2</td>
<td>12</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>2U</td>
<td>4</td>
<td>24</td>
<td>48</td>
<td>96</td>
</tr>
<tr>
<td>3U</td>
<td>6</td>
<td>36</td>
<td>72</td>
<td>144</td>
</tr>
<tr>
<td>4U</td>
<td>12</td>
<td>72</td>
<td>144</td>
<td>288</td>
</tr>
</tbody>
</table>
A. Manufacturers:
   1. Black Box.
   2. Corning.
   4. Or approved equal.

2.9 SPLICE CLOSURES UNDERGROUND

A. Function: Enclose branch and inline splices in underground applications.

B. Available in canister (butt) and in-line styles to fit most applications.

C. Sizes:
   1. Small: Accommodate up to 72 single-fiber splices or 144 ribbon-fiber splices using 12 fiber ribbons.
   2. Medium: Accommodate up to 288 single-fiber splices or 432 ribbon-fiber splices.

D. Housing:
   1. Nonmetallic, resistant to solvents, stress cracking, and creep.
   2. Material shall be compatible with chemicals and other materials to which they might be exposed in normal applications.

E. End Caps:
   1. Feature two express ports for uncut feeder cables.
   2. Capable of accepting additional cables without removal of sheath retention or strength-member-clamping hardware on previously installed cables or disturbing existing splices.

F. Quick-seal mechanical seal drop ports.

G. Optical Fiber Closure:
   1. Capable of accepting optical fiber cable commonly used in interoffice, outside plant, and building entrance facilities.
   2. Provide clamping mechanism to prevent pistoning of central member or strength members, and to prevent cable sheath slip or pullout.
   3. Ability to double cable capacity of installed canister splice closure by use of a kit. Such a conversion shall not disturb existing cables or splices.
H. Encapsulation shall not be required to resist water penetration.

I. Re-enterable.

J. Bonding:
   1. Provide hardware to facilitate bonding and grounding of metal components in closure and armored cable sheath.
   2. Cable bonding hardware shall be able to accommodate a copper conductor equal to or larger than 6 AWG.

K. Installation shall not require specialized tools or equipment other than those normally carried by installation crews.

2.10 FIBER OPTIC CONNECTOR AND PIGTAILS

A. Pre-polished connectors (preferred) or connectorized pigtails are fusion spliced to the cable. Connectors shall not be installed and polished in the field.
   1. Single-mode, 2 meter length, ultra PC polish, SC connector, fusion spliced, heat shrink protected on the splice.
   2. Multi-mode, 2 meter length, regular polish, SC connector, fusion spliced, heat shrink protected on the splice.

B. Fiber Optic Adapters
   1. Fiber optic adapters shall be color coded to differentiate between single-mode and multi-mode fibers. Blue-colored adapters shall be used for single-mode angled-polished connections, and Beige-colored adapters for multi-mode connections.

C. Fusion-splice Protection Sleeves
   1. The Installer shall protect all fusion splices with rod-reinforced heat-shrink protective sleeves.

D. Splice Trays
   1. The Installer shall use metallic splice trays that contain 24 splices with foam combs and pads for fiber strain relief.
   2. Trays shall be stackable, contain a plastic polycarbonate protective cover, and have a hole in the center for vertical and horizontal mounting.
E. Splice cases shall be water-tight and re-enterable. Secure all cables in the splice case and end plates in accordance with manufacturer’s specifications, ensuring a watertight seal.

F. Exercise special care when assembling the case as to not damage any conductors and/or splice modules. Splicing technicians must have a manufacturer’s installation certification for the splices and splice cases being installed.

1. The splice enclosure shall not be flooded with encapsulate.

2. Perform a pressure test each case for leaks at 12 psi, ensuring a watertight seal.

3. Bond the cable’s metallic sheath/shield (if armored) to the metallic splice case with the bonding bar assembly provided with the splice case, and in accordance with manufacturers specifications.

4. Connect the splice case to the manhole/building grounding grid using a #6 AWG solid copper wire or bonding tape.

2.11 CONNECTORS

A. General:


2. SC, ST, LC, and V-PIN connectors. SDIA Information Technology Infrastructure Standards Construction Manual preferences the use of LC connectors with Fiber Patch Panels. Coordinate this standard requirement during the Submittal process based upon hardware to be provided.

3. Pull Strength: 0.2 N minimum.

4. Durability: Sustain minimum 500 mating cycles without violating other requirements.
   b. Polarizing key on duplex connector systems.

5. Attenuation:
   a. In accordance with TIA 568-C.3.
   b. Maximum of 0.75 dB per connector pair.
B. Manufacturer:

1. Schweitzer Engineering Laboratories, Inc.
2. AMP.
3. Black Box.
4. Or approved equal.

2.12 PATCHCORDS

A. General:

1. In accordance with TIA 568-C.3.
2. Function: Connect fiber centers to network nodes, such as computer workstations and end devices (switches, IED, RTAC).
3. Fiber Characteristics: In accordance with requirements for fiber optic cable.
4. Cable Configuration:
   a. Individual tight-buffer thermoplastic, fibers single or multimode, to match fibers being jumpered on.
   b. Protected with kevlar strength members and enclosed in thermoplastic jacket.
5. Length: Standard, to meet requirements shown, plus minimum 3 meters at workstations.
6. Connectors:
   a. As required by Article Connectors.
   b. On-axial Pull Strength: 33 N.
   c. Normal-to-Axial Pull Strength: 22 N.
7. Cable Rating: OFNR or OFNP.
8. Color: Per standards or as indicated.
9. Measured for insertion loss with the following values for each connector:
   a. Typical of 0.3 dB and maximum of 0.5 dB (LC typical of 0.1 dB and maximum of 0.3 dB).
   b. OM3 fiber shall be measured for insertion loss with the following values for each connector pair: Typical of 0.15 dB and maximum of 0.25 dB.
B. Manufacturers:
1. Schweitzer Engineering Laboratories, Inc.
2. Black Box.
3. Corning.
4. Or approved equal.

2.13 COLOR CODING

A. Fiber Optic Adapters:
1. Fiber optic adapters shall be color coded to differentiate between single-mode and multi-mode fibers. Blue-colored adapters shall be used for single-mode angled-polished connections, and Beige-colored adapters for multi-mode connections.

2. Single mode and Multimode fibers.
   a. Single Mode: Yellow.
   b. Multi-mode: Orange or Aqua.
   c. Ethernet: Green or Blue.

B. Isolated grounds to reduce electrical noise shall be provided if specified. Isolated grounding receptacles shall be colored orange or marked with an orange triangle.

C. Innerducts: Orange.

D. Conduits: Reference Section 26 05 33, Raceway and Boxes.

2.14 CONDUIT

A. In accordance with Section 26 05 33, Raceway and Boxes.

2.15 SPARES

A. Provide the following spares as specified in this Section:
2. Qty (1) Reel 1000 Feet of Multi-Mode: 50/125/250-micron, 6-Fiber.
3. Spare Qty (10%) Fiber-Optic Connectors (each type used).
4. Spare Qty (5%) Fiber-Optic Patch Chords (each type used).
5. Spare Qty (5) Fiber-Optic Transceivers (each type used).
6. Spare Qty (2) Fiber-Optic Repeaters (each type used).

7. Spare Qty (2) Fiber-Optic Termination Splice Kits complete (each type used).

2.16 ACCESSORIES

A. Hardware: Provide cable clamps, strain reliefs, blocking and grommet kits, closures, and fan outs for complete installation.

PART 3 EXECUTION

3.1 PREPARATION

A. Conduit:

1. Ensure installed conduit system conforms to fiber optic system requirements, including:
   a. Conduits and Innerducts: Size and number.
   b. Access Holes, Handholes, and Pull Boxes: Location and size, to ensure cables and innerducts may be installed without exceeding manufacturer's limitations.
   c. Outlet Boxes: Size to coordinate with outlet cover plates for adequate volume and bend radius.

2. Expansion Plugs: Seal conduit to stop ingress of water and grit with fabricated expansion plugs.

3. Existing Conduit:

4. Ensure duct bank, conduit, and other confined routing is free and clear of debris before cable placement.

B. Innerduct:

1. In accordance with manufacturer's recommendations.

2. In all fiber optic conduits.

3. Install no more than one innerduct of each color in single conduit.

4. Terminate innerducts in conduit with fabricated termination kits.

5. Identify innerducts at both ends by methods such as color-coding or waterproof tags wired through innerduct wall.

6. Sealing:
   a. Cabled Innerducts: Seal cables into innerducts to stop ingress of water and grit with fabricated expansion seals that have separate seals for each cable.
b. Innerduct to Conduit: Seal gaps between innerducts and conduit with sealing compound such as 3M Ductseal.

c. Empty Innerducts: After installation, seal with fabricated expansion plugs to stop ingress of water and grit. Remove plugs as required to install cables.

### 3.2 INSTALLATION

#### A. Fiber Optic Cable:

1. Specified fiber counts, routing, origination, and terminating points are shown on Drawings.

2. Install three (3) loops of fiber-optic cable slack within each communications access handhole, manhole and large pull box encompassing the interior dimensions of the communication access handhole, manhole, and large pull box. Reference access supports this section.

3. Install (loop) 60 minimum feet of fiber-optic cable slack within communications access handhole and manhole which support future ATO and SCP applications as shown on Drawings.

4. Installation by manufacturer’s certified installer.

5. Install cables in accordance with manufacturer’s requirements.

6. Install cable directly from shipping reels. Ensure that cable is:
   a. Not dented, nicked, or kinked.
   b. Not subjected to pull stress greater than manufacturer’s specification.
   c. Not bent to a radius below manufacturer’s minimum bend radius.
   d. Not subjected to treatment that may damage fiber strands during installation.

7. Cables per Conduit or Innerduct: In accordance with NFPA 70 NEC conduit fill limitations.

8. During installation, the minimum bending radius shall be 20 times the cable diameter. After installation the minimum bending radius shall be 10 times the cable diameter.

9. If fiber optic cable is damaged during installation, movement or storage, the Installer shall replace the cable at the Installer’s expense.

10. There shall be NO repairs to damaged cable. Damaged cable shall be removed from the site and replaced with a new cable.
11. Except for fusion-spliced connectors or factory-connectorized, pre-terminated pigtails, the Installer shall not use fusion splicing or mechanical splicing to repair any damage to any part of the cable prior-to, during, or after installation.

12. Damage includes but is not limited to; breaks in the fiber opens, abrading the cable jacket to expose the fibers or conductors, bending the cable more than the manufacturer’s specification for bend radius and exceeding the manufacturer’s tensile load installation specification.

13. All installed lengths of fiber shall be brand new and continuous. The Installer shall not fusion splice two short pieces of cable to make a longer piece, unless providing distribution from a high count cable to lower count cables.

14. Fibers optic cables run underground shall have three labels attached. One label shall be attached on the spare coiled-up fiber or in the center between the entrance and exit of the manhole. One label shall be attached within twelve inches of the entrance and one label within twelve inches of the exit of the conduits in the manhole.

15. If calculation indicates cable will attenuate signals more than 8 dB, reroute may be allowed if approved by Engineer.

16. Splices:
   a. Install fiber optic cables in un-spliced lengths from fiber centers to fiber centers unless with the Authority approval and inspection, the fiber distances require outside splices in access holes and as protected by splice closures.
   b. With the Authority written approval and inspection use fusion or mechanical splice fibers, using apparatus applicable to type and size of fiber being spliced. Insert loss of splicing unit shall not exceed 0.2 dB on single-mode fibers and 0.25 dB on multimode fibers.
   c. Splice cases shall be watertight and re-enterable. Secure all cables in the splice case and end plates in accordance with manufacturer’s specifications, ensuring a watertight seal.
   d. Exercise special care when assembling the case as to not damage any conductors and/or splice modules. Splicing technicians must have a manufacturer’s installation certification for the splices and splice cases being installed.
   e. Splice modules should contain encapsulate to prevent water damage in the event the case is damaged and water enters the case.
   f. The splice enclosure must not be flooded with encapsulate.
   g. Perform a pressure test each case for leaks at 12 psi, ensuring a watertight seal.
h. Bond the cable’s metallic sheath/shield (if armored) to the metallic splice case with the bonding bar assembly provided with the splice case, and in accordance with manufacturers specifications.

i. Connect the splice case to the manhole/building grounding grid using a #6 AWG solid copper wire or bonding tape.

17. Connector: Insertion loss on multimode connections exceeding 0.5 dB and 0.4 dB on single-mode connections not permitted.

18. Identification:
   a. Identify cable on both ends, in access holes, and pull points.
   b. In accordance with TIA 606.

19. Arrange cable, equipment, and hardware to provide neat appearance and accessibility for servicing.

20. Access Handholes and Manholes:
   a. Provide supports for cables in access handholes and manholes at 20-inches along sides of handholes and manholes.
   b. While maintaining minimum bend radius, lace cables and loops of cables neatly to supports to keep them out of way of personnel.

B. Fiber Center, Fiber Distribution Frame, and Housing: Install securely in field panels or enclosures as shown on Drawings.

C. Cable Terminations:

1. In accordance with TIA 568-C.3.

2. Fan out fiber cable to allow direct connectorization of connectors.
   a. Sleeve over individual fibers with transparent furcation tubes.
   b. At point of convergence of furcation tubes, provide strain relief with metal or high density plastic fan-out collar.

3. Break-out Kits:
   a. Terminate cables using manufacturer-supplied break-out kits.
   b. Terminate in accordance with manufacturer’s recommendations.

4. Slack:
   a. Fiber Centers, Hubs, and Switches: Minimum, 3-meter slack fiber at each end, coiled neatly in cable management equipment.
   b. Communications Management Outlets: Minimum, 1-meter slack fiber, coiled neatly in outlet box.
5. Connectors:
   a. Terminate minimum 90 fibers in each cable to specified connector.
   b. Connect into fiber management system.

D. Ethernet Fiber Optic Repeaters:
   1. Install repeaters in accordance with manufacturer’s instructions.
   2. Location: Install transceivers securely in enclosures as shown on Drawings.
   3. Power: As indicated on Drawings.

E. Ethernet Fiber-to-Copper Transceivers:
   1. Install transceivers in accordance with manufacturer’s instructions.
   2. Location: Install transceivers securely in field panels, close to network nodes and fiber centers.
   3. Power: Energize each transceiver from its field panel’s UPS, if applicable.
   4. Connections:
      a. Connect transceiver to fiber optics and network node.
      b. Lace fiber optics neatly in place, routed through wireways.

F. Conduit: Install in accordance with Section 26 05 33, Raceway and Boxes.

3.3 LABELING CONVENTIONS

A. Conform to TIA 606A or to requirements specified by The Authority or representative. Reference Section 26 05 53.
   1. All labels shall be computer and label maker generated.
   2. Labeling scheme will be reviewed with the Authority IT Department prior to installation.

B. Fiber- Optic Conduit
   1. All conduit runs shall be labeled on origin and destination ends.
   2. Innerduct/Fabric Multi-Celled Ducting in Pull Boxes, Maintenance Holes, and Manholes.
3. Every innerduct and/or fabric multi-celled duct installed, shall have a brass or plastic tag that contains the origin, destination, and the owner. These tags shall be placed at both ends and in every pull box, handhole, or manhole along the pathway. These tags shall be securely fastened so that they cannot be accidentally removed.

C. Cables

1. All cables shall be labeled, and that labeling schedule provided on all as-built drawings and printouts.

D. Fiber Optic Jumpers

1. All fiber patch jumpers will be labeled by the Contractor.

2. All fibers in a jumper shall be identified with white heat shrink labels, or wrap around label 5/8 inch to 3/4 inch wide by 1 to 1 1/2 inch long, with lettering clearly visible and shall be placed near the boot of the connector.

3. The heat shrink label shall not be shrunk.

4. Near port of jumper will include the area code, rack number, shelf number, and port number. Far port of the jumper will include the area equipment code, rack number, shelf number, and port number.

5. Circuit number will be reviewed with the Authority.

3.4 FIELD QUALITY CONTROL

A. General:

1. Advise Engineer at least 48 hours in advance of each test. Engineer shall have option to witness and participate actively in tests.

2. In accordance with Section 1D – Special Conditions.

3. Provide equipment, instrumentation, supplies, and skilled staff necessary to perform testing.

4. Outlets, cables, patch panels, and associated components shall be fully assembled and labeled prior to field testing.

5. Testing performed on incomplete systems shall be redone on completion of the Work.

6. Document Test Results: Confirm each cable has at least specified number of fibers that meet standards, in accordance with As-Built Fiber Optic Cable Installation form included as Supplement to this section.
7. Confirm quantities and sizes of conduit and innerduct, in accordance with As-Built Conduit/Innerduct Installation form included as Supplement to this section.

B. Test Equipment:

1. Field test instruments shall have latest software and firmware installed.

2. Optical Fiber Cable Testers:
   a. Field test instrument shall be within calibration period recommended by manufacturer.
   b. Optical Loss Test Set (OLTS):
      1) Single-mode Optical Fiber Light Source:
         a) Provide dual laser light sources with central Wavelengths of 1,310 nm (plus or minus 20 nm) and 1,550 nm (plus or minus 20 nm).
         b) Output Power: Minus 10 dBm, minimum.
         c) Manufacturer: Fluke Networks, or approved equal.
      2) Multimode Optical Fiber Light Source:
         a) Provide dual LED light sources with central wavelengths of 850 nm (plus or minus 30 nm) and 1,300 nm (plus or minus 20 nm).
         b) Output Power: Minus 20 dBm minimum.
         c) Meet launch requirements of TIA/EIA 455-78. This launch condition can be achieved either within the field test equipment or by use of an external mandrel wrap, as described in Clause 11 of TIA 568-C.3, with Category 1 light source.
         e) Manufacturer: Fluke Networks, or approved equal.
      3) Power Meter:
         a) Provide 850 nm, 1,300/1,310 nm, and 1,550 nm wavelength test capability.
         b) Power Measurement Uncertainty: Plus or minus 0.25 dB.
         c) Store reference power measurement.
         d) Save at least 100 results in internal memory.
         e) PC interface (serial or USB).
         f) Manufacturer: Fluke Networks, or approved equal.
      4) Optional Length Measurement: Capable of measuring optical length of fiber using time-of-flight techniques.

3. Optical Time Domain Reflectometer (OTDR):
   a. Bright, color transmissive LCD display with backlight.
   b. Rechargeable for 8 hours of normal operation.
   c. Weight with battery and module of not more than 4.5 pounds and volume of not more 200 cubic inches.
   d. Internal nonvolatile memory and removable memory device with at least 16 MB capacity for results storage.
   e. Serial and USB ports to transfer data to PC.
   f. Single-mode OTDR:
(1) Wavelengths: 1,310 nm (plus or minus 20 nm) and 1,550 nm (plus or minus 20 nm).
(2) Event Dead Zone: 2 meters maximum at 1,310 nm and 2 meters maximum at 1,550 nm.
(3) Attenuation Dead Zone: 15 meters maximum at 1,310 nm and 15 meters maximum at 1,550 nm.
(4) Distance Range: Minimum 10,000 meters.

4. Dynamic Range: Minimum 10 dB at 1,310 nm and 1,550 nm.
   Multimode OTDR:
   a. Wavelengths: 850 nm (plus or minus 20 nm) and 1,300 nm (plus or minus 20 nm).
   b. Event Dead Zone: 1 meter maximum at 850 nm and 2 meters maximum at 1,300 nm.
   c. Attenuation Dead Zone: 6 meters maximum at 850 nm and 15 meters maximum at 1,300 nm.
   d. Distance Range: 2,000 meters minimum.
   e. Dynamic Range: Minimum 10 dB at 850 nm and 1,300 nm.
   f. Manufacturer: Fluke Networks or approved equal.

5. Fiber Microscope:
   a. Magnification: 250X or 400X for end-face inspection.
   b. Manufacturer: Fluke Networks.

6. Integrated OLTS, OTDR, and Fiber Microscope:
   a. Test equipment that combines into one instrument such as OLTS, OTDR, and fiber microscope may be used.
   b. Manufacturer: Fluke Networks, or approved equal.

C. Conduit Test:

1. Test and seal spare conduits.

2. Conduit and Innerduct Testing:
   a. Blow full-diameter mouse through each spare conduit and innerduct to verify they are unrestricted over full length.
   b. If conduit is restricted over full length, advise Engineer.

3. Documentation: Confirm conduit test As-Built Conduit/Innerduct Installation form documentation includes details of innerducts.
D. Cable Testing:

1. Test procedures and field test instruments shall comply with applicable requirements of:
   a. LIA Z136.2.
   b. TIA/EIA 455-78.
   c. TIA/EIA 455-133.
   d. TIA 526-7.
   e. TIA 526-14.
   f. TIA 568-C.1.
   g. TIA 568-C.3

2. TIA TSB 140. Test attenuation and polarity of installed cable plant with OLTS and installed condition of cabling system and its components with OTDR.

3. Verify condition of fiber end face.

4. Perform on each cabling link (connector to connector).

5. Perform on each cabling channel (equipment to equipment).

6. Do not include active devices or passive devices within link or channel other than cable, and connectors. For example, link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

7. Document Tests:
   a. OLTS dual wavelength attenuation measurements for single-mode and multimode links and channels.
   b. OTDR traces and event tables for single-mode and multimode links and channels.

E. Fiber Testing Parameters:

1. Each cabling link shall be in compliance with the following test limits:
   a. Optical Loss Testing:
      1) Backbone (single-mode and multimode) Link:
         a) Calculate link attenuation by the formulas specified in TIA 568-C.1.
         b) Values for Attenuation Coefficient (dB/km) are listed in the table below:
### Attenuation Coefficient

<table>
<thead>
<tr>
<th>Type of Optical Fiber</th>
<th>Wavelength (nm)</th>
<th>Attenuation Coefficient (dB/km)</th>
<th>Wavelength (nm)</th>
<th>Attenuation Coefficient (dB/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-mode (Inside plant)</td>
<td>1310</td>
<td>1.0</td>
<td>1550</td>
<td>1.0</td>
</tr>
<tr>
<td>Single-mode (Outside plant)</td>
<td>1310</td>
<td>0.5</td>
<td>1550</td>
<td>0.5</td>
</tr>
<tr>
<td>Multimode 50/125 µm</td>
<td>850</td>
<td>3.5</td>
<td>1300</td>
<td>1.5</td>
</tr>
</tbody>
</table>

b. OTDR Testing:
   1) Reflective Events: Maximum 0.75 dB.
   2) Nonreflective Events: Maximum 0.3 dB.

c. Magnified Endface Inspection:
   1) Visually inspect fiber connections for end-face quality.
   2) Scratched, pitted, or dirty connectors shall be diagnosed and corrected.

F. Diagnosis and Correction:

1. Installed cabling links and channels shall be field tested and pass test requirements and analysis as described herein.

2. Link or channel that fails these requirements shall be diagnosed and corrected.

3. Document corrective action and follow with new test to prove corrected link or channel meets performance requirements.

4. Provide final and passing result of tests for links and channels.

G. Acceptance: Acceptance of test results shall be given in writing after Project is tested and completed in accordance with Contract Documents and satisfaction of The Authority.
H. Test Execution:

1. Optical Fiber Cable Testing:
   a. Tests performed that use laser or LED in test set shall be carried out with safety precautions in accordance with LIA Z136.2.
   b. Link and channel test results from OLTS and OTDR shall be recorded in test instrument upon completion of each test for subsequent uploading to a PC in which administrative documentation may be generated.
      1) Record end-face images in memory of test instrument for subsequent uploading to a PC and reporting.
   c. Perform Testing:
      1) On each cabling segment (connector to connector).
      2) On each cabling channel (equipment to equipment).
      3) Using high-quality test cords of same fiber type as cabling under test.
         a) Test cords for OLTS testing shall be between 1 meter and 5 meters in length.
         b) Test cords for OTDR testing shall be approximately 100 meter for launch cable and at least 25 meters for receive cable.

2. Optical Loss Testing (OLTS):
   a. Backbone Link:
      1) Test single-mode at 1,310 nm and 1,550 nm in accordance with TIA 526-7, Method A.1, One Reference Jumper or equivalent method.
      2) Test multimode at 850 nm and 1,300 nm in accordance with TIA 526-14A, Method B, One Reference Jumper or equivalent method.
      3) Perform tests in both directions.

3. OTDR Testing:
   a. Test backbone, horizontal, and centralized links at appropriate operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss.
      1) Single-mode: 1,310 nm and 1,550 nm.
      2) Multimode: 850 nm and 1,300 nm.
   b. Test each fiber link and channel in one direction.
   c. Install launch cable between OTDR and first link connection.
   d. Install receive cable after last link connection.

4. Length Measurement:
   a. Record length of each fiber.
   b. Measure optical length using OLTS or OTDR.
5. Polarity Testing:
   a. Test paired duplex fibers in multi-fiber cables to verify polarity in accordance with sub-clause 10.3 of TIA/EIA 568-C.1.
   b. Verify polarity of paired duplex fibers using OLTS.

6. Test Results Documentation:
   a. Test results saved within field-test instrument shall be transferred into Windows-based database utility that allows for maintenance, inspection, and archiving of test records. These test records shall be uploaded to the PC unaltered. For example, “as saved in the field-test instrument.” The file format, CSV (comma separated value), does not provide adequate protection of these records and shall not be used.
   b. Available for inspection by the Authority or the Authority’s representative during installation period. Submit within 5 working days of completion of tests on cabling served by a telecommunications room or of backbone cabling.
   c. Database for project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered on CD-ROM or DVD prior to The Authority acceptance of building. CD-ROM or DVD shall include software tools required to view, inspect, and print test reports.
   d. Circuit IDs reported by test instrument shall match specified label identification.
   e. Provide in electronic database for each tested optical fiber with the following information:
      1) Identification of Site.
      2) Name of test limit selected to execute stored test results.
      3) Name of personnel performing test.
      4) Date and time test results were saved in memory of tester.
      5) Manufacturer, model, and serial number of field test instrument.
      6) Version of test software and version of test limit database held within test instrument.
      7) Fiber identification number.
      8) Length for Each Optical Fiber: Optionally the index of refraction used for length calculation when using a length capable OLTS.
      9) Test results to include OLTS attenuation link and channel measurements at appropriate wavelength and margin; difference between measured attenuation and test limit value.
      10) Test results to include OTDR link and channel traces, and event tables at appropriate wavelength.
      11) Length for each optical fiber as calculated by the OTDR.
      12) Overall pass/fail evaluation of link-under-test for OLTS and OTDR measurements.
I. Drawings:

1. Record Copy: Provide at end of Project on CD-ROM or DVD.
   a. Auto CAD format and include notations reflecting as-built conditions of additions and variations from Drawings provided, such as to cable path and termination point.
   b. Auto CAD drawings are to incorporate test data imported from test instruments.

2. As-built Drawings:
   a. Include, but not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts, and frame installation details.
   b. Include field changes made up to construction completion:
      1) Field directed changes to pull schedule.
      2) Field directed changes to cross connect and patching schedule. Horizontal cable routing changes.
      3) Backbone cable routing or location changes.
      4) Associated detail Drawings.

3.5 TRAINING

A. Train the Authority’s staff in the following skills:

   1. Connectorizing fibers.
   2. Testing quality of connectors, and fibers.

B. Schedule: Provide two 8-hour training sessions on consecutive weekdays, to suit the Authority’s schedule.

C. Materials: Provide hardware for training, including fibers, and connectors, kits.

D. Tools: Provide one of tool kits for trainees’ use.

3.6 SUPPLEMENTS

A. Supplements listed below, following “End of Section,” are part of this Specification.

   1. As-Built Fiber Optic Cable Installation Form.
   2. As-Built Conduit/Innerduct Installation Form.
PROJECT: SDIA Power System SCADA Fiber-Optic Communication System

Contractor:

Signed by:

AS-BUILT FIBER OPTIC CABLE

INSTALLATION Cable Identification:
Routing: From: In:
(Identify field panel, control room, etc. in building)

Through: 1
(Identify access hole, building, gallery, etc.)

Through: 2 Through: 5
Through: 3 Through: 6
Through: 4 Through: 7

To: In:
See As-Built Conduit/Innerduct Installation forms for identification of conduits/innerducts cable is routed through.

Acceptable Attenuation:
Multimode Fibers

cable length*
850 nm: $3.5 \text{ dB/km} \times \text{m} + 1.5 \text{ dB} = \text{ dB}
1300 nm: $1.0 \text{ dB/km} \times \text{m} + 1.5 \text{ dB} = \text{ dB}

*Contractor to provide actual length installed, within ±0.1 km.

<table>
<thead>
<tr>
<th>Fiber ID</th>
<th>Use/Spare</th>
<th>Measured Attenuation (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Hub-to-Node</td>
</tr>
<tr>
<td>850 nm</td>
<td>1,300 nm</td>
<td>850 nm</td>
</tr>
</tbody>
</table>
Single-mode Fibers

cable length*
1310 nm: \([A: 1.0] [B: 0.5]\) dB/km x \(\text{km} + 1.5 \text{ dB} = \) dB
1550 nm: \([A: 1.0] [B: 0.5]\) dB/km x \(\text{km} + 1.5 \text{ dB} = \) dB

*Contractor to provide actual length installed, within ±0.1 km.

PROJECT: **SDIA Power System SCADA Fiber-Optic Communication System**

Contractor:


Signed by:


AS-BUILT CONDUIT/INNERDUCT INSTALLATION

From: To:

(Identify building, access hole, field panel, etc.) Sheet 1 of 1

Conduits:
Used: 4 inches; 2 inches
Spare: 4 inches; 2 inches Confirm all spares unrestricted:
Yes/No (Provide number of conduits in each category)

Innerducts:

Conduit ID* Innerduct ID Cable ID / Spare

__________________________
__________________________
__________________________
__________________________
__________________________
__________________________
__________________________
__________________________

(Continued overleaf delete if not applicable)

*Provide conduit ID if required to identify innerduct uniquely in the access hole, if for example, color-coded innerduct is used in more than one conduit. If innerducts are tagged uniquely, leave this column blank.

**END OF SUPPLEMENT 26 09 17**
PART 1 GENERAL

1.1 REFERENCES

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


2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
   c. C57.12.00, Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
   d. C57.12.22, Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High-Voltage Bushings, 2,500 kVA and Smaller.
   e. C57.12.26, Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers for Use with Separable Insulated High Voltage Connectors.
   h. C57.106, Guide for Acceptance and Maintenance of Insulating Oil in Equipment.
   i. C62.11, Metal-Oxide Surge Arrestors for Alternating-Current Power Circuits (>1 kV).
3. National Electrical Manufacturers Association (NEMA):
   a. TR 1, Transformers, Regulators, Reactors.


5. Underwriters Laboratories Inc. (UL).

6. Dept. Of Energy, 10 CFR Part 431.196, Subpart K, Table 1.2

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data, include rated nameplate date, capacities, dimensions, minimum clearances, weights, installed devices and features, fuse manufacturer type and rating for each size and type of transformer and transformer accessory.

2. Shop Drawings, wiring and connection diagrams including power, signal and control wiring.

3. Dimensional Drawings, including center of gravity in two places, assembled weight.

4. Transformer nameplate data, including impedance.

5. Schematic and connection diagrams.

6. Reinforced or precast concrete pad design Drawings and Seismic Anchorage and Bracing Calculations for seismic attachments, braces, and anchorages. Include IBC and project specific criteria in addition to manufacturer’s specific criteria used for the design; sealed by a Structural Engineer registered in the State of California.

7. Custom Paint Color; submit color samples for Authority choice.

B. Informational Submittals:

1. Manufacturer Seismic Qualification Certification, Submit certification that transformer assembly and components will withstand seismic forces defined in seismic design. Provide Seismic Anchorage and Bracing Calculations: for seismic attachments, braces, and anchorages. Include IBC and project specific criteria in addition to the
manufacturer’s specific criteria used for the design; Signed and sealed by a Structural Engineer registered in the State of California.

2. Operation and Maintenance Data: As specified in Section 1D–Special Conditions, Article 1D-51 Project Closeout.

3. Factory test reports certified.

4. Field quality control test reports. Installation Instructions and Manufacturer’s Certificate of Proper Installation in accordance with Section 1D – Special Conditions, Article 1D-12 Certificates of Compliance.

1.3 QUALITY ASSURANCE


B. UL listed and labeled.

C. Contractor shall ensure that the manufacturer has a minimum of 15 years of experience in the production of medium voltage transformers similar to the type and size and specified in this project. Manufacturer shall have the ability to readily provide replacement parts for a minimum period of ten years, from the date of completion of the project.

1.4 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage and deliver prior to 75 percent Project completion the following spare parts, special tools, and materials:

1. One quart of paint to match color and quality of equipment final shop finish.

2. Four sets of spare fuse links for each replaceable fuse size.

3. Penta head socket for 1/2-inch socket drive.

SPECIAL GUARANTEE

A. Provide manufacturer’s extended guarantee or warranty, with Authority named as beneficiary, in writing, as special guarantee for all medium voltage pad mounted transformers and appurtenances furnished on this project. Special guarantee shall provide for replacement of pad mounted transformers and appurtenances during a period of 3 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be the responsibility of the Contractor for three years after date of Substantial Completion.
PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Eaton/Cooper Power System.
B. ABB.
C. Schneider.
D. General Electric.
E. Or equal.

2.2 GENERAL

A. Integral Unit: Stainless steel compartmental type unit consisting of transformer, oil-filled tank, and high and low voltage terminating compartments, assembled on a common structural base.

B. Anchor Bolts: Type 316 stainless steel and sized by equipment manufacturer.

2.3 TRANSFORMER

A. kVA Rating: As shown.
B. Primary Voltage: 12.0 kV line-to-line volts, three-phase, Delta, 60-Hz.
C. Secondary Voltage: 480/277V or 208/120V grounded-wye, or as required.
D. Basic Impulse Level (BIL) Rating:
   1. 125 BIL for 15 kV insulation class transformers.
   2. 30 kV BIL for secondary.
E. Temperature Rise: 65 degrees C above 30 degrees average ambient with maximum ambient not to exceed 40 degrees C. Transformer shall be rated to operate at rated load 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.
F. Impedance: (Nominal, subject to industry tolerance)
   1. 1.35 percent minimum for transformers rated 150 kVA and less.
   2. 3.0 percent minimum for transformers rated 225, 300, and 500 kVA.
   3. 5.75 percent for transformers rated 750 kVA and above.
G. Efficiency: Meet or exceed values in Table 1.2, 10 CFR Part 431. Subpart K.

H. Dielectric Coolant: Fully biodegradable, nontoxic, and nonbio-accumulating fluid, qualifying as “less flammable” per CEC 450.23; Factory Mutual Approved or UL Classified.

I. Primary Taps:
   1. Full capacity Voltage Taps, two 2-1/2 percent below and two 2-1/2 percent above, rated voltage.
   2. Externally operated no-load tap changer.

J. Provisions for locking handle in any position.

K. Coil Conductors: Copper windings.

L. Sound Level: In accordance with manufacturer’s standards.

2.4 ENCLOSURE

A. In accordance with IEEE C57.12.28 requirements.

B. Welded stainless steel transformer tank, with cooling panels when required, and lifting eyes.

C. 12-gauge stainless steel terminal compartment enclosure having no exposed screws, bolts, or other fasteners that are externally removable.

D. Provide one (1) Spyglass IR scan port per door approximately level with the LV bushings and terminations.

E. Color: Provide Munsell 7GY3.29/1.5 finish, as approved in writing by the Authority.
2.5 TERMINAL COMPARTMENTS

A. General: IEEE C57.12.28, enclosed high and low voltage compartments side by side, separated by steel barrier, bolted to transformer tank.
   
   1. Doors:
      a. Individual, full-height, air-filled.
      b. Low voltage door with three-point latching mechanism, vault type handle, and single padlocking provision.
      c. High voltage door fastenings inaccessible until low voltage door has been opened.
      d. Door Bolts: Penta-head type.
      e. Lift-off, stainless steel hinges and door stops.
      f. Removable front sill to facilitate rolling or skidding over conduit stubs.
      g. Recessed lock pocket, with stainless steel door release bolt adjacent to secondary compartment door handle.

B. High Voltage Compartment:
   
   1. Dead front in accordance with IEEE C57.12.26 type construction.
   
   2. Bay-o-net type protective fuses, in series with internal, liquid-immersed, current limiting fuses.
   
   3. High voltage bushing wells, loop feed provision.
   
   4. Transformer grounding pads.
   
   5. Surge Arresters, Distribution class, Dead Front, elbow-type, metal-oxide-varistor units, 12kV 10.2 MCOV rated, one for each primary phase; complying with IEEE C62.11 and NEMA LA 1. Support from tank wall within high-voltage compartment. Transformer shall have three arresters for loop feed circuits.
   

C. Low Voltage Compartment:
   
   1. Live front in accordance with IEEE C57.12.26 type construction.
   
   2. Low voltage stand-off type bushings.
   
   3. Grounding pads in high voltage and low voltage compartments.
   
   4. Stainless steel equipment nameplate.
   
   5. Liquid level gauge
   
   6. 1-inch upper filter press and filling plug.
7. Drain valve with sampling device and pressure-vacuum gauge mounted external to the compartment in a lockable NEMA 4X stainless steel enclosure.

8. Dial type thermometer ac.

9. Pressure relief valve.

10. Pressure relief device, self-resealing with indicator.

11. Pressure gauge ac.

12. Mounting provision for current and potential transformers.


2.6 BUSHINGS

A. High Voltage:

1. Dead front Termination:
   a. Universal bushing well rated at 25 kV in accordance with IEEE 386.
   b. Bushings externally clamped and front removable.
   c. Rated for 200 amperes continuous, 125 kV BIL.
   d. Standoff brackets located adjacent to bushings.

B. Low Voltage:

1. Molded epoxy bushing clamped to tank with 4, 6, or 8 hole spade type terminals as required for low voltage connection applications.

2. Rated 200 percent of continuous full-load current, 30 kV BIL, 600 volts.

3. Internally connected neutral extending to neutral bushing.

2.7 HIGH VOLTAGE SWITCHING

A. Internal, oil-immersed, gang-operated load-break, manually operated switches.

B. Hot stick operated handle located in high voltage compartment.

C. Capable of operating at full-load current.

D. Feed Switch: Four-position, loop/radial or as shown.
2.8 **HIGH VOLTAGE PROTECTION**

A. Combination Oil-Immersed Bayonet Expulsion and Current Limiting Fuses:
   
   1. Accessibility:
      
      a. Bayonet expulsion fuse accessible through primary compartment.
      b. Current-limiting fuse accessible through tank handhole.

   2. Expulsion Fuse for Low Current Faults: Interrupting capacity of 1,800 amperes RMS asymmetrical.


   4. Bayonet fuse externally replaceable with hot stick, provide drip shield.

2.9 **LOW VOLTAGE PROTECTION**

2.10 **SURGE ARRESTORS**

A. Elbow Valve Type: Uninsulated body, 9 kV, 12.7 kV MCOV with barriers in accordance with IEEE C62.11.

2.11 **TANK GROUNDING PADS**

A. High and Low Voltage Compartments:

   1. Connected together with bare No. 2/0 stranded copper conductors.

   2. Delta-wye with low voltage neutral internally connected and brought out to insulated low voltage bushing.

   3. Low voltage neutral connected to externally mounted insulating bushing in low voltage compartment and grounded to tank with removable strap.

2.12 **TAP CHANGER WARNING SIGN**

A. Red laminated plastic, engraved to white core.

B. Engrave to read: DO NOT OPERATE WHEN TRANSFORMER ENERGIZED.

C. Mount above tap changer handle.
2.13 FACTORY TESTS

A. Production tests in accordance with IEEE C57.12.90 and IEEE C57.12.00, Section 8 and Table 16.


C. Heat run and efficiency tests in accordance with IEEE C57.12.90 and IEEE C57.12.00.

PART 3 EXECUTION

3.1 GENERAL

A. Secure to mounting pads with anchor bolts per Seismic requirements.

B. Install plumb and longitudinally in alignment with pad or adjacent building wall.

C. Ground neutrals and enclosures in accordance with applicable codes.

D. Install surge arrestor elbows where shown on Drawings.

E. Identification, as required in Section 26 05 53 identification

3.2 ADJUSTMENTS

A. Adjust voltage taps to obtain rated output voltage under normal operating load conditions.

END OF SECTION 26 12 02
PART 1  GENERAL

1.1  REFERENCES

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

1. UL 508A, Industrial Control Panels.

2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. C57.12.28, Pad Mounted Equipment Enclosure Integrity.
   b. C37.66, Standard Requirements for Oil-Filled Capacitor Switches for Alternating-Current Systems.
   c. 1036, Guide for Application of Shunt Power Capacitors.
   e. 18, Standard for Shunt Power Capacitors.
   f. 386, Standard for Separable Connectors.


1.2  SUBMITTALS

A. Action Submittals, submit to The Authority per contract:

1. Descriptive product information, custom paint color samples for the Authority approval.

2. Capacitor, surge, protective device, cable, bus, and harmonic mitigation reactors calculations.


4. Complete schematic and wiring diagrams showing all terminations.

5. Itemized Bill of Material (BOM).

6. Operational descriptions.

7. Pad, conduit, and cable entry Drawings.

8. Name plate information.

10. Weights shipping and assembled.

11. Technical Data Sheets for all internal components or instruments provided.

12. Material listing:
   a. Time coordination plots between capacitor fuses, main disconnect fuses, case rupture curves, and upstream overcurrent protective devices. Damage curve for the capacitor supply cables shall be coordinated with upstream overcurrent protective device.
   b. Upon approval of above, a digital copy on CD ROM shall be provided.


14. Reinforced or precast concrete pad design Drawings and Seismic Anchorage and Bracing Calculations for seismic attachments, braces, and anchorages. Include IBC and project specific criteria in addition to manufacturer’s specific criteria used for the design; sealed by a Structural Engineer registered in the State of California.

B. Informational Submittals submit to The Authority per contract:

1. Manufacturer Seismic Qualification Certification, submit certification that pad-mounted capacitor bank assembly and components will withstand seismic forces defined in 26 05 29. Provide Seismic Anchorage and Bracing Calculations: for seismic attachments, braces, and anchorages. Include IBC and project specific criteria in addition to the manufacturer’s specific criteria used for the design; Signed and sealed by a Civil or Structural Engineer registered in the State of California.

2. Unwitnessed Certified Factory Test Reports.

3. Installation Instructions and Manufacturer’s Certificate of Proper Installation in accordance with Section 1D – Special Conditions, Article 1D-12 Certificates of Compliance.

4. Operation and Maintenance Data: As specified in Section 1D – Special Conditions, Article 1D-51 Project Closeout.

5. Manufacturer’s Certificate of Proper Installation in accordance with Section 1D – Special Conditions, Article 1D-12 Certificates of Compliance.
1.3 EXTRA MATERIALS

A. Furnish, tag, and box for shipment, and storage and deliver prior to 60 percent Project completion the following spare parts, special tools, and materials:

1. One quart of paint to match color and quality of equipment final shop finish.

2. Pentahead socket for 1/2-inch socket drive.

3. Ten percent spare capacitor fuses.

4. One oil switch.

5. One capacitor of each rating.

1.4 SPECIAL GUARANTEE

A. Provide manufacturer’s extended guarantee or warranty, with Authority named as beneficiary, in writing, as special guarantee for all medium voltage pad mounted capacitor banks and appurtenances furnished on this project. Special guarantee shall provide for replacement of pad mounted capacitor banks and appurtenances during a period of 3 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be the responsibility of the Contractor for three years after date of Substantial Completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Northeast Power Systems Inc.

B. Scott Engineering.

C. Elliott Industries.

D. Or equal.
2.2 GENERAL

A. This specification is for a low profile, medium voltage, three phase above-grade, pad-mounted capacitor bank consisting of two steps of 600 kVAR for 1200kVAR total at 12 kV three-phase. The bank shall be controlled by Power System SCADA (PSS). All controls, switching devices, and protection features are enclosed in an all-welded compartmentalized 316 stainless steel enclosure that meets or exceeds C57.12.28. The bank shall come fully assembled and ready for interconnection.

B. The ratings of the capacitor bank, switching devices, capacitors, fuses, and all other applicable components shall have ratings designed for application on the following system:

1. Nominal System Voltage: 12kV.
2. Maximum System Voltage: 15kV.
3. System Basic Insulation Level (BIL): 125kV BIL at 15kV.
4. Three Phase Short Circuit Rating at Capacitor Bank (RMS Symmetrical Amps): As directed in writing by the Authority.
5. Line-Ground Short Circuit Rating at Capacitor Bank (RMS Symmetrical Amps): As directed in writing by the Authority.

C. Operating Conditions:

1. Location: outdoors, above ground.
2. Ambient Temperature: Maximum 45 Degrees C in direct sunlight.

2.3 ENCLOSURE

A. The capacitor bank shall consist of a single compartmentalized 11 gauge stainless steel enclosure that meets or exceeds all of the requirements of C57.12.28. The enclosure shall house all components, including fuses, capacitors, capacitor switches, and associated controls. All components shall be accessible and removable from the front or rear of the enclosure. The front side of the enclosure shall have a dead-front compartment and a control compartment. The rear of the enclosure shall be of a live-front design. Equipment layout and access shall be as follows:

1. Control compartment: Contains the capacitor bank controller, ancillary control components, and nameplate. Compartment accessed from the front without having to open the live-front or incoming dead-front compartment and completely segregated from the live-front and incoming dead-front compartments.
2. Incoming Dead-Front Compartment: Contains bushing wells that accept load-break bushing well inserts, three parking stands, a ground bus, and a hinged Lexan viewing window. The Hinged Lexan viewing window allows for viewing of blown fuse indicators, and provides access to the capacitor fuses. Provide one Spyglass IR Port per door.

3. Live-Front Compartment: Contains full-width silver plated copper ground bus, capacitor switches, control power transformer, transient inrush reactors, capacitors, capacitor fuses, and associated bus and bus support insulators. Component shall be removable from this compartment. Rodent guards shall be located on the bottom of compartment. Provide one (1) Spyglass IR Port per door.

B. The base of the enclosure shall be equipped with C4x5.4 structural steel (formed channel bases will not be accepted) and shall provide for flush mounting on a flat, rigid mounting surface. Removable steel lifting plates consisting of 1/2 inch steel shall be located at each corner and shall allow for balanced lifting.

C. The enclosure shall restrict the entry of water. All seams shall be welded and ground smooth. The roof shall be cross-kinked to prevent standing moisture.

D. Pentahead bolts and associated threaded receptacles, hinges, hinge pins, and internal fasteners shall be AISI Type 304 stainless steel.

E. All access doors shall be fastened with a device that requires a pentahead tool to permit unlatching the door only after the padlock has been removed. This pentahead device or bolt shall be coordinated such that the padlock may not be inserted into the hasp until the access door is fully latched and the pentahead device is secured.

1. A minimum of one pentahead device or bolt and padlocking means shall be provided for each of the front and rear access doors. The pentahead device or bolt shall be surrounded by a non-rotating guard or shall be recessed such that the pentahead device or bolt can be engaged only by the proper tools. The dimensions of the pentahead bolt and non-rotating recess shall comply with C57.12.28.

2. The pentahead device or bolt shall not be readily removable during normal operation of the doors, and if removed or disengaged, there shall be no holes remaining that would permit entry of a wire into the enclosure. Bi-folding doors may be fastened with a single padlock and pentahead device or bolt. Access, however, shall be such that a positive and separate action must be taken to open the second door only after the first access door has been opened.
F. The doors shall be flush and removable in the open position. They shall be equipped with stainless steel hinges and hinge pins, and 3-point latching handles. The handles shall be padlockable and shall secure the pentahead bolt in the closed position. All doors shall be equipped with door stays to hold doors in the open position.

G. All ventilation louvers shall be backed with a stainless steel mesh and washable filter. The louver design shall prevent the entry of foreign objects such as sticks, rods, or wires.

H. Thermostatically controlled strip heaters shall be supplied in all compartments. A thermostatically controlled fan shall be supplied for ambient control of the capacitor bank. Thermostat setting to be verified in writing with Engineer of Record.

I. The enclosure shall have a continuous 1/4-inch x 1 inch silver-plated copper ground bus that spans the full width of the enclosure.

J. The bushing wells in the incoming dead-front compartment shall be located no less than 7.5 inches from the edge of the cabinet. The bushings shall be spaced 11 inches apart, with parking stands located 4.5 inches from each bushing.

K. The enclosure shall be prepared and painted with a high-solid epoxy coating as specified below.

   1. Multistage process applied to interior and exterior surfaces, joints, and blind areas prior to enclosure assembly.
      a. Pretreatment protective film.
      b. Baked epoxy finished coating.
      c. Baked acrylic enamel top coating in accordance with IEEE C57.12.28.

   2. Color: Munsell 7GY3.29/1.5, olive green.

   3. Meets or exceeds:
      a. Salt-spray test in accordance with ASTM B117.
      b. Humidity test in accordance with ASTM D2247 and ASTM D714.
      c. Accelerated weather tests in accordance with ASTM G154, ASTM D659, and ASTM D523.
      d. Adhesion tests in accordance with ASTM D3359, Method B and ASTM D2794.
      e. Corrosion tests in accordance with ASTM D1654.
      f. Abrasion tests in accordance with ASTM D4060.g.Oil resistance testing with no shift in color, streaking, blistering, or loss of hardness.
2.4 GROUND SWITCH

A. An externally operated ground switch shall be provided to ground the capacitors after the incoming power conductors are disconnected and placed on the parking stand. The ground switch shall be pad-lockable in either the open or closed position and shall only be accessible from the dead-front compartment. The ground switch shall be tested in accordance with ANSI/IEEE standards. Test reports shall be furnished.

B. A Lexan window shall be provided in the dead-front compartment to view the position of the ground switch

2.5 GROUP CAPACITOR FUSES

A. Each stage of the pad-mounted capacitor bank shall be group fused with a current limiting fuse. The fuses shall be full range and shall be equipped with blown fuse indicators.

B. The blown fuse indicators shall be visible through a hinged Lexan access panel from within the dead-front compartment. This hinged access panel shall provide for hot-stick replacement of the fuses after the incoming power conductors are disconnected and placed on the parking stands.

2.6 SURGE ARRESTERS

A. The capacitor bank shall be equipped with Distribution Class Surge Arresters. The rating of the Surge Arrester shall be recommended by the capacitor bank supplier.

2.7 TRANSIENT INRUSH REACTORS

A. Transient inrush reactors shall be provided for multi-stage capacitor banks to limit the magnitude and frequency of inrush currents due to back-to-back switching operations. The reactors shall be completely impregnated with an epoxy resin that will reduce noise, promote heat dissipation, and provide protection in harsh environments. The reactors shall limit the di/dt of the capacitor inrush current to 3.6x107 amps/second. Calculations shall be provided.

B. The inrush reactors shall be rated for at least 135 percent of the stage current. When expansion capability is necessary, the rating shall be sufficient for 135 percent of the maximum capacity of the stage.
2.8 VACUUM SWITCHES

A. The capacitor bank stages shall be controlled by three single-phase gang-operated vacuum switches that have been tested for capacitor switching in accordance with ANSI Standard C37.66 and the maximum voltage rating of the bank.

B. The control system shall prevent the vacuum switches from operating more than once in a 5-minute period.

2.9 CAPACITORS

A. The automatic capacitor bank shall be equipped with all-film, low loss, double-bushing capacitors. The capacitors shall be designed, manufactured, and tested to meet and/or exceed all applicable NEMA and ANSI/IEEE standards. Capacitors shall be manufactured in North America and shall be manufactured by Cooper, GE, or ABB.

B. Each capacitor shall contain an internal discharge resistor to reduce the stored voltage to 50 volts or less within 5 minutes from disconnection.

C. The capacitors shall be connected in ungrounded-wye and shall be protected from sustained over voltages due to capacitor unit failure and/or system ground faults. The bank design shall allow for grounding the neutral point of the capacitor bank if desired.

D. The pad-mounted bank shall be designed to hold 6 capacitors per stage. When only three capacitors are being utilized per stage, space and provisions for three additional capacitors, fuses, and all necessary components, shall be provided. Provisions shall include the following at a minimum:

1. Weld-on studs for mounting future capacitors.

2. Phase bus, neutral bus, and fuse mounts shall accommodate or be supplied for the future expansion.

E. The capacitors shall be accessible from the live-front compartment in the rear of the enclosure and shall be mounted horizontally on C4x5.4 structural steel channel.
2.10 PHASE AND GROUND BUS

A. All phase and ground bus shall be silver plated copper for maximum conductivity and corrosion resistance. The copper shall be CA110 Square edge, hard temper per ASTM B187. The bus shall not have a current density greater than 1200 amps/in². Where expansion capability is required, the bus shall be rated for the maximum capacity of the bank.

2.11 BUSHINGS AND TERMINALS

A. Bushings shall be 200 amp, 25 kV, air-insulated bushing wells, (125 kV BIL). Bushing wells shall be pressure-molded Cycloaliphatic epoxy.

2.12 CONTROLS

A. All low voltage controls shall be isolated from the high voltage compartments. All controls shall be accessible while the bank is energized. The control compartment shall allow for bottom entry of control wires without having to enter the medium voltage live-front or dead-front compartment. The control compartment shall be equipped with a swing out panel to allow access to panel mounted controls.

B. All control wires that connect to components inside high voltage compartment shall be in metal conduit or wire troughs that are formed as part of the capacitor bank.

C. The pad-mounted capacitor bank shall be equipped with a control power transformer that has both primary and secondary overcurrent protection. The control power transformer shall be connected between phases A and B on the line-side of 15kV capacitor fuses.

D. A 15-amp GFI Convenience outlet shall be provided in the control compartment.

E. The pad-mounted capacitor bank shall be equipped with three potential transformers to measure voltage on all three phases.

2.13 NAMEPLATE

A. A nameplate shall be permanently attached to the interior of the control compartment. The nameplate shall contain the following minimum information:

1. Manufacturer.
2. Month and year of manufacture.
3. Serial number.
4. kVAR rating of bank.
5. Voltage and frequency rating of bank.

6. Shipping and assembled weight.

7. Surge arrester rating.

8. Reactor ratings.


2.14 SOURCE QUALITY CONTROL

A. General:

1. The Authority may actively participate in many of the tests.

2. The Authority reserves right to test or retest specified functions.

3. The Authority’s decision will be final regarding acceptability and completeness of testing.

4. Contractor and Manufacturer’s Representative shall coordinate and supply on-hand all personnel and testing equipment to support all Source Quality Control activities.

5. Procedures, Forms, and Checklists:
   a. Except for Unwitnessed Factory Test, conduct tests in accordance with, and documented on, the Authority accepted procedures, forms, and checklists.
   b. Describe each test item to be performed.
   c. Have space after each test item description for sign off by appropriate party after satisfactory completion.

6. Required Test Documentation: Test procedures, forms, and checklists signed by the Authority, and Contractor.

7. Conducting Tests:
   a. Provide special testing materials and equipment.
   b. Wherever possible, perform tests using actual process variables, equipment, and data.
   c. If not practical to test with real process variables, equipment, and data provide suitable means of simulation.
   d. Define simulation techniques in test procedures.
   e. Test Format: Cause and effect.
      1) Person conducting test initiates an input (cause).
      2) Specific test requirement is satisfied if correct result (effect), occurs.
B. Unwitnessed Factory Tests:

1. Scope: Inspect pad mounted capacitor banks to ensure it is operational and ready for delivery to Project Site.
   Location: Pad-mounted Capacitor Bank Manufacturer’s Facility.
2. Integrated Test:
   a. Interconnect and test.
   b. Exercise and test functions.
   c. Provide testing of all hardware and communications to demonstrate a complete assembly.

C. Witnessed Factory Demonstration Test (FDT):

1. Contractor shall coordinate and schedule factory tests with Manufacturer’s Representative, and The Authority.
2. Contractor shall be present with Manufacturer’s Representative, and the Authority for Witnessed FDT.
3. Test reports shall indicate test procedures and instrumentation use to measure and record data.
4. Test reports shall be certified by testing personnel and stamped and signed by a Professional Engineer Licensed in the State where tests are performed.
5. Contractor and Manufacturer's Representative shall supply on-hand all personnel and testing equipment to support FDT activities.
6. Notify the Authority of test schedule 4 weeks prior to start of test.
7. Scope:
   a. Test pad-mounted capacitor bank to demonstrate it is operational.
   b. Location: Manufacturer’s Facility.
8. Correctness of motorized operations, contacts switches, staged capacitor banks, alarms, CCVTs, CTs, and PTs and wiring to input/output termination points.
   a. Demonstrate each discrete and analog signal at terminal strips.
   b. Demonstrate correctness of each analog signal using current and voltage sources.
9. Loop-Specific Functions: Demonstrate functions as defined by the Authority:
   a. All required functions for 100 percent of components.
   b. Timing: Include tests for timing requirements.
   c. Diagnostics: Demonstrate online and offline diagnostic tests and procedures.
10. Correct deficiencies found and complete prior to shipment to Site.

11. Failed Tests:
   a. Repeat and witnessed by the Authority.
   b. With written approval of the Authority, certain tests may be conducted by and witnessed by the Authority designee as part of Functional Test.

12. Make following documentation available to the Authority at test site both before and during FDT:
   b. Master copy of FDT procedures.
   c. List of equipment to be tested including make, model, and serial number.
   d. Approved hardware Shop Drawings for equipment being tested.
   e. Approved preliminary software documentation Submittal.

13. Daily Schedule for FDT:
   a. Begin each day with meeting to review day’s test schedule.
   b. End each day with each meeting to review day’s test results and to review or revise next day’s test schedule.

   D. Deliver pad-mounted capacitor bank to project site after successful completion of factory demonstration testing.

PART 3 EXECUTION

3.1 INSTALLATION

   A. Install equipment in accordance with manufacturer's instructions and recommendations.

   B. Identification label, to be installed on outside of equipment and to meet speciation requirement Section 26 05 53.

   C. Secure equipment to mounting pads with anchor bolts of sufficient number for specified seismic conditions.

   D. Install equipment plumb and in longitudinal alignment with pad or adjacent building wall.

   E. Ground enclosures in accordance with Section 26 05 26 Grounding and Bonding for Electrical Systems.
3.2 MANUFACTURER’S SERVICES

A. Furnish manufacturer’s representative in accordance with Section 01 43 33, Manufacturer’s Field Services, for the following services at Site, for minimum person-days listed below, travel time excluded:

1. One person-day for installation assistance, final adjustment, and initial energization of equipment.

2. Two person-days for functional and performance testing and completion of Manufacturer’s Certificate of Proper Installation.

3. One person-day for post-startup training.

B. Furnish training of the Authority personnel at such times as requested by the Authority.

END OF SECTION 26 13 15
SPECIAL PROVISIONS
DIVISION 26 – ELECTRICAL
SECTION 26 13 19.02

PAD-MOUNTED ATO SWITCHGEAR

PART 1 GENERAL

1.1 REFERENCES

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

1. ASTM International (ASTM):
   i. D3359, Standard Test Methods for Measuring Adhesion by Tape Test.
   l. G154, Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.

2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems above 600V.
   b. 1247, Standard for Interrupter Switches for Alternating Current, Rated Above 1000V.
   c. C37.60, Standard for High-Voltage Switchgear and Control gear.

   d. C37.74, Standard for Subsurface, Vault, and Padmounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems up to 38 kV.
e. C57.12.28, Switchgear and Transformers, Pad-Mounted Equipment, Enclosure Integrity.


1.2 DEFINITIONS

A. SCADA – Supervisory Control and Data Acquisition.

B. Line Switch – Connection Way for Loop Conductors. Combination of Vacuum Fault Interrupter and Isolating Switch Operated in Tandem by a Single Lever Action.

C. Load Switch Interrupter – Connection Way for Load Conductors. Combination of Vacuum Fault Interrupter and Isolating Switch Operated in Tandem by a Single Lever Action.

D. WAY – Numbered Physical Line In or Load Out. 3-Phase, 600 AMP Bushing Connection to the Bus.

E. Switched Way – A Way Connected to the Bus through a Three-Phase Group Operated Line or Load Switch.

1.3 SUBMITTALS

A. Action Submittals submit to the Authority per contract:
   1. Descriptive and detailed modifications to existing pad-mounted switchgear.
   2. Descriptive product information for switchgear and enclosure. Custom paint color samples of enclosure for the Authority written approval.
   3. Dimensional drawings including weight and center of gravity for switchgear.
   4. Itemized bill of material.
   5. Operational description, including initial startup, checking and commissioning procedure.
   6. Installation instructions (switchgear and outer enclosure).
   7. Switchgear configurations for line in/out ways plus load interrupter ways.
   8. Power Operated Line Switch(s) data and circuitry.
   9. Power Operated Load Interrupter Switch(s) data and circuitry.
10. Current Transformers, Potential (Voltage) Transformers, and Capacitive Voltage sensing bushings data.

11. Field interface modules.

12. Conduit entrance locations.

13. Point-to-Point field control and signal wiring diagrams – ATO to SCADA cabinet.

14. Concrete pad details.

15. Base spacer details.


17. Factory Demonstration Test (FDT) Unwitnessed and Witness Testing Forms. Reference Section 26 09 14 Power System Supervisory Control and Data Acquisition (SCADA) for requirements.

18. Reinforced or precast concrete design Drawings and Seismic Anchorage and Bracing Calculations for seismic attachments, braces, and anchorages. Include IBC and project specific criteria in addition to manufacturer’s specific criteria used for the design; sealed by a Structural Engineer registered in the State of California.

B. Informational Submittals, submit to the Authority per contract:

1. Drawings and Seismic Anchorage and Bracing Calculations for seismic attachments, braces, and anchorages. Include IBC and project specific criteria in addition to manufacturer’s specific criteria used for the design; sealed by a Structural Engineer registered in the State of California.

2. Unwitnessed and Witnessed Certified Factory Test Reports.

3. Manufacturer’s installation instructions.

4. Manufacturer’s Certificate of Proper Installation in accordance with Section 1D – Special Conditions, Article 1D-12 Certificates of Compliance.

5. Operation and Maintenance Data: As specified in Section 1D – Special Conditions, Article 1D-51 Project Closeout.
1.4 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following special tools and material:

1. Two operating handles for each switchgear (ATO) (as required).

2. One pentahead socket for each switchgear (ATO).

3. Two sets of three 25kV Elbow grounding jumpers, 3 feet in length, complete with storage bag for each set.

4. One can of primer and one can of finish coat paint of the same style as the original finish.

1.5 QUALITY ASSURANCE

A. Environmental Quality: Switchgear tank shall not contain SF6 gas or insulating high fire point liquid or mineral oil for its insulating medium.

1.6 SPECIAL GUARANTEE

A. Provide manufacturer’s extended guarantee or warranty, with the Authority named as beneficiary, in writing, as special guarantee for all medium voltage pad mounted switchgear and appurtenances furnished on this project. Special guarantee shall provide for replacement of pad mounted switchgear and appurtenances during a period of 3 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be the responsibility of the Contractor for three years after date of Substantial Completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS (BASIS OF DESIGN IS FIRST NAMED)

A. Innovative Switchgear Solutions, Inc., Pad Mounted Medium Voltage Insulated Switchgear.

B. Or equal.

2.2 GENERAL

A. Pad mount switchgear suitable for 12,000 volts nominal, three-phase, three-wire grounded electrical system having an available short-circuit current at medium voltage terminals of amperes rms symmetrical as shown on Drawings.
B. Provide pad mounted switchgear that is the product of a single manufacturer. Assembled units with component parts of several manufacturers will not be acceptable with the exception that minor items as terminal blocks, test switch, wiring, etc., may be manufactured by others.

C. Pad mount switchgear is arranged and operated to provide FMD with a primary selective loop system extending 12kV primary loop from 12kV Main Switchgear A or 12kV Main Switchgear B to connected loads. Line Switches shall be monitored and controlled to perform the following operations:

1. Line Switch One (1) way Closed and Line Switch Two (2) way Closed.
2. Line Switch One (1) way Closed and Line Switch Two (2) way Opened.
3. Line Switch One (1) way Opened and Line Switch Two (2) way Closed.
4. Line Switch One (1) way Opened and Line Switch Two (2) way Opened.
5. Load Interrupter Switch four (4) way, five (5) way, and six (6) way Opened and Closed remotely by SCADA.

D. Configurations:

1. Pad mounted switchgear arranged with two (2) way independently power operated line switches, and two (2) way independently power operated load interrupter switches as shown on Drawings.

2. Pad mounted switchgear arranged with two (2) way independently power operated line switches, and three (3) way or four (4) way independently power operated load interrupter switches as shown on Drawings. The following descriptions apply throughout the remainder of this Specification Section:
   a. Four (4) way implies two (2) load interrupter switches.
   b. Five (5) way implies three (3) load interrupter switches.
   c. Six (6) way implies four (4) load interrupter switches.

3. Bus: Three-phase junction common to four (4) way, five (5) way, and six (6) way configurations.

E. Power switching local and remote operated by 12kV Power System Supervisory Control and Data Acquisition System.

G. Operating Conditions:
   1. Ambient Temperature: Maximum 40 degrees C.
   2. Equipment shall be fully rated without derating for these operating conditions.

H. Anchor Bolts: Type 316 stainless steel, length sized by manufacturer.

2.3 EQUIPMENT RATINGS

A. Integrated switchgear assembly ratings at 60-Hz.

1. Voltage: 25 kV nominal, 27.0 kV maximum.

2. Insulation Level: 125 kV BIL.


4. Three-Pole Line Switch (2 ways – Vacuum Fault Interrupter):
   a. Current: 600 continuous amperes, 600 amperes load make and drop.
   b. 12.5 kA Symmetrical-Momentary, Make and Latch, Fault Closing and Fault Interrupting.
   c. 20 kA Asymmetrical-Momentary, Make and Latch, Fault Closing and Fault Interrupting.

   a. Current: 600 continuous amperes, 600 amperes load dropping amperes make and drop.
   c. 20 kA Asymmetrical-Momentary, Make and Latch, Fault Closing and Fault Interrupting.

B. Operating Conditions:

1. Location: outdoors, above ground, marine air.

2. Ambient Temperature: Maximum 40 Degrees C.

3. Elevation: 25 feet above sea level max.

4. Equipment shall be fully rated with derating for these operating conditions.
2.4 ENCLOSURE

A. Pad-mounted, front access freestanding, self-supporting construction with welded structural and butt joints having external seams ground flush and smooth. Provide custom brackets for supporting two single-phase potential transformers by attachment to tank stands.

B. Enclosure sides, doors, roof, bottom flange and steel barriers constructed with 12-gauge Type 304 stainless steel. Provide Two (2) 4-inch conduit knockouts on both sides of enclosure.

C. Tamper resistant with no externally accessible hardware in accordance with security requirements of IEEE C57.12.28.

D. Removable lifting tabs bolted to blind-tapped sockets with resilient anticorrosion material between tabs and enclosure.

E. Enclosure Base:
   1. Consisting of continuous 90-degree galvanized steel flanges welded to enclosure and turned inward for bolting to concrete pad.
   2. Coat enclosure flange with wax-based anticorrosion moisture barrier.

F. Enclosure Roof:
   1. Overlapping edges creating mechanical maze and ventilating openings.
   2. Insulating non-drip compound applied to underside.

G. Doors: Double doors and constructed with edge flanges overlapping door openings to form mechanical maze.

H. Door Latch:
   1. Automatic positive action, three-point, spring-loaded latching mechanism for each door or set of doors.
   2. Wind bracing for 90-degree (or greater) door opening.

I. Finish:
   1. Multistage process applied to interior and exterior surfaces, joints, and blind areas prior to enclosure assembly.
      a. Pretreatment protective film.
      b. Baked epoxy or powder-coated finished coating.
      c. Baked acrylic enamel top coating in accordance with IEEE C57.12.28.
2. Color: Munsell 7GY3.29/1.5, olive green as approved, in writing, by the Authority.

3. Tests:
   a. Salt-spray test in accordance with ASTM B117.
   b. Humidity test in accordance with ASTM D2247 and ASTM D714.
   c. Accelerated weather tests in accordance with ASTM G154, ASTM D4214, and ASTM D523.
   d. Adhesion tests in accordance with ASTM D3359, Method B and ASTM D2794.
   e. Corrosion tests in accordance with ASTM D1654.
   f. Abrasion tests in accordance with ASTM D4060.
   g. Oil resistance testing with no shift in color, streaking, blistering, or loss of hardness.

J. Base Spacer:
   1. Type 304 stainless steel, 12 gauge, with top and bottom flanges to match switch enclosure size and bolting pattern. Furnish all 316 stainless steel bolts, washers, nuts, locknuts for connecting the switch enclosure.
   2. Base spacer to be approximately 12-inches high, unless different size is shown on the Drawings.

2.5 STAINLESS STEEL TANK
   A. Factory welded, single Type 304 stainless steel air-filled, dead front, tank.
   B. A means of lifting the tank (multiple lifting eyes) shall be provided.
   C. Features:
      1. Switchgear shall be air filled and completely sealed.
      2. Switchgear shall withstand system voltage up to 27 kV at ambient environmental conditions.
      3. Viewing windows to permit inspection of open isolation switch contacts and nameplate indicated viewed position.

2.6 GROUND-CONNECTION PADS
   A. Provided in each compartment on inside at bottom door stile with momentary rating equal to, or exceeding, short-circuit ratings of switchgear.
   B. Constructed of 5/8-inch-thick nickel-plated steel, with oxide inhibitor and sealant coating, welded to enclosure.
2.7 MEDIUM VOLTAGE BUS

A. Copper bus bar and bus supports.
B. Round-edged, hard-drawn copper bar in accordance with ASTM B187.
C. Silver plated and insulated.
D. Bus rated 600 amperes, continuous, minimum.

2.8 LINE SWITCH (VACUUM)

A. Three-pole, non-fused, power group-operated vacuum load operator with quick-make and quick-break mechanism for full load, motorized open and close switching in accordance with IEEE C37.58.

B. Switch Operation and Features:
   1. Two (2) three-phase vacuum insulated interrupters.
   2. 600 Amp continuous and load break.
   3. Control and monitoring provided under Section 26 09 13, Power Measurement and Control and Section 26 09 14, Power System Supervisory Control and Data Acquisition (SCADA).
   4. Motor ratings: 24 VDC, 15 amps inrush, 6-amps operating, 3 seconds operating time.

C. Line switches shall not require an integral ground switch. Each switch way shall have a single operating lever that simultaneously opens the three-phase vacuum interrupter and the isolation switch in a single movement for complete isolation of the external bushings,
2.9 **LOAD INTERRUPTER SWITCH (VACUUM)**

A. Three-pole, non-fused, power group-operated vacuum load operators with quick-make and quick-break mechanism for full load, motorized open and close switching in accordance with IEEE C37.58.

B. Interrupter shall have a three-time duty cycle fault-closing rating as specified. Interrupter shall have the ability to close the designated number of times against a three-phase fault with the asymmetrical (peak) current in at least one phase equal to the rated values and clear the resulting fault current with the interrupter remaining operable and able to carry and interrupt the rated current.

C. Control and monitoring provided under Section 26 09 13, Power Measurement and Control and Section 26 09 14, Power System Supervisory Control and Data Acquisition (SCADA).

D. Features:

1. Four (4) way, five (5) way, and six (6) way three-phase vacuum load interrupters as shown on Drawings.

2. 600 Amp continuous and load break on all ways.

3. Control and monitoring provided under Section 26 09 13, Power Measurement and Control and Section 26 09 14, Power System Supervisory Control and Data Acquisition (SCADA).

4. Motor ratings: 24 VDC, 15 amps inrush, 6-amps operating, 3 seconds operating time.

5. Load Interrupter switches shall not require an integral ground switch. Each switch way shall have a single operating lever that simultaneously opens the three-phase vacuum interrupter and the isolation switch in a single movement for complete isolation of the external bushings.

2.10 **BUSHINGS AND BUSHING WELLS**

A. All bushings and bushing wells shall be located on one side of the switchgear to reduce the required operating clearance.

B. Busing and bushing wells shall confirm to ANSI/IEEE Standard 386.

C. Busing rated 600 amperes continuous shall be provided with a threaded copper stud.
2.11 CONTROL WIRING

A. CEC, Type SIS, single-conductor, Class B, stranded copper, rated 600 volts for low voltage power, control, and instrumentation.

B. Individual seven-strand, copper conductors, twisted and covered with a 100 percent aluminum, polyester shield with tinned copper drain wire and overall outer jacket, rated 600 volts, 90 degrees C minimum for transducer output and analog circuits.

C. Conductor Lugs: Pre-insulated, self-locking, spade type with reinforced sleeves.

D. Wire Markers: Each wire individually identified with permanent markers at each end.

E. Internal circuit wiring crossing shipping splits to have plug connectors.

F. Splices: Not permitted.

G. Signal Interface with SCADA:

1. Provide all sensors, devices, interface modules, dry contact relays, signal and control conductors, terminations, and termination cabinet to support the following minimum interface with SCADA:
   a. Line Switch Way (1, 2) opened/closed tripped Status.
   b. Line Switch Way (1, 2) open/close/trip Command.
   c. Load Interrupter Switch Way (4, 5, 6) opened/closed/tripped Status (as shown).
   d. Load Interrupter Switch Way (4, 5, 6) open/close/trip Command (as shown).
   e. Cabinet intrusion (single and both doors open).
   f. Line Switch Way (1, 2) three-phase voltage.
   g. Line Switch Way (1, 2) three-phase current.
   h. Load Interrupter Switch Way (4, 5, 6) three-phase current (as shown).
   i. Note: Three-phase voltage for solar and power factor correction loads will be provided by Suppliers of solar and power factor correction packages and route directly to SCADA Cabinets as shown.
2.12 POTENTIAL TRANSFORMERS

A. Provide additional bushings on the switch tank and connected directly to bushing connected to line side switching to power two (2) 1500 VA potential transformers. Secondary side of potential transformers to provide input AC power to battery charger system, SCADA cabinet space heaters, and miscellaneous 120V ac instrumentation.

B. Manufacturer:

1. ABB, VIL 95 (788IA 93G07).
2. Or approved equal, (no known equal).

C. Internal current transformers on line and load ways to provide load current monitoring, fault isolation and over-current protection as required in Section 26 09 13, Power Measurement and Control.

2.13 LABELING

A. Nonmetallic, per Section 26 05 53 with integral lettering and symbols, mounted with corrosion resistant fasteners.

B. Warning Labels:

1. Attach to exterior surface of each external door, labels reading CAUTION—HIGH VOLTAGE-KEEP OUT.
2. Attach to internal surface of each external door and on all barriers used to prevent access to live parts, labels reading DANGER—HIGH VOLTAGE—KEEP OUT—QUALIFIED PERSONS ONLY.

C. Rating Labels: Attach inside each door, or set of double doors, labels indicating:

1. Voltage rating.
2. Main bus continuous rating.
3. Short-circuit ratings in amperes rms symmetrical and MVA three-phase symmetrical at rated nominal voltage.
4. Load interrupter switch type.
5. Load interrupter switch ratings, including duty-cycle fault-closing and short time momentary, amperes rms asymmetrical and 1 second, amperes rms symmetrical.
D. **Connection Labels**: Attach inside each door, or set of double doors, and inside each switch-operating hub access cover, labels showing three-line connection diagram for interrupter switches, and bus along with manufacturer’s model number.

E. Phase identification numbers 1, 2, and 3 above each phase connection at each line switch and each load interrupter switch.

### 2.14 **NAMEPLATES**

A. Deep etched stainless steel on outside of each door, or set of double doors, indicating:

1. Manufacturer’s information: name, catalog number, model number, date of manufacture, and serial number.

2. Arrangement: (4-way, 5-way, 6-way).

3. Switch and bus ratings: voltage, current, short-circuit, phase, BIL, and MVA.

4. Tag identification (as shown).

B. Riveted to door surface.

### 2.15 **SOURCE QUALITY CONTROL**

A. General:

1. The Authority will actively participate in many of the tests.

2. The Authority reserves right to test or retest specified functions.

3. The Authority’s decision will be final regarding acceptability and completeness of testing.

4. Contractor and Manufacturer’s Representative shall coordinate and supply on-hand all personnel and testing equipment to support all Source Quality Control activities.

5. Procedures, Forms, and Checklists:
   a. Except for Unwitnessed Factory Test, conduct tests in accordance with, and documented on, THE AUTHORITY accepted procedures, forms, and checklists.
   b. Describe each test item to be performed.
   c. Have space after each test item description for sign off by appropriate party after satisfactory completion.
6. Required Test Documentation: Test procedures, forms, and checklists signed by the Authority, Engineer, and Contractor.

7. Conducting Tests:
   a. Provide special testing materials and equipment.
   b. Wherever possible, perform tests using actual process variables, equipment, and data.
   c. If not practical to test with real process variables, equipment, and data provide suitable means of simulation.
   d. Define simulation techniques in test procedures.
   e. Test Format: Cause and effect.
      1) Person conducting test initiates an input (cause).
      2) Specific test requirement is satisfied if correct result (effect), occurs.

B. Switchgear assembly shall be production tested in accordance with IEEE C37.1247, IEEE C37.60, and IEEE C37.74.

C. Unwitnessed Factory Tests:
   1. Scope: Inspect pad mounted switchgear to ensure it is operational and ready for delivery to Project Site as described herein.
   2. Location: Pad Mounted Switchgear Manufacturer’s Facility.
   3. Integrated Test:
      a. Interconnect and test.
      b. Exercise and test functions.
      c. Provide testing of all hardware and communications to demonstrate a complete assembly.

D. Witnessed Factory Demonstration Test (FDT):
   1. Contractor shall coordinate and schedule factory tests with Manufacturer’s Representative, PSS Integrator, and the Authority.
   2. Contractor shall be present with Manufacturer’s Representative, PSS Integrator, and the Authority for Witnessed FDT.
   3. Contractor shall include costs to send and retrieve pad mounted switchgear (4-way) to and from PSS Integrator’s Facility if required. Reference Section 26 09 14, Power System Supervisory Control and Data Acquisition (SCADA) and this Section 26 13 16.02 Pad-Mounted Switchgear for additional requirements. Equipment shall not be released back to supplier until all testing is completed.
   4. Test reports shall indicate test procedures and instrumentation use to measure and record data.
5. Test reports shall be certified by testing personnel and stamped and signed by a Professional Engineer Licensed in the State where tests are performed.

6. Contractor and Manufacturer’s Representative shall supply on-hand all personnel and testing equipment to support FDT activities.

7. Notify the Authority of test schedule 4 weeks prior to start of test.

8. Scope:
   a. Test pad mounted switchgear to demonstrate it is operational.
   b. Location: Manufacturer’s Facility.

9. Correctness of motorized operations, contacts, switches, CTs, and PTs and wiring to input/output termination points.
   a. Demonstrate each discrete and analog signal at terminal strips.
   b. Demonstrate correctness of each analog signal using current and voltage sources.

10. Loop-Specific Functions: Demonstrate functions shown on Point IO Drawings, control diagrams, loop specifications as identified within Specification Section 26 09 16, Power System Application Software:
    a. All required functions for 100 percent of components.
    b. Timing: Include tests for timing requirements.
    c. Diagnostics: Demonstrate online and offline diagnostic tests and procedures.

11. Correct deficiencies found and complete prior to shipment to Site.

12. Failed Tests:
    a. Repeat and witnessed by the Authority.
    b. With written approval of the Authority, certain tests may be conducted by PSS Integrator and witnessed by the Authority as part of Functional Test.

13. Make following documentation available to the Authority at test site both before and during FDT:
    b. Master copy of FDT procedures.
    c. List of equipment to be tested including make, model, and serial number.
    d. Approved hardware Shop Drawings for equipment being tested.
    e. Approved preliminary software documentation Submittal.

14. Daily Schedule for FDT:
    a. Begin each day with meeting to review day’s test schedule.
    b. End each day with each meeting to review day’s test results and to review or revise next day’s test schedule.
E. Deliver pad-mounted switchgear to project site after successful completion of factory demonstration testing.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install equipment in accordance with manufacturer’s instructions and recommendations.

B. Secure equipment to concrete pad with anchor bolts of sufficient size and number adequate for specified seismic conditions.

C. Tighten current-carrying bolted bus connections and enclosure framing and panel bolts to manufacturer’s recommendations.

D. Coordinate terminal connections with installation of secondary feeders.

3.2 MANUFACTURER’S SERVICES

A. Furnish manufacturer’s representative in accordance with Section 01 43 33, Manufacturer’s Field Services, for the following services at Site, for minimum person-days listed below, travel time excluded:

1. 2 person-days for installation assistance, final adjustment, and initial energization of equipment.

2. 2 person-days for functional and performance testing and completion of Manufacturer’s Certificate of Proper Installation.

3. 1 person-days for post-startup training.

4. 2 person-days to support Factory Demonstration Testing (FDT). Reference Section 26 09 14 Power System Supervisory Control and Data Acquisition (SCADA). Furnish training of the Authority personnel at such times as requested by the Authority.

END OF SECTION 26 13 19.02
PART 1 GENERAL

1.1 REFERENCES

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

1. National Electrical Manufacturers Association (NEMA):
   a. PB 2, Deadfront Distribution Switchboards.
   b. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).


3. Underwriters Laboratories (UL):
   a. 489, Standard for Safety for Molded-Case Circuit Breakers,
   b. Molded-Case Switches, and Circuit Breaker Enclosures.
   c. 891, Standard for Safety for Switchboards.
        1561, Standard for Safety for Dry-Type General Purpose and Power Transformers.

1.2 SUBMITTALS

A. Action Submittals, submit through the Authority per contract:

1. Descriptive product 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.


8. Bus data.

9. Incoming line section equipment data.
10. Transformer section equipment data.

11. Conduit entrance locations.

12. Anchoring instructions and details.

13. Reinforced or pad-mounted concrete design Drawings and Seismic Anchorage and Bracing Calculations for seismic attachments, braces, and anchorages. Include IBC and project specific criteria in addition to manufacturer’s specific criteria used for the design; sealed by a Structural or Civil Engineer registered in the State of California.

B. Informational Submittals, submit through the Authority per contract:

1. Manufacturer Drawings, and Seismic Anchorage and Bracing Calculations, for seismic attachments, braces, and anchorages. Include IBC and project specific criteria in addition to manufacturer’s specific criteria used for the design; signed and sealed by a Structural or Civil Engineer registered in the State of California.

2. Unwitnessed Certified Factory Test Reports.

3. Manufacturer’s installation instructions.

4. Manufacturer’s Certificate of Proper Installation in accordance with Section 1D – Special Conditions, Article 1D-12 Certificates of Compliance.

5. Operation and Maintenance Data: As specified in Section 1D – Special Conditions, Article 1D-51 Project Closeout.

1.3 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with California Electrical Code (CEC). 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 CEC.

2. Materials and equipment manufactured within scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.
1.4 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage and deliver prior to 60 percent Project completion the following spare parts:

1. Fuses: One complete set of spare fuses of each current rating, both power and control.
2. Lights: One complete set of spare indicating lights.
3. Paint: One pint, to match enclosure exterior finish in color and quality.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

2. Square D.
4. Or equal.

2.2 GENERAL REQUIREMENTS

A. Equipment suitable for electrical system and available short-circuit current at line terminals as shown on Drawings.

B. Comply with NEMA PB 2 and UL 891.

C. Switchboard and its major components to be manufactured and assembled by single manufacturer in order to achieve standardization for appearance, operation and maintenance, spare parts replacement, and manufacturer's services.

D. Lifting lugs on equipment and devices weighing over 100 pounds.

E. Operating Conditions:

1. Ambient Temperature: Maximum 40 degrees C.
2. Equipment shall be fully rated without derating for the above operating conditions.
2.3 STATIONARY STRUCTURE

A. Type: NEMA PB 2 construction, dead front, completely metal enclosed, self-supporting.

B. Sections bolted together to form one rigid assembly capable of being moved into position and bolted directly to floor without use of floor sills.

2.4 ENCLOSURE

A. Equipment Finish: Baked enamel applied over rust-inhibiting phosphated base coating.

   1. Color:
      a. Exterior: Gray finish as approved in writing by Authority.
      c. Unpainted Parts: Plated for corrosion resistance.

B. Aisle-less Outdoor Enclosure:

   1. NEMA 250, Type 3R 316 Stainless Steel enclosing NEMA 250, Type1, enclosed switchboard.

   2. Hinged, full-height doors with three-point latch operated by vault-type handle with multiple padlocking provisions for each front and rear, switchboard section.

   3. Minimum 10-inch front access space between exterior door and front of interior switchboard doors.

   4. Gasketed doors, rear panels end panels, and sloped roof having 4-inch minimum overhang on all sides.

   5. Support assembly on 4-inch modular base or two 6-inch-high I-beams running parallel to switchboard length.

   6. Steel bottom enclosure and support assembly undercoated with coal tar emulsion.

   7. Ventilating louvers with filters in front door and rear panels.

   8. Space Heaters: Thermostatically controlled 250-watt, 120-volt, in each switchboard vertical section and powered from internally fused power control transformer sized for continuous operating heat load.

   9. Adjustable thermostat for temperature range of 50 degrees F to 70 degrees F.
10. Provide protective device, control power transformer, wiring, and connections integral to switchboard assembly to operate space heaters.

C. Interior cover: Outdoor applications use provide Flir 4/12, 316 Stainless Steel IR Ports, as required, per the manufacturer component layout, sufficient to see all phase and neutral conductor terminations, bussing splices and breaker terminations. For indoor applications use standard Flir Type 4/12 aluminum IR Ports.

2.5 BUSWORK

A. Material: Phase: insulated tin-plated copper throughout entire length of sufficient cross section to limit temperature rise at rated current to 55 degrees C.

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 as shown.

D. Main Horizontal Bus: Non-tapered, continuous current rating as shown.

E. Neutral Bus: Continuous current rating as shown.

F. Ground Bus:
   1. Tin-plated copper.
   2. Rating: As shown.
   3. Bolted to each vertical section.

G. Extend each bus entire length of switchboard.

2.6 PROTECTIVE DEVICES

A. Insulated-Case Circuit Breakers:
   1. Main, and Feeder Protective Devices, Breakers 1000 Ampere Frame and Above: Individually mounted draw-out and Fixed, individually mounted as shown. UL 489 listed for 100 percent of continuous ampere rating, suitable for use with 75 degrees C wire at full 75 degrees C ampacity when mounted in switchboard.
   2. Arrangement: Fully rated main and branch feeder as shown.
   3. Frame Sizes: As shown with solid-state trip units.
4. Interrupting Rating: as shown.

5. Selective override circuit having short-time adjustment for selectivity up to rated rms short-time rating.

6. Two-step, stored energy mechanism with maximum of five cycle closings.


8. Control Power Voltage: 120V ac or 48 V dc as shown.


10. Color-Coded Visual Indicators: Contact OPEN and CLOSE, plus mechanism CHARGE and DISCHARGED.

11. Draw-Out Construction:
   a. Individual compartments, sheet steel top, bottom, and sides with padlockable door.
   b. Flame retardant, arc track resistance nonmetallic rear barrier.
   c. CTs, where shown, mounted within appropriate breaker compartment.
   d. Stationary contacts extended to bus through rear barrier.
   e. Secondary contact engagement maintained in CONNECTED and TEST positions.
   f. Draw-out mechanism with disconnecting contacts, wheels, and interlocks.
      1) Equipped with means to rack breaker into CONNECTED, TEST, and DISCONNECTED positions.
      2) Full withdraw position allowing breaker removal and tilt for inspection.
      3) Door closable with breaker in any position.
   g. External visual breaker position indicator.
   h. Each compartment designed for specific breaker frame size.
   i. Each breaker compartment fully equipped with electrical connections, bolted metal barrier across compartment face and compartment door.
   j. Battery backup for trip unit, size and voltage ratings as required.

12. Breaker Control: Charge pushbutton, control switch, and red and green indicating lights.
13. Provide contacts rated at 10Amps, 120Vac for remote indication of the following conditions:
   a. Breaker tripped.
   b. Breaker Open.
   c. Breaker Closed.


15. Test Facilities:
   a. Breakers with integral external test points for portable test kit.
   b. One, handheld test kit for functional testing of trip circuitry.
   c. Separately mounted panel to test ground fault by not tripping breaker.

B. Mechanical interlock to prevent opening compartment door while breaker is in closed position

C. Molded-Case Circuit Breakers:

1. Main, (Below 1000 Amps) and Branch Feeder Protective Devices: Individually mounted, suitable for use with 75 degree C wire at full 75 degree C ampacity when mounted in switchboard.

2. Arrangement: Branch feeder breakers group-mounted as shown.

3. Breakers below 150-Ampere Frame: Continuously adjustable magnetic pickups five to ten times trip rating.


5. Interrupting Rating: as shown.

6. Mechanical interlock to prevent opening compartment door while breaker is in closed position.

7. Provide contacts rated at 10 Amps, 120 Vac for remote indication of the following conditions:
   a. Breaker tripped.
   b. Breaker Open.
   c. Breaker Closed.

D. Ground Fault Protection: (Where shown)

1. Ground sensor encircling phase conductors and neutral conductor, where used.

2. Solid-state sensing relay and monitor/test panel.
3. Zero sequence current detection, adjustable over range shown.
4. Monitor panel with fault detection indicating light, test, and reset buttons.
5. Control Power Source: Suitable to operate circuit protective device when connected to faulted phase conductor.

E. Breaker Accessories:
1. Shunt trip for mains.
2. Auxiliary status switches for breaker open-close status and remote monitoring.
3. Digital power meter as shown, see 2.12. A

2.7 SOLID-STATE TRIP UNIT

A. Flux-shift trip and current sensors.

B. Protective Programmers:
1. Self-powered, automatic rms sensing micro-electronic processor with battery backup unit, size and ratings as required.
2. No external relays or accessories.
3. Printed circuit cards with gold-plated contacts.
4. Programmable Controls:
   a. Fixed-point, with repetitive accuracy and precise unit settings.
   b. Trip adjustments made by nonremovable, discrete step switching.

5. Field-Installable Rating Plugs:
   a. Long-time pickup LED indicator and test receptacle.
   b. Matching load and cable requirements.
   c. Interlocked with tripping mechanism.
   d. Breaker to remain trip-free with plug removed.
   e. Keyed rating plugs to prevent incorrect application.

7. Selective Coordination Time/Current Curve Shaping Adjustable Functions:
   a. Current setting.
   b. Long-time pickup.
   c. Long-time delay.
   d. Instantaneous pickup with short-time for main and feeders as shown.
   e. Short-time pickup main and feeders as shown.
   f. Short-time delay for main and feeders with I2T function, and IN-OUT switch as shown.
   g. Ground fault pickup.
   h. Ground fault delay with I2T function.

8. Fixed, instantaneous pickup for feeders as shown.

9. Fault Trip Indicators: Mechanical push-to-reset type for overload and short-circuit overload plus ground fault trip.

10. Rejection Pins: For each programmer frame size.

C. Phase Current Sensors:
   2. Fixed, mounted on breaker frame.
   4. One toroidal type for each phase.

D. Ground Fault Sensor:
   1. Neutral bar single-ratio CT mounted in cable compartment.
   3. Shorting bar.

E. Portable Test Set: ac/dc static, full function unit for checking programmer’s time-current characteristics of programmer.
2.8 CONTROL WIRING

A. Control, Instrumentation, and Power/Current Circuits: CEC, Type SIS, single-conductor, Class B, stranded copper, rated 600 volts.

B. Transducer Output/Analog Circuits: Shielded cable rated 600 volts, 90 degrees C minimum.

C. Conductor Lugs: Preinsulated, self-locking, spade-type, with reinforced sleeves.

D. Identification: Individually, with permanent wire markers at each end.

E. Enclose in top and vertical steel wiring troughs, and front-to-rear in nonmetallic wiring troughs.

F. Splices: Not permitted in switchboard wiring.

2.9 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 switchboard.

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 terminal blocks.

I. Manufacturer:

1. General Electric; Type EB-5
2. Square D.
4. Or approved equal.
2.10 UTILITY METERING SWITCHBOARD - NOT USED

2.11 INSTRUMENTATION AND METERING

A. As specified in Section 26 09 13, Power Measurement and Control.

2.12 POWER METER

A. As specified in Section 26 09 13, Power Measurement and Control.

2.13 IDENTIFICATION

A. Nameplates:

1. Master:
   a. Deep-etched aluminum, with manufacturer’s name and model number.
   b. Riveted to main vertical section.

2. Circuit Breaker Cubicle and Door-Mounted Device reference Section 26 05 52 Electrical Identification:
   a. Engraved, acrylic.
   b. Color: White with black.
   c. Characters: Block-type, 3/16-inch high.
   d. Size: Manufacturer’s standard.
   e. Inscription: As shown on one-line diagram.
   g. Attachment Screws: Stainless steel panhead.

B. Section Identification:

1. Stamped metallic, riveted to each vertical section.

2. Serial number, bus rating, and section reference number.

3. Size: Manufacturer’s standard.

C. Cubicle Labels, reference Section 26 05 53 Electrical Identification:

1. Nonmetallic, applied inside each cubicle compartment.

2. Device serial number, rating, and description.

D. Metering Instruments: Meter type identified on meter face below pointer or dial.

E. Control Switches: Deep etched, aluminum escutcheon plate.
F. Relays and Devices:
   1. Stamped metallic, riveted to instrument case.
   2. Manufacturer’s name, model number, relay type, and rating data.

G. Switchboard Sign:
   1. Two signs each on front of switchboard.
   2. Engraved, phenolic.
   3. Size: Manufacturer’s standard.
   5. Characters: Gothic-type, 1 inch high.
   6. Inscription: DANGER/HIGH VOLTAGE/KEEP OUT.
   7. Attachment: Four rivets each sign.

H. Mimic buss

2.14 ACCESSORIES

A. Portable circuit breaker lifting device: Floor supported, roller based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.

2.15 FACTORY TESTING

A. Performance tests in accordance with UL 891 and production tests in accordance with NEMA PB-2.

B. Certified Test Report.
PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer’s instructions and recommendations.

B. Install switchboards on concrete base, of 4-inch nominal thickness as shown on Drawings.

C. Secure to mounting pads with anchor bolts of sufficient size and number adequate for specified seismic conditions.

D. Install plumb and in longitudinal alignment with pad or wall.

E. Coordinate terminal connections with installation of secondary feeders.

3.2 MANUFACTURER’S SERVICES

A. Furnish manufacturer’s representative in accordance with Section 01 43 33, Manufacturer’s Field Services, for the following services at Site, for minimum person-days listed below, travel time excluded:

1. 2 person-days for installation assistance, final adjustment, and initial energization of equipment.

2. 2 person-days for functional and performance testing.

3. 1 person-day for adjustment of relay settings.

B. Furnish startup services and training of Authority personnel at such times as requested by the Authority.

END OF SECTION 26 14 13
PART 1 GENERAL

1.1 WEATHER LIMITATIONS

A. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used as fill or backfill until material completely thaws.

B. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.4 SEQUENCING AND SCHEDULING

A. Dewatering: Conform to applicable requirements of Section 31 23 19.01, Dewatering, prior to initiating excavation.

B. Excavation Support: Install and maintain, as specified in Section 31 41 00, Shoring, as necessary to support sides of excavations and prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 GENERAL

A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work.

B. Excavate to within tolerance of plus or minus 0.1 foot, except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base, topsoil, and similar items, wherever applicable.

C. Trim to neat lines where concrete is to be deposited against earth.

D. Do not over-excavate without written authorization of the Authority.

3.2 UNCLASSIFIED EXCAVATION

A. Excavation is unclassified. Complete all excavation regardless of the type, nature, or condition of the materials encountered.
3.3 TRENCH WIDTH


3.4 STOCKPILING EXCAVATED MATERIAL

A. Confine stockpiles to approved areas only, per requirements of Section 01010, Summary of Work.

3.5 DISPOSAL OF SPOIL

A. Dispose of excavated materials, which are unsuitable or exceed quantity needed for fill or backfill offsite, in accordance with the requirements of Section 01010, Summary of Work.

B. Dispose of debris resulting from removal of surface features and underground facilities as specified in Section 01 04 50, Cutting and Patching, 02 41 00, Demolition, and Section 02 41 01, Electric Utilities Demolition, for demolition debris.

END OF SECTION 31 23 16
PART 1  GENERAL

1.1  BACKGROUND INFORMATION

A.  Ground water may be encountered in trench and manhole excavations. Exact elevation of water table is not known. Water table may vary with tide and rainfall. Soils are known to be sandy in nature and have lenses of fatty clays. Fatty clays store water from rain events and can release if the lens is broken open by excavation during trench work for installation of duct banks and manholes.

B.  Related Sections:

1.  Section 1D “Special Provisions”

2.  Section 01010 “Summary of Work”

3.  Section 31 23 16 “Excavation”

4.  Section 31 23 23.15 “Trench Backfill”

5.  Section 31 41 00 “Shoring”

1.2  SUBMITTALS

A.  Informational Submittals:

1.  Two phase water control plan.

2.  Well permits.

3.  Calculations of water quantity.

4.  Test results from observation wells and from de-watering devices.

5.  Waste Discharge permits.
6. Water Level Elevations Observed in Observation Wells: Submit same day measured.

7. Settlement Benchmark Elevations: Submit weekly record.

8. Inflow Measurements: Submit weekly record.

1.3 WATER CONTROL PLAN

A. As a minimum, include:

1. Descriptions of proposed two phase groundwater and surface water control facilities including, but not limited to, observation wells, water quantity estimation calculations, equipment; methods; standby equipment and power supply, means of measuring inflow to excavations, pollution control and erosion facilities, discharge locations to be utilized, preliminary approval of use of discharge point and fee required for use, testing, and provisions for immediate temporary water supply as required by this section.

2. Phase one, observation, to include, but not limited to, monitoring wells along excavation route to determine water table depth.

3. Phase two, dewatering, to include, but not limited to, dewatering equipment and description of method and time frames, quantity estimates of water removed, treated and disposed or put back into the ground.

4. Drawings showing locations, dimensions, and relationships of elements of each system and location of redundant parts for each phase of dewatering and sequencing plan to coincide with overall work plan.

5. Design calculations demonstrating adequacy of proposed dewatering systems and components for each phase.

6. Plan shall be prepared and signed by contractor and all of the following: a QSD, signed and sealed by a soils and civil engineer.

7. If system is modified during installation or operation revise or amend and resubmit Water Control Plan.
1.4 QUALITY CONTROL

A. Comply with authorities having jurisdiction for discharge and disposal from pumping operations to the municipal sanitary sewer system.

B. Perform Work in accordance with The Authority, City of San Diego, County of San Diego, State of California, and Federal Regulations.

C. Maintain operating records, at a minimum, including start and stop times, quantity of water pumped, and quantity of water disposed of.

D. Provide one copy to the Authority, and maintain one copy at the Work site, of discharge permit obtained from San Diego Metropolitan Wastewater Department.

E. Provide copies to the Authority of all receipts of disposal fees paid to the City of San Diego.

F. Field Reports: Weekly test and monitoring reports.

G. Qualifications:

   1. Installer: Company specializing in performing work of this section with minimum 5 years documented experience and responsible for design, operation, and maintenance of dewatering system.

   2. Assume sole responsibility for dewatering and surface water control systems and for loss or damage resulting from partial or complete failure of protective measures and settlement or resultant damage caused by water control operations.

   3. Design, install, and monitor the operation of dewatering under direct supervision of a Professional Engineer experienced in design of this Work and licensed in the State of California.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. Remove and control water during periods when necessary to properly accomplish Work.

B. Contractor shall work with the Engineer and Geotechnical Engineer to determine the applicable dewatering systems to the specific field conditions, location of work, and any operational restrictions imposed by the Authority.
3.2 SURFACE WATER CONTROL

A. Provide dewatering and surface water control systems to permit Work to be completed in dry conditions or reduced wet conditions.

B. Remove surface runoff controls when no longer needed.

3.3 DEWATERING SYSTEMS

A. Provide, operate, and maintain dewatering systems of sufficient size and capacity to permit excavation and subsequent construction on dry and stable sub grade. Continuously maintain excavations free of water, regardless of source, and until backfilled to final grade.

B. Design and Operate Dewatering Systems:
   1. To prevent loss of ground as water is removed.
   2. To avoid inducing settlement or damage to existing facilities, completed Work, or adjacent property.
   3. To relieve artesian pressures and resultant uplift of excavation bottom or quick conditions.

C. Furnish tankage, pumps, piping and appurtenances as required to control and manage the flowrates and volumes of extraneous water encountered during the Work.

D. Provide sufficient redundancy in each system to keep excavation free of water in event of a single or multiple component failure.

E. Provide 100 percent emergency power backup with automatic startup and switchover in event of electrical power failure.

F. Provide supplemental ditches and sumps only as necessary to collect water from local seeps. Do not use ditches and sumps as primary means of dewatering. Addition pavement shall not be removed to accomplish. Other means must be used to control water.

3.4 MONITORING FLOWS

A. Monitor volume of water pumped per calendar day from excavations, as Work progresses. Also monitor volume of water introduced each day into excavations for performance of Work. Monitor flows using measuring devices acceptable to Engineer.
3.5 SAMPLING AND TESTING

A. Comply with the City of San Diego Industrial Wastewater Control Program for Groundwater Discharge Permit requirements for sampling and testing, if needed.

B. Provide a sampling location for the dewatering operation to allow the Authority and the City of San Diego to sample and test water.

C. If no contaminants are determined by The Authority and the City of San Diego to be present, the contractor shall be responsible for continuing the dewatering operation in conformance with the plans and these specifications.

D. If contaminants are determined to be present, cease dewatering operations immediately and notify the Authority.

3.6 DISPOSAL OF WATER

A. Method of discharge shall be in accordance with approved water control plans.

B. The Contractor is solely responsible for the violations of the discharge permit caused by the Contractor’s actions or lack of action in the dewatering process.

C. Treat water collected by dewatering operations, as required by regulatory agencies, prior to discharge, if allowed. At no time shall discharge be allowed into the storm drain system. Plan to control water from dewatering shall have two levels of containment. In addition, all inlets, downstream of work area, shall be protected.

D. Discharge water into the approved municipal sanitary system access location.

E. Discharge water as required by waste discharge permit and in manner that will not cause erosion or flooding, or otherwise damage existing facilities, completed Work, sewer system or adjacent property.

F. Remove solids from treatment facilities and perform other maintenance of treatment facilities as necessary to maintain their efficiency.
3.8 PROTECTION OF PROPERTY

A. Make assessment of potential for dewatering induced settlement. Provide and operate devices or systems, including but not limited to reinjection wells, infiltration trenches and cutoff walls, necessary to prevent damage to existing facilities, completed Work, and adjacent property.

B. Securely support existing facilities, completed Work, and adjacent property vulnerable to settlement due to dewatering operations. Support shall include, but not be limited to, bracing, underpinning, or compaction grouting.

END OF SECTION 31 23 19.01
PART 1 GENERAL

1.1 REFERENCES

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


2. ASTM International (ASTM):
   c. C117, Standard Test Method for Materials Finer than
      75 Micrometer (No. 200) Sieve in Mineral Aggregates by
      Washing.
   d. C136, Standard Test Method for Sieve Analysis of Fine and
      Coarse Aggregates.
   f. C618, Standard Specification for Coal Fly Ash and Raw or
      Calcined Natural Pozzolan for Use in Concrete.
   g. C1012/C1012M, Standard Test Method for Length Change
      of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
   h. D698, Standard Test Methods for Laboratory Compaction
      Characteristics of Soil Using Standard Effort (12,400 ft- lbf/ft3
      (600 kN-m/m3)).
   i. D1140, Standard Test Methods for Amount of Material in Soils
      Finer than No. 200 (75 micrometer) Sieve.
   j. D1557, Standard Test Methods for Laboratory Compaction
      Characteristics of Soil using Modified Effort (56,000 ft-lbf/ft3
      (2,700 kN-m/m3)).
   k. D2487, Standard Practice for Classification of Soils
      for Engineering Purposes (Unified Soil Classification System).
   l. D4253, Standard Test Methods for Maximum Index Density and
      Unit Weight of Soils Using a Vibratory Table.
   m. D4254, Standard Test Methods for Minimum Index Density
      and Unit Weight of Soils and Calculation of Relative Density.
   n. D4318, Standard Test Methods for Liquid Limit, Plastic Limit,
      and Plasticity Index of Soils.
   o. D4832, Standard Test Method for Preparation and Testing of
      Controlled Low Strength Material (CLSM) Test Cylinders.

1.2 DEFINITIONS

A. Base Rock: Granular material upon which manhole bases and other structures are placed.

B. Bedding Material: Granular material upon which pipes, conduits, cables, or duct banks are placed.

C. Imported Material: Material obtained by Contractor from source(s) offsite.

D. Lift: Loose (uncompacted) layer of material.

E. Pipe Zone: Backfill zone that includes full trench width and extends from prepared trench bottom to an upper limit above top outside surface of pipe, conduit, cable or duct bank.

F. Prepared Trench Bottom: Graded trench bottom after excavation and installation of stabilization material, if required, but before installation of bedding material.

G. Relative Density: As defined by ASTM D4253 and ASTM D4254.

H. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes producing a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids. Satisfying both of the following requirements, as defined in ASTM D2487:

1. Coefficient of Curvature: Greater than or equivalent to 1 and less than or equivalent to 3.
2. Coefficient of Uniformity: Greater than or equivalent to 4 for materials classified as gravel, and greater than or equivalent to 6 for materials classified as sand.

1.3 SUBMITTALS

A. Action Submittals, submit through the Authority per contract:

1. Shop Drawings: Manufacturer’s descriptive literature for marking tapes.
2. Samples:
   a. Trench stabilization material.
   b. Bedding and pipe zone material.
   c. Granular drain.
   d. Granular backfill.
   e. Sand(s).
B. Informational Submittals, submit through the Authority per contract:

1. Catalog and manufacturer’s data sheets for compaction equipment.

2. Certified Gradation Analysis: Submit not less than 30 days prior to delivery for imported materials or anticipated use for excavated materials, except for trench stabilization material that will be submitted prior to material delivery to Site.

3. Controlled Low Strength Material: Certified mix design and test results. Include material types and weight per cubic yard for each component of mix.

PART 2 PRODUCTS

2.1 MARKING TAPE

A. Detectable:

1. Solid aluminum foil, visible on unprinted side, encased in protective high visibility, inert polyethylene plastic jacket.

2. Foil Thickness: Minimum 0.35 mils.

3. Laminate Thickness: Minimum 5 mils.


5. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
   a. 12KV lines shall have the words “HIGH VOLTAGE” added to the continuous marking.

6. Joining Clips: Tin or nickel-coated furnished by tape manufacturer.

7. Manufacturers and Products:
   a. Reef Industries; Terra Tape, Sentry Line Detectable.
   b. Mutual Industries; Detectable Tape.
   c. Presco; Detectable Tape.
   d. Or equal.
B. Color: In accordance with APWA Uniform Color Code.

<table>
<thead>
<tr>
<th>Color</th>
<th>Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Electric power lines, cables, conduit, FO Cable and lighting cables</td>
</tr>
<tr>
<td>Orange</td>
<td>Communicating alarm or signal lines, cables, or conduit</td>
</tr>
<tr>
<td>Yellow</td>
<td>Gas, oil, steam, petroleum, or gaseous materials</td>
</tr>
<tr>
<td>Green</td>
<td>Sewers and drain lines</td>
</tr>
<tr>
<td>Blue</td>
<td>Potable water</td>
</tr>
<tr>
<td>Purple</td>
<td>Reclaimed water, irrigation, and slurry lines</td>
</tr>
</tbody>
</table>

*As specified in NEMA Z535.1, Safety Color Code.

2.2 TRACER WIRE

A. Material: Minimum 12-gauge solid copper or copper jacket with a steel core, with high-density polyethylene (HDPE) or high-molecular weight polyethylene (HMWPE) insulation suitable for direct bury.

B. Splices: Use wire nut or lug suitable for direct burial as recommended by tracer wire manufacturer.

C. Manufacturers:

1. Copperhead Industries, LLC.
2. Performance Wire & Cable Inc.
4. Or equal.

2.3 TRENCH STABILIZATION MATERIAL

A. Base Rock:

1. Clean, washed, hard, durable 1-inch minus crushed rock or gravel, or pit run, free from clay balls, other organic materials, or debris.
2. 100 percent retained on #4 sieve.
B. Slurry Encasement:
   1. Dry sand, water and cement mixture. For slurry encased conduits as needed for future interception.
   2. 180 pounds of ASTM C150/C150M, Type V Cement in each cubic yard of sand.
   3. For 12kv encasement use homogenous mixed color: RED
   4. Clean potable water.

C. Geotextile:
   1. Tensar Triax TX-5.
   2. Tencate Mirafi RS580i.
   3. Or equal.

2.4 BEDDING MATERIAL AND PIPE ZONE MATERIAL

A. Unfrozen, friable, and no clay balls, roots, or other organic material.

B. Clean or gravelly sand with less than 5 percent passing No. 200 sieve, as determined in accordance with ASTM D1140, or gravel or crushed rock within maximum particle size and other requirements as follows unless otherwise specified.
   1. Duct Banks: 3000 PSI Concrete.

2.5 EARTH BACKFILL

A. Soil, loam, or other excavated material suitable for use as backfill. Reference Section 01010 regarding spoils disposition.

B. Free from roots or organic matter, refuse, boulders and material larger than 1/2 cubic foot, or other deleterious materials.

2.6 CONTROLLED LOW STRENGTH MATERIAL BACKFILL (CLSM)

A. Select and proportion ingredients to obtain compressive strength between 50 psi and 150 psi at 28 days in accordance with ASTM D4832.

B. Materials:
   1. Cement: ASTM C150/C150M, Type V.
3. Fly Ash (Pozzolan): Class F or Class C fly ash in accordance with ASTM C618, except as modified herein:
   a. ASTM C618, Table 1, Loss on Ignition: Unless permitted otherwise, maximum 3 percent.
   b. Test in accordance with ASTM C1012/C1012M to verify sulfate resistance is acceptable.
   c. No more than 15 percent of cement materials by weight.

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

2.7 CONCRETE BACKFILL

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

   B. Mix: ASTM C94/C94M, Option A.
      1. Cement: ASTM C150/C150M, Type V.
      3. Design for Minimum Compressive Strength at 28 Days: 3,000 psi.

2.8 SOURCE QUALITY CONTROL

   A. Perform gradation analysis in accordance with ASTM C136 for:
      1. Earth backfill, including specified class.
      2. Trench stabilization material.
      3. Bedding and pipe zone material.

   B. Certify Laboratory Performance of Mix Designs:
      1. Controlled low strength material.
      2. Concrete.
PART 3    EXECUTION

3.1    TRENCH PREPARATION

A.    Water Control:

1.    Promptly remove and dispose of water entering trench as necessary to grade trench bottom and to compact backfill and install manholes, pipe, conduit, direct-buried cable, or duct bank.

2.    Do not place concrete, lay pipe, conduit, direct-buried cable, or duct bank in water. As specified in Section 31 23 19.01, Dewatering.

3.    Remove water in a manner that minimizes soil erosion from trench sides and bottom.

4.    Provide continuous water control until trench backfill is complete.

B.    Remove foreign material and backfill contaminated with foreign material that falls into trench.

3.2    TRENCH BOTTOM

A.    Grade with hand tools, remove loose and disturbed material, and trim off high areas and ridges left by excavating bucket teeth. Allow space for bedding material. The Authority will engage a qualified Geotechnical Engineer to observe excavated trench bottom on 50-foot to 100-foot intervals at the discretion of the Geotechnical Engineer based on the field conditions, or each day's production if less, to verify trench bottom subgrade is firm utilizing standard field methods (i.e., probing the soil) prior to proceeding with duct bank installation and backfill. It is expected native non-clayey materials will be 90 percent or greater relative density of maximum density. Where native clayey materials are encountered, unstable or unsuitable trench bottom subgrade may be determined by the Geotechnical Engineer.

B.    If unstable or unsuitable trench bottom subgrade is determined, Geotechnical Engineer will determine type of stabilization and depth of over-excavation, if any required.

3.3    TRENCH STABILIZATION MATERIAL INSTALLATION

A.    Rebuild trench bottom with trench stabilization material.

B.    Place material over full width of trench in 6-inch lifts to required grade, providing allowance for bedding thickness.
C. Place geotextile in trench as shown on contract documents. Place additional lifts of rock and wrap rock as shown in the detail on the contract documents. Finished rock and geotextile section should be two "burrito" type circles of geotextile, one inside the other. The finished "burrito" sections to be covered with two additional inches of rock over the geotextile.

D. Compact finished section as to provide a firm, yielding support for the bedding material prior to placing concrete for trench sections. Geotechnical Engineer is to determine the ability of the trench stabilization to support the ductbanks.

E. Compact each lift to provide a firm, unyielding support for the bedding material prior to placing succeeding lifts.

### 3.4 BEDDING

A. Furnish imported bedding material where, in the opinion of Engineer, excavated material is unsuitable for bedding or insufficient in quantity.

B. Place over full width of prepared trench bottom in two equivalent lifts when required depth exceeds 8 inches.

C. Hand grade and compact each lift to provide a firm, unyielding surface.

D. Minimum Thickness: 3 inches.
   1. Conduit: 3 inches.
   2. Duct Banks: 3 inches.

E. Check grade and correct irregularities in bedding material. Loosen top 1 inch to 2 inches of compacted bedding material with a rake or by other means to provide a cushion before laying each section of pipe, conduit, direct-buried cable, or duct bank.

F. Install to form continuous and uniform support except at bell holes, if applicable, or minor disturbances resulting from removal of lifting tackle.

G. Bell or Coupling Holes: Excavate in bedding at each joint to permit proper assembly and inspection of joint and to provide uniform bearing along barrel of pipe or conduit.
3.5 BACKFILL PIPE ZONE

A. Upper limit of pipe zone shall not be less than following:
   1. Conduit: 6 inches, unless shown otherwise.
   2. Duct Bank: 6 inches, unless shown otherwise.

B. Restrain pipe, conduit, cables, and duct banks as necessary to prevent their movement during backfill operations.

C. Place material simultaneously in lifts on both sides of pipe and, if applicable, between pipes, conduit, cables, and duct banks installed in same trench.

D. Pipe 6-Inch and Smaller Diameter: First lift less than or equivalent to 1/2 pipe diameter.

E. Thoroughly tamp or vibrate, including area under haunches, supplemented by “walking in” and slicing material under haunches with a shovel to ensure voids are completely filled.

F. Do not use power-driven impact compactors to compact pipe zone material.

3.6 MARKING TAPE INSTALLATION

A. Continuously install marking tape along centerline of buried piping, on top of last lift of pipe zone material at depth shown on Drawings. Coordinate with piping installation Drawings.
   1. Detectable Marking Tape: Install with nonmetallic piping, PVC Conduit and waterlines.

3.7 BACKFILL ABOVE PIPE ZONE

A. General:
   1. Process excavated material to meet specified gradation requirements.
   2. Adjust moisture content as necessary to obtain specified compaction.
   3. Do not allow backfill to free fall into trench or allow heavy, sharp pieces of material to be placed as backfill until after at least 2 feet of processed backfill or CLSM (if substituted) has been provided over top of duct bank.
B. Controlled Low Strength Material:

1. Discharge from truck mounted drum type mixer into trench, via pump or chute.

2. Place in lifts as necessary to prevent uplift (flotation) of new and existing facilities.

3. In vehicle traveled areas fill entire trench section to pavement finish grade for a temporary driving surface, and screed off excess and finish with a float.

4. In other areas fill trench section as shown.

3.8 MAINTENANCE OF TRENCH BACKFILL

A. After each section of trench is backfilled, maintain surface of backfilled trench even with adjacent ground surface until final surface restoration is completed.

B. Concrete Pavement: Replace settled slabs as specified in Section 32.13.13, Airfield Concrete Pavement.

C. Asphaltic Pavement: Replace settled areas or fill with asphalt as specified in Section 32.12.16, Asphalt Paving.

D. Other Areas: Add excavated material where applicable and keep surface of backfilled trench level with adjacent ground surface.

1.9 SETTLEMENT OF BACKFILL

A. Settlement of trench backfill, or of fill, will be considered a result of defective compaction of trench backfill.

END OF SECTION 31 23 23.15
PART 1  GENERAL

1.1  SUBMITTALS

   A.  Action Submittals:

      a.  Excavation support plan.
      b.  Movement monitoring plan.
      c.  Trench excavation plan.
      d.  Movement measurement and data, reduced results indicating movement trends and corrective actions plan.

1.2  QUALITY ASSURANCE

   A.  Provide surveys to monitor movements.

1.3  DEFINITIONS

   A.  The underground electrical infrastructure is defined as new duct bank, conduit, manholes, and handholes installed per the construction plans from the excavated limits up to the future pavement elevations.

1.4  DESIGN CRITERIA

   A.  The temporary support systems for the underground electrical system, as defined above, shall be designed for the subsurface conditions experienced during excavations and shall support adjacent traffic or aircraft loads as occurs.

PART 2  PRODUCTS (NOT USED)
PART 3 EXECUTION

3.1 GENERAL

A. Design, provide, and maintain shoring, sheeting, and bracing as necessary to support the sides of excavations and to prevent detrimental settlement and lateral movement of existing facilities, supporting base material, adjacent property and completed work.

B. Shoring will be required at all manhole or handhole locations and in trench locations, as described above.

3.2 EXCAVATION SUPPORT PLAN

A. For excavation exceeding 5 feet in depth, provide an adequate safety system meeting the requirements of California Labor Code Section 6707, applicable local construction safety orders, and federal requirements.

B. Sealed by a licensed Civil Engineer registered in the State of California who has a minimum of 5 years' experience in the design of similar soil support plans in similar soil and groundwater conditions.

C. Addressing the following topics:

   a. Details of shoring, bracing, sloping, or other provisions for worker protection from hazards of caving ground.

   b. Design assumptions and calculations.

   c. Methods and sequencing of installing excavation support for the optional manholes, as defined above, to prevent the movement of soil and groundwater at the excavation.

   d. Proposed locations of stockpiled excavated material.

   e. Minimum lateral distance from the crest of slopes for vehicles and stockpiled excavated materials.

   f. Anticipated difficulties and proposed resolutions.

   g. Anticipated timeframe for installation and removal of the support system that corresponds to the construction hours set for the project.

   h. Methods and sequencing of installed shoring removal. No shoring system shall be abandoned in place.
D. At anytime the Contractor’s personnel are not present within the immediate vicinity of the work area, open excavations shall be covered with steel plates to protect worker and aircraft safety. Steel plates shall be designed to cover the excavated area with 2 feet of overhang in all directions and shall be of adequate strength to support the heaviest aircraft at the airport. Steel plates shall have bevel edges to provide smooth transition and shall be anchored in a way that prevents movement from aircraft, jet wash or traffic.

3.3 MOVEMENT MONITORING PLAN

A. Prepare a movement monitoring plan addressing following topics:
   a. Survey control.
   b. Location of monitoring points.
   c. Plots of data trends.
   d. Interval between surveys.
   e. Corrective action plan.

3.4 REMOVAL OF EXCAVATION SUPPORT

A. Remove the excavation support in a manner that will maintain support as excavation is backfilled. Removal of the support system shall be performed in a manner that will not disturb the manhole, pipeline, compacted backfill, or adjacent construction.

C. Any void left by the shoring system or voids created by removal of the shoring system shall be backfilled with CLSM or as approved by the Engineer to provide support between the backfill and the native soil.

D. Do not begin to remove the excavation support until the support can be removed without damage to existing facilities, completed work, or adjacent property.

END OF SECTION 31 41 00
I. 12kV SYSTEM ADDITIONAL MODIFICATION REQUIREMENTS

A. EXTENSIONS-ADDITIONS-RELOCATIONS DOWNSTREAM OF EXISTING LIST PROCESSES

1. Coordination

   a) During scheduled coordination meetings, the designated Authority Manager and the Authority, or their designated representative (DR), are to identify which projects (in various stages of development) may require Extensions, Additions, or Relocations (downstream of an existing LIS) to the Electrical Distribution System’s Electrical or SCADA Infrastructure.

   b) Pending project design submittals and plans shall be distributed for review and comment as they become available. The Authority Manager, or DR, is to collect and consolidate the Authority’s review comments in order to provide a composite response.

   c) The Authority Manager, or DR, is to provide preliminary system modification requirements feedback to the Authority.

2. Modification Notification

   a) As a particular project requiring Extensions, Additions, or Relocations (downstream of an existing LIS) to the Electrical Distribution System Infrastructure is approved for design, a formal request for service letter is to be presented to the Authority Manager, or DR, by the Authority and is to include:

      1. An executive summary of the project.
      2. Project scope and layout including physical location on campus.
      3. Project’s “requested” Electrical Distribution System load requirements with statistical support.

         (a) THE AUTHORITY REQUEST FOR SERVICE- FORM

            (i) Attach “requested” load requirements. Use SDG&E REQUEST FOR SERVICE- FORM

            (ii) Attach SDG&E Notification of intent to increase load- if applicable. –SEE SAMPLE

      4. Project’s SCADA requirements.
3. Design

a) The Authority director, or DR, is to evaluate and calculate the “actual” (electric utility perspective) power requirements that the Authority is to incorporate into its design of the modification to the Electrical Distribution System’s Electrical or SCADA Infrastructure.

b) The Authority is to provide:
   1. Engineer’s estimate of the required Electrical Distribution Systems Infrastructure modification work.
   2. Modified Electrical Distribution System Infrastructure construction design and associated documents.
   3. Scheduling and coordination with the Authority.

c) The Authority is to incur costs for-
   1. Modifications to Electrical Distribution Systems Electrical or SCADA Infrastructure, including but not limited to labor, material and equipment.
   2. Engineered revisions to the Electrical Distributions Systems Short Circuit Coordination Study, SCADA configuration, and any verification and/or adjustments to protection relay settings.
   3. Engineered revisions to the Arc Flash Hazard Analysis, existing posted labels, and one line diagrams as needed.
   4. Revisions to Master Electrical and SCADA Systems diagrams.

4. Modification

a) The Authority shall perform modifications to the Airport’s Electrical Distribution Systems Infrastructure.
   1. Job walk.
   2. Develop MOP/Sequence of work.
   3. Shutdown Request.
      (a) THE AUTHORITY REQUEST FOR SHUTDOWN/SWITCHING-FORM.
      (b) SDIA- TENANT ADVISORY- FORM.
      (c) SDIA –SDG&E 12kV CLOSED TRANSITION SWITCHING PLAN-if applicable (see sample)
   4. Pre-con meeting.
      (a) MOP run through.
   5. Electrical Infrastructure Modification construction activities.
      (a) Safety.
      (b) Construction/Inspections.
      (c) Acceptance Testing/Commissioning.
      (d) Contractor-produced As-built drawings to the
5. Documentation

a) The Authority provided project As-build single line drawing and detailed interconnection and wiring diagrams.
b) The Authority provided revised Infrastructure drawings.
c) The Authority provided revised SCADA communications diagram.

B. NEW ATO AND MAJOR LOOP MODIFICATION-EXTENSION

1. Coordination

a) During scheduled coordination meetings, the designated the Authority Manager and the Authority, or their designated representative (DR), are to identify which projects (in various stages of development) may require a new ATO, Major Loop Modification, or Extension to the Electrical Distribution System’s Electrical or SCADA Infrastructure.
b) Pending project design submittals and plans shall be distributed for review and comment as they become available. The Authority Manager, or DR, is to collect and consolidate the Authority’s (Lead Electrician and the Authority’s 3rd Party Contractor) review comments in order to provide a composite response.
c) The Authority Manager, or DR, is to provide preliminary system modification requirements feedback to the Authority.

2. Modification Notification

a) As a particular project requiring a new ATO, or Major Loop Modifications, or Extensions to the Electrical Distribution System Infrastructure is approved for design, a formal request for service letter is to be presented to the Authority Manager, or DR, by the Authority and is to include:
   1. An executive summary of the project.
   2. Project scope and layout including physical location on campus.
   3. Project’s “requested” Electrical Distribution System load requirements with statistical support.
      (a) THE AUTHORITY REQUEST FOR SERVICE FORM
          (i) Attach “requested” load requirements. Use SDG&E REQUEST FOR SERVICE- FORM
          (ii) Attach SDG&E Notification of intent to increase load if applicable. SEE SAMPLE
   4. Project’s SCADA requirements.
3. Design
   a) The Authority director, or DR, is to evaluate and calculate the “actual” (electric utility perspective) power requirements that the Authority is to incorporate into its design of the modification to the Electrical Distribution System's Electrical or SCADA Infrastructure.
   b) The Authority is to provide:
      1. Engineer’s estimate of the required Electrical Distribution Systems Infrastructure modification work.
      2. Modified infrastructure construction design and associated documents.
      3. Scheduling and coordination with the Authority.
   c) The Authority is to incur costs for:
      1. Modifications to Electrical Distribution Systems Electrical or SCADA Infrastructure, including but not limited to labor, material and equipment.
      2. Engineered revisions to the Electrical Distributions Systems Short Circuit Coordination Study, SCADA configuration, and any verification and/or adjustments to protection relay settings.
      3. Engineered revisions to the Arc Flash Hazard Analysis, existing posted labels, and one line diagrams as needed.
      4. Revisions to Master Electrical and SCADA Systems diagrams.

4. Modification
   a) The Authority shall perform modifications to the Airport's Electrical Distribution Systems Infrastructure.
      1. Job walk.
      2. Develop MOP/Sequence of work.
      3. Shutdown Request.
         (a) THE AUTHORITY REQUEST FOR SHUTDOWN/SWITCHING FORM.
         (b) SDIA- TENANT ADVISORY- FORM.
         (c) SDIA—SDG&E 12kV CLOSED TRANSITION SWITCHING PLAN-if applicable (see sample)
      4. Pre-con Meeting.
         (a) MOP run through.
      5. Switching coordination with SDG&E Operations.
      6. Electrical Infrastructure Modification construction activities.
         (a) Safety.
         (b) Construction/Inspections.
         (c) Acceptance Testing/Commissioning.
         (d) Contractor-produced As-built drawings to the Authority for record (Hardcopy and PDF).
5. Documentation  
   a) The Authority provided project As-build single line drawing and detailed interconnection and wiring diagrams.  
   b) The Authority provided revised Infrastructure drawings.  
   c) The Authority provided revised SCADA communications diagram.  

C. ELIMINATION OF SYSTEM COMPONENTS (PERMANENTLY)  

1. Coordination  
   a) During scheduled coordination meetings, the designated the Authority Manager and the Authority, or their designated representative (DR), are to identify which projects (in various stages of development) may require the permanent elimination of Electrical Distribution System’s Electrical or SCADA Infrastructure components.  
   b) Pending project design submittals and plans shall be distributed for review and comment as they become available. the Authority Manager, or DR, is to collect and consolidate the Authority’s (Lead Electrician and the Authority’s 3rd Party Contractor) review comments in order to provide a composite response.  
   c) The Authority Manager, or DR, is to provide preliminary system modification requirements feedback to the Authority.  

2. Modification Notification  
   a) As a particular project requiring permanent elimination of Electrical Distribution System Infrastructure components is approved, a formal notification letter is to be presented to the Authority Manager, or DR, by the Authority and is to include:  
      1. An Executive Summary of the Project.  
      2. Project Scope and Layout including Physical Location on Airport’s campus.  
      3. Project’s SCADA requirements.  

3. Design  
   a) The Authority director, or DR, is to evaluate potential impacts and effects to the Electrical Distribution System as a result of the modification and issue a summary brief.  
   b) The Authority is to provide-  
      1. Engineers estimate of the required Electrical Distribution Systems Infrastructure modification work.  
      2. Modified infrastructure construction design and associated documents.  
      3. Scheduling and coordination with the Authority.  
   c) The Authority is to incur costs for-  
      1. Modifications to Electrical Distribution Systems Electrical
or SCADA Infrastructure, including but not limited to labor, material and equipment.

2. Engineered revisions to the Electrical Distributions Systems Short Circuit Coordination Study, SCADA configuration, and any verification and/or adjustments to protection relay settings.

3. Engineered Revisions to the Arc Flash Hazard analysis, existing posted labels, and one line diagrams as needed.

4. Revisions to Master Electrical and SCADA Systems diagrams.

4. Modification

a) The Authority shall perform modifications to the Airport’s Electrical Distribution Systems Infrastructure.
   1. Job walk.

   2. Develop MOP/Sequence of work.

3. Shutdown request.
   (a) THE AUTHORITY REQUEST FOR SHUTDOWN/SWITCHING-FORM.
   (b) SDIA- TENANT ADVISORY- FORM.
   (c) SDIA –SDG&E 12kV CLOSED TRANSITION SWITCHING PLAN-if applicable (see sample)

4. Pre-con meeting.
   (a) MOP run through.

5. Switching coordination with SDG&E Operations-if needed.

6. Electrical Infrastructure Modification
   Construction Activities.
   (a) Safety.
   (b) Construction/Inspections.
   (c) Acceptance Testing/Commissioning.
   (d) Contractor-produced As-built drawings to the Authority for record (Hardcopy and PDF).

7. Removed equipment is to remain the property of the Authority.

5. Documentation

a) The Authority Provided Project As-build single line drawing and detailed interconnection and wiring diagrams.

b) The Authority Provided Revised Infrastructure drawings.

c) The Authority Provided Revised SCADA communications diagram.
II. RELATED SAMPLE REFERENCE FORMS

A. THE AUTHORITY REQUEST FOR SERVICE-FORM
B. THE AUTHORITY REQUEST FOR MV ELECTRICAL SHUTDOWN/SWITCHING-FORM
C. SDIA- TENANT ADVISORY-SAMPLE
D. 12KV CLOSE TRANSITION SWITCHING PLAN
AUTHORITY REQUEST FOR SERVICE

Project Title

CIP or Project Number

Date

PRIMARY CONTRACT INFORMATION

SDCRAA Project Manager

Department

Direct Phone #

Cell Phone #

Email Address

PROJECT INFORMATION

1. Modification Downstream of LIST
   - Extension
   - Addition
   - Relocation
   - New Transformer

2. Major Modification
   - New ATO
   - Loop Modification/Extension

3. Elimination of System Components

4. SCADA System Modification

5. Will Temporary Electrical Service be required?  
   - No
   - Yes
   - If yes, Date Needed

Project Location:

PROJECT TIMELINE

Start of Construction Date

Date Initial Service Needed

DESIGN FIRM CONTRACT INFORMATION

Name of Primary Contact

Title

Phone #  Direct  Extension #

Cell Phone #

Email Address

Mailing Address

City  State  Zip
OPERATING INFORMATION

Type of Facility
(Example: Office, Parking, Utility Structure, Terminal)

Operating Hours

<table>
<thead>
<tr>
<th>Hours Per Day</th>
<th>Days Per Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical Daily Operating Hours</td>
<td>AM PM</td>
</tr>
<tr>
<td>From</td>
<td>AM PM</td>
</tr>
<tr>
<td>To</td>
<td>AM PM</td>
</tr>
</tbody>
</table>

Please describe other operating characteristics
(Example: Standby Generator, Diesel, Natural Gas, PV Solar Generation)

ELECTRICAL DISTRIBUTION SYSTEM LOAD REQUIREMENTS

☐ Attach project’s “requested” load requirements with statistical support and associated drawings

☐ Attached SDG&E Notification of Intent to Increase Load- if applicable

RECEIPT OF APPLICATION

Authority Manager or Designated Representative Date

COMMENTS
The Authority REQUEST FOR MV ELECTRICAL SHUTDOWN/SWITCHING

Request must be submitted at least 14 days prior to any shutdown or switching.

Request for electrical shutdown is based on OSHA Section 1910.333 (a) (1) which establishes a prerequisite criteria that energized (live) parts to which a worker may be exposed must be de-energized before a worker works on or near them, unless the employer can demonstrate that de-energizing introduces additional or increased hazards, or is infeasible due to equipment or operations limitations as per OSHA regulation and interpretations.

Purpose of Shutdown/Switching: ____________________________

Requested by: Name:_________________ Company:____________________

Date: _______________ Cell Phone: _______________ Email

Location of Work: ____________________________

    Circuit ID: __________ Loop ID: __________ Equipment ID: __________

Requested Start Date: _______________ Time: _______________

Proposed Finish Date: _______________ Time: _______________

Brief description of work to be performed/MOP:

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________

(To be completed by Facility Management Lead Electrician or Supervisor)

SHUTDOWN/SWITCHING APPROVED ____________________________ DATE __________

(SIGNATURE/ TITLE)
(Check Reason) Shutdown/Switching is not approved because:
*Time and date ( ), Unfeasible due to operational limitations ( ), other ( )

(Explain)________________________________________________________________________________________

*If date and time is not approved, provide next available date and time that is available________________________
| CONTACT PERSON | Name: Chris Rose  
| | Phone 24/7: (619)520-5382  
| | Email: crose@san.org |

**Today's Date:** 07/19/2016  
**Tenant Advisory No:** Numbered by Air Ops  
**Subject:** 12 KV Closed Transition Electrical Switching  
**Date of Activity:** Wednesday, July 27th 1:00 AM (LAST FLIGHT) to 3:00 AM  
**Location/Area:** Airport Wide

ALL – The Authority Electrical Maintenance Staff will be transferring SDGE primary electrical circuits that feed the Airport, the transferring and testing may affect the following areas:

**Terminal 1:** May experience a temporary electrical outage  
**Terminal 2 East:** May experience a temporary electrical outage  
**Terminal 2 West including Green Build:** May experience a temporary electrical outage  
**All Parking Lots:** May experience a temporary electrical outage
Commuter Terminal: May experience a temporary electrical outage

Smart Curb, USO, Central Plant, and PMO: May experience a temporary electrical outage

Rental Car Center: May experience a temporary electrical outage

FBO (Signature): May experience a temporary electrical outage

ARFF: May experience a temporary electrical outage

FMD and Trades Shops: May experience a temporary electrical outage.

Note: We are testing our close transition function along with SDGE for reliability and functionality we are not expecting to lose power to the any of these locations, but there is always a possibility any questions or clarification please don’t hesitate to contact me. Thanks.

(Approver: C.R.)

FOR QUESTIONS PLEASE CALL OR EMAIL THE 24/7 CONTACT PROVIDED
SDG&E AND SAN DIEGO COUNTY REGIONAL AIRPORT AUTHORITY

12KV CLOSE TRANSITION SWITCHING PLAN

DATE: 11/08/2016
TIME: 2A.M. or last flight
Parallel circuits 457 and 496 perform close transition. **CLOSE** LSW-02 in ATO-CUP-0300 and **OPEN** LSW-01 in ATO-CUP-0300
Parallel circuits 457 and 496 perform close transition. **CLOSE** LSW-01 in ATO-CT-0130 and **OPEN** LSW-01 in ATO-SA-0140.
Parallel circuits 457 and 496 perform close transition. **CLOSE** LSW-02 in ATO-T2W-0230 and **OPEN** LSW-01 in ATO-T2W-0210.
Parallel circuits 457 and 496 perform close transition. **CLOSE** LSW-02 in ATO-RCC-0530 and **OPEN** LSW-01 in ATO-NTC-0570

**Note:** Adding approximately 2MW at Peak to circuit 457 for duration of 8 days. The approximate total peak demand would be 9 MW for circuit 457.

DATE: 11/16/2016
TIME: 2A.M. or last flight
Parallel circuits 457 and 496 perform close transition. **CLOSE** LSW-01 in ATO-CUP-0300 and **OPEN** LSW-02 in ATO-CUP-0300
Parallel circuits 457 and 496 perform close transition. **CLOSE** LSW-01 in ATO-SA-0140 and **OPEN** LSW-02 in ATO-T1-0100.
Parallel circuits 457 and 496 perform close transition. **CLOSE** LSW-01 in ATO-T2W-0210 and **OPEN** LSW-02 in ATO-T2E-0200.
Parallel circuits 457 and 496 perform close transition. **CLOSE** LSW-01 in ATO-NTC-0570 and **OPEN** LSW-02 in ATO-TDRN-0500

**Note:** Adding approximately 6 MW at peak to circuit 496 for duration of 8 days. The approximate total peak demand would be 9MW for circuit 496