San Francisco International Airport

A&E Standards

Electrical – Basic Requirements

Division 26 – Electrical

Version 3.1 | SEP Subgroup 4.4 | March 2018

PREFACE

PURPOSE OF THIS DOCUMENT

The intent of this document is to disseminate the San Francisco International Airport's (SFO's or Airport's) expectations regarding the information presented to designers, engineers, general contractors and other industry specialists. The material provided in the following sections includes the minimal requirements, general information, design criteria, guide specifications and details for the Basic Electrical Requirements at SFO. While this document addresses major areas of concern to SFO, it is not an all-inclusive document.

HOW TO USE THIS DOCUMENT

This document should be used as a resource for the development of project specific design documents including drawings, details and specifications. It is the responsibility of the design, engineering and construction professionals to adhere to all codes and regulations related to the content presented.

SCOPE

This section contains the Standards and Criteria for General Electrical Requirements. Any questions or concerns regarding the items or equals specified must be submitted to the Standards Committee in writing. All final decisions regarding products shall be made at the Airport's discretion. If the Engineer of Record presents items that are not specified or named equals, they must be brought to the Standards Committee for evaluation of those products.

GENERAL INFORMATION

A. Electrical Finish Work shall require design coordination once the electrical contractor is brought on to coordinate with the architects. Placement of switches, outlets, etc. shall be well designed.

B. Layout and space use above critical rooms such as load centers and ITT SSR rooms shall be carefully considered.

MC CABLE

Prior to implementing any of the references to Metal-Clad (MC) Cable detailed in these Standards, the Architect/Engineer must obtain written approval to use MC Cable from his or her SFO Project Manager.

DRAWING REQUIREMENTS

A. All design disciplines including the architectural/engineering sub-consultants and the trade bid package subcontractors shall prepare documents using Revit in the current version utilized by the Airport in compliance with the Airport's Building Information Modeling (BIM) requirements as described in document 00 73 87: BIM requirements, unless waived by the Chief Development Officer.

B. When Revit models may not be applicable, (for example, tasks with underground infrastructure beyond a building footprint), Civil 3D may be used to model utilities and applicable infrastructure if approved by the Chief Development Officer.

C. Refer to technical specifications for As-Built requirements.

D. Documents and plans submitted to SFO shall be searchable using PDFs with live text. This includes, but is not limited to, text and symbols. The document shall also provide the capability to turn layers on and off. Any project using legacy documents which may be composed image files shall be converted to live text via Optical Character Recognition (OCR).

Version	Publish Date	Revisions	Reviewed By
3.1	March 2018 *The March 2018 version was uploaded to SFOConstruction.com in November 2018*	BIM language updated	Josephine Pofsky, N. King
3.0	December 2017	Combined edits; formatting	SFO Electrical Engineering; Greg McCarthy; N. King,
2.0	February 2017	---	SFO Electrical Engineering
1.0	June 2015	---	SFO Electrical Engineering

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SECTION 26 05 00 – GENERAL ELECTRICAL REQUIREMENTS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Work included: Provide all required labor, project equipment and materials, tools, construction equipment, safety equipment, transportation, test equipment, and appurtenances, and satisfactorily complete all electrical work included in these Specifications or required for a complete and fully operating facility.

1.2 QUALITY ASSURANCE

A. Codes: All electrical equipment and materials, including installation and testing, shall conform to the following applicable codes:

1. National Electrical Code (NEC), latest edition
2. California Electrical Code, latest edition
3. National Electrical Safety Code (NESC), latest edition
4. Occupational Safety and Health Act (OSHA) standards
5. Rules for Construction of Underground Electric Supply and Communication Systems, General Order No. 128, Public Utilities Commission of the State of California, (G.O. 128), January 2006 edition; Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems, International Electrical Testing Association (NETA), 91 or latest edition.

B. Variances: In instances where two or more codes are at variance, the most restrictive requirements shall apply.

C. Standards: Equipment shall conform to applicable standards of American National Standards Institute (ANSI), Electronics Industries Association (EIA), Institute of Electrical and Electronics Engineers (IEEE), and National Electrical Manufacturers Association (NEMA). The revisions of these standards in effect on the date of issuance of the Contract Documents shall apply.

D. Underwriters Laboratories (UL) listing is required for all equipment and materials where such listing is offered by the Underwriters Laboratories or certified by Nationally Recognized Testing Laboratory (NRTL).

1.3 INSPECTION OF THE SITE AND EXISTING CONDITIONS

A. After award of contract, verify the location of existing aboveground and underground utilities. Protect all existing utilities during construction.

1.4 DRAWINGS

A. Drawing: The electrical drawings are diagrammatic and show only general locations of equipment, devices and raceway, unless specifically dimensioned; exact locations of electrical equipment shall be verified in the field with the Airport Project Manager. The contractor shall be responsible for the proper

routing of raceway due to actual field conditions, subject to the approval of the Airport Project Manager. Electrical drawings do not attempt to show complete details of building construction that affect installation. Diagrams are schematic only and do not necessarily show physical arrangement of equipment. Refer to drawings of other trades for additional details, which affect work.

B. As-Built Conditions:

1. Maintain a complete and accurate record of As-Built conditions for the Electrical construction work.

2. Record all work that is installed on a daily basis.

3. Upon completion of the work, submit to the Project Manager a complete description, including exact measurements, of the electrical work performed.

4. Locate all underground conduits by accurate field-measured dimensions from walls and corners, etc., of surrounding structures.

1.5 SUBMITTALS

A. Materials List: Submit manufacturer's catalog cut sheets as product data for each item for review and approval prior to installation. The catalog cut sheets shall include the manufacturer's name and provide sufficient information to show that the materials meet the requirements of the Specifications. Where more than one item or catalog number appears on a catalog cut, clearly identify the specific item(s) or catalog number(s) proposed.

1.6 FACTORY TESTS

A. Submit reports of factory tests and adjustments performed by equipment manufacturers to the Engineer prior to field testing and adjustment of the equipment. These reports shall identify the equipment and show dates, results of tests, measured values and final adjustment settings. Provide factory tests and adjustments for equipment where factory tests are specified in the equipment Specifications.

1.7 COORDINATION

A. Coordinate the electrical work with the other trades, code authorities, utilities, and the Airport. General Contractor, Electrical Contractor and Security Contractor shall coordinate all electrical requirements to ensure that all hardware can function as intended

B. When 2 trades join together in an area, make certain that no electrical work is omitted.

1.8 OUTSIDE BRANCH CIRCUITS AND FEEDERS

A. Concrete encasement shall be minimum of 3" around outer walls of raceways and minimum of 2" between raceways.

B. Concrete shall be Portland cement type with 4 sacks cement per cubic yard of concrete, maximum coarse aggregate size of 3/8" and shall have minimum strength of 3000 psi after 20 days. Amount of water shall not exceed slump required for placement. Five pounds red lead oxide shall be added per cubic yard of concrete for medium voltage raceway encasement only.

C. Minimum size conduit installed underground for street or area lighting shall be 1.5" trade size.

1.9 LIGHTNING PROTECTION

A. Power, lighting, and flag poles shall be grounded to a grounding electrode placed into the bottom of the pole foundation. The grounding electrode shall be a ground rod or a coil of bare copper cable #6 AWG or larger. The grounding electrode shall be bonded to the pole with a #6 AWG copper cable terminated in approved lugs or clamps at the electrode and pole base, per NFPA 78-1983 (ANSI).

1.10 POWER SHUTDOWNS

A. General:

1. Carry out operations in a manner which will minimize power shutdowns.

2. All power shutdowns are subject to the Shutdown Procedure described below.

3. Refer to FORM 23 AED for advance notice requirements.

B. Shutdown Procedure

1. Application: This procedure applies to all electrical facilities within Airport including those owned and operated by tenants.

2. Purpose: Purpose of this procedure is primarily to protect safety of workmen involved and general public, and secondarily to coordinate construction work so that service interruptions will be held to an absolute minimum.

3. Responsibilities: It will be the duty of the Contractor to read and comply with this procedure and to inform all agents and employees of this procedure.

4. General Requirements: All electric service interruptions shall be subject to following requirements:

a. All switching operations of existing electrical equipment shall be performed by or under supervision of Airport electrical personnel. Medium voltage service switches shall be operated only by Airport electrical personnel.

b. Service interruptions shall be held to a minimum.

c. Inquiry and preliminary scheduling of medium voltage or major power shutdown shall be made before submitting written request for shutdown.

d. Permission for shutdown must be obtained on SAN FRANCISCO REQUEST FOR UTILITY SHUTDOWN Form (Form 23 AED)

e. Times and durations of shutdown will be set by the Airport. Work may have to be performed at any time, day or night, in calendar week, including weekends, and shall be done at no expense to the Airport.

f. Work may be terminated before completion and service temporarily restored at any time as directed by Facilities Division at no expense to the Airport.

g. Contractor shall follow approved work phasing sequence and other specific directives of the Project Manager.

5. Preparation and Use of Form 23 AED:

    a. Contractor shall obtain blank Form 23 AED from the Inspector and shall fill out first portion of form giving circuit or area affected, date, time and duration of shutdown, and shall, when necessary, attach an 8.5" by 11" sketch for clarification of work to be done.

    b. Inspector shall review and initial form, return copy No. 4 to the Contractor and transmit remaining copies to Head Airport Electrician.

    c. Head Airport Electrician shall contact Airport Operations and obtain necessary clearances and approvals. Airport Operations reviewer shall initial and date form when deemed necessary by Airport Electrician.

    d. Head Airport Electrician shall review form, make any changes in request for shutdown that are deemed necessary, approve it and perform shutdown. Contractor shall sign receipt of clearance. Head Airport Electrician shall then retain copy No. 3, and Contractor shall retain remaining copies. Should request be disapproved, reasons for disapproval shall be noted on form and form returned to the Inspector. The Inspector and Contractor shall each retain one copy of disapproved requests for record. Resubmitted requests shall be made on new forms.

    e. Upon completion of work described on form, Contractor shall sign form and transmit copies No. 1 and No. 2 to Head Airport Electrician for restoration of service. Head Airport Electrician will sign form to indicate service restoration and transmit copy No. 2 to Contractor. Copy No. 1 shall be kept in Head Airport Electrician's files.

    f. Each stage of a series of shutdowns shall be requested on separate form. Restoration of service shall be recorded on same form as request for shutdowns must be requested on day-to-day basis with separate form required for each shutdown

1.11 TEMPORARY SERVICE

A. Electrical energy shall be available during construction in such quantities and at such times as they are available from Airport's electrical system.

B. Contractor shall furnish and install all equipment, including metering connections (if required), transformers, power lines, and other materials necessary for extending power to site of work, and shall remove all such connections, equipment and temporary lines when they are no longer required.

    1. Installations shall be made in locations designated by the Airport Project Manager.

1.12 WORKMANSHIP

A. Assign a qualified representative who shall supervise the electrical construction work from beginning to completion and final acceptance.

B. Perform all labor using qualified craftsman, who have had experience on similar projects. Provide first-class workmanship for all installations.

C. All equipment shall be installed in a neat and workmanlike manner. Appearance and safety, as well as utility, shall be given consideration in the design of details.

D. Ensure that all equipment and materials fit properly in their installations.

E. Perform any required work to correct improperly fit installations at no additional expense to the Airport

1.13 EXCAVATION AND BACKFILL

A. Provide the excavations for electrical equipment foundations and trenches for conduits as required.

B. Exercise caution during all excavation work and avoid damage to existing aboveground and underground utilities. Field verify the location of all utilities before proceeding with any nearby work.

1.14 INSTALLING EQUIPMENT

A. Provide the required inserts, bolts and anchors, and securely attach all equipment and materials to their supports.

1.15 CUTTING, DRILLING, AND WELDING

A. Provide the required cutting, drilling, and welding that is required for the electrical construction work.

B. Structural members shall not be cut or drilled, except when favorably reviewed by licensed Civil or Structural Engineer. Use a core drill wherever it is necessary to drill through concrete or masonry.

C. Provide the required welding for equipment supports. Conduits and fittings shall not be welded to structural steel. Obtain a welding permit from SFO Fire Marshal prior to performing any welding work.

D. Perform patch work with the same materials as the surrounding area and finish to match.

1.16 PROTECTIVE DEVICE COORDINATION

A. The Contractor shall pay all costs of engaging the services of a recognized independent testing laboratory or coordination analysis consultant for the proper system coordination of the protective devices furnished on this project. The Contractor shall submit the name and qualifications of the laboratory or consultant for review by the Engineer.

B. The protective device on the line side closest to the fault or abnormal conditions shall isolate the problem portion of the system and minimize damage in that portion. The rest of the system shall be maintained in normal service. The coordination shall be in conformance with the recommendations of latest IEEE Standard 242.

C. The Contractor shall submit to the Engineer for a review the analysis which shall include impedance and short circuit calculations, list of any assumptions made in the analysis, the recommended settings of the protective devices and the system time/current characteristic curves. The submittal shall be made so as to allow time for review and resubmittal, if necessary before the implementation of final settings and adjustments by the testing laboratory or by the Airport Project Manager.

1.17 FIELD TESTS

A. Tests shall be in accordance with applicable procedures as described in NETA Acceptance Testing Specifications.

B. Give sufficient notice to the Engineer prior to any test so that he/she may witness the test.

C. Provide the services of a recognized independent testing laboratory and pay all costs of performing the inspections and tests as specified herein.

D. The testing laboratory shall provide all materials, equipment, labor and technical supervision to perform such tests and inspections. It is the intent of these tests to assure that all electrical equipment is operational within industry and manufacturer's tolerances and is installed in accordance with the Contract Documents and manufacturer's instructions. The tests and inspections shall determine the suitability for energization.

E. The testing laboratory shall meet federal OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907. Membership in the International Electrical Testing Association (NETA) constitutes proof of these qualifications, submit to the Engineer for review. Testing laboratory shall be Electrical Testing and Controls, Electro-Test, Power Systems, or equal.

F. Perform routine insulation resistance, continuity and rotation tests for all distribution and utilization equipment prior and in addition to tests performed by the testing laboratory specified herein. Supply a suitable and stable source of test power to the test laboratory at each test site. The testing laboratory shall specify requirements. Notify the testing laboratory when equipment becomes available for acceptance tests. Work shall be coordinated to expedite project scheduling. All testing shall be performed in the presence of the Engineer. The testing laboratory shall be responsible for implementing all final settings and adjustments on protective devices and tap changes. Any system material or workmanship which is found defective on the basis of acceptance tests shall be reported directly to the Engineer. The testing laboratory shall maintain a written record of all tests and upon completion of project, assemble and certify a final test report.

G. The testing laboratory shall have a calibration program which maintains all applicable test instrumentation within rated accuracy. The accuracy shall be traceable to the National Bureau of Standards in an unbroken chain. Instruments shall be calibrated in accordance with the following frequency schedule:

1. Field instruments – 6 months' maximum
2. Laboratory instruments – 12 months
3. Leased specialty equipment – 12 months
4. Date calibration labels shall be visible on all test equipment.

H. Where testing pursuant to NETA requirements is required in these specifications, submit a test report which includes the following:

1. Summary of project
2. Description of equipment tested
3. Description of test
4. List of test equipment used in calibration and calibration date
5. Test results
6. Conclusions and recommendations
7. Appendix, including appropriate test forms
    a. The test report shall be bound and its contents certified. Submit one (1) hard copy and one (1) electronic copy of the completed report directly to the Engineer no later than 30 days after completion of the test unless directed otherwise.

I. Safety practices shall include, but are not limited to, the following requirements:

1. Occupational Safety and Health Act– OSHA

2. Accident Prevent Manual for Industrial Operations, Latest Edition, National Safety Council, Chapter 4

3. Applicable state and local safety operating procedures.

J. All field tests shall be performed with apparatus de-energized except where otherwise specifically required by Section 8 of the latest Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems published by NETA. The testing laboratory shall have a designated safety representative who shall be present on the project and supervise operations with respect to safety. Circuits operating in excess of 600 volts between conductors shall have conductors shorted to ground by a hot-line grounded device approved for the purpose. In all cases, work shall not proceed until the safety representative has determined that it is safe to do so. The testing laboratory shall have available sufficient protective barriers and warning signs to conduct specified test safely.

K. Electrical equipment and materials furnished and installed by the Contractor, and the testing equipment listed below shall be tested in accordance with the "Inspection and Test Procedures" and "System Function Tests" (Section 8) of the latest Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems published by NETA. Tests shall not include any tests listed as optional in the aforementioned NETA Specifications unless specifically noted in respective equipment specifications for this project.

L. Retesting will be required for all unsatisfactory tests after the equipment or system has been repaired. Retest all related equipment and systems if required by the Engineer. Repair and retest equipment and systems which have been satisfactorily tested but later fail, until satisfactory performance is obtained.

M. Putting Equipment and Cables into Service: Submittal and favorable review of the specified factory and field tests shall occur before the Contractor is permitted to place the respective equipment or cable into service.

1.18 CLEANING EQUIPMENT

A. Thoroughly clean all soiled surfaces of installed equipment and materials.

1.19 CLEAN-UP

A. Upon completion of the electrical work, remove all surplus materials, rubbish, and debris that accumulated during the construction work. Leave the entire area neat, clean, and acceptable to the Engineer.

END OF SECTION 26 05 00

SECTION 26 05 01 – BASIC MATERIALS & METHODS

PART 1 – GENERAL

1.1 SUMMARY

A. The requirements of this Section apply to all work under electrical work under where applicable.

B. Wiring shall be installed under this Section. Material shall include the following:

1. Raceways, boxes and associated fittings

2. Wire and Cable

C. Related Sections include the following:

1. Standards and Criteria for General Electrical Requirements.

1.2 SUBMITTALS

A. Provide catalog cut sheets for the following items:

1. Conduits and fittings

2. Pullboxes

3. Wire and splicing material

4. Wiring devices

5. Cable support and conduits support

PART 2 – PRODUCTS

2.1 RACEWAYS

A. Raceways shall be provided for all conductors, including communications and low energy control circuits unless otherwise specified herein or noted on the drawings.

B. Raceways shall be hot-dipped galvanized rigid steel conduit unless otherwise specified herein or noted on the drawings.

C. Conduits and Tubing

1. Minimum conduit size shall be 0.75".

2. Rigid conduit shall be full weight steel pipe, hot-dipped galvanized and threaded.

3. Electrical metallic tubing (EMT) shall be steel thin wall pipe.

4. Flexible steel conduit shall be continuous single strip, galvanized. Flexible conduits in exterior locations, locations below ground level and in any damp or wet locations shall be PVC covered

liquid-tight.

5. Fittings:

   a. Fittings for rigid conduit shall be threaded type.

   b. Fittings for electrical metallic tubing shall be all steel bodied compression type or set screw.

   c. Fittings for flexible conduit shall be one piece cast screw-on type or dual screw clamp type. Fittings for liquid-tight flexible conduit shall be compression type.

D. Direct buried rigid steel conduit and fittings shall be permanently coated with 40 mil PVC coated conduit shall meet applicable NEMA requirements.

E. Boxes

1. Boxes in interior dry locations shall be stamped galvanized steel with knockouts unless otherwise specified.

   a. Switch and receptacle outlet boxes shall be 4" square, 1.5" deep unless larger size is required.

   b. Lighting fixture outlet boxes shall be 4" octagon, 1.5" deep.

   c. Junction boxes shall be 4" square, 1.5" deep minimum.

2. For indoor locations, boxes where noted to be larger than available stamped boxes shall be galvanized cold gauge sheet steel with screw on covers.

3. Concrete boxes shall be as noted on the drawings.

4. Boxes intended for outdoor and wet locations shall be intended for use in the location unless otherwise specified. Special finished shall be required in certain areas as designated on the drawings. Provide with threaded hubs and gaskets if necessary.

2.2 WIRE AND CABLE

A. Low Voltage Cable (600 volts and under)

1. Low voltage wires for general wiring, including transformer windings shall be copper conductor of the type and size shown on the drawings and specified herein with thermoplastic insulation of 600 volt rating and 90-degree C temperature rating. Wire shall conform to IPCEA Publication No. S-61-402 (NEMA Publication WC5-1973) with additions as detailed in this specification.

   a. Copper conductors shall be annealed uncrated or coated copper wire.

   b. Conductors 14 AWG or smaller shall be solid, and conductors 12 AWG and larger shall be stranded.

   c. Control wiring 14 AWG and smaller can be stranded wire.

   d. Unless otherwise specified, conductor types for each application shall be as noted below:

SERVICE	**TYPE (Per N.E.C.)**
Feeder and Underground Circuits	THHN/THWN-2 rated at 90 °C
Branch Circuits	THHN/THWN-2 rated at 90 °C
Control	THHN/THWN-2 rated at 90 °C
In Switchboards	Stranded rated at 90 °C

Branch Circuits into or thru lighting fixtures	THHN/THWN-2 rated at 90 °C

B. Color Coding: Provide color coding for all circuit conductors. Insulation color shall be white for 120V and grey for 277V neutrals, and green for grounding conductors. An isolated ground conductor shall be identified with an orange tracer in the green body. Ungrounded conductor colors shall be as follows:

1. 120/208 Volt, 3 Phase: (A) black, (B) red, (C) blue
2. 277/480 Volt, 3 Phase: (A) brown, (B) orange, (C) yellow
3. 120/240 Volt, 1 Phase: Red and Black

PART 3 – EXECUTION

3.1 INSTALLATION OF RACEWAYS

A. Raceways shall be provided for all conductors, including communications and low energy control circuits unless otherwise specified herein or noted on the drawings. Raceways shall be installed parallel or perpendicular to building members and concealed in finished areas.

B. All feeders shall run in conduit as specified in contract documents.

C. Conduits for power system, embedded in concrete, exposed in exterior locations, or exposed in interior locations and susceptible to physical damage less than five feet above finished floors or platforms shall be rigid steel. Conduits in dry locations; hollow concealed spaces; or exposed in interior locations more than 5′ above floors or platforms may be steel electrical metallic tubing or MC Cable.

D. MC Cable can be used on branch circuit to light fixtures and receptacle loads in concealed space only.

E. Using MC Cable: To implement any reference to MC Cable in these A&E Standards, the architect/engineer must receive written approval from his or her SFO Project Manager.

F. Conduits to motors or other equipment where vibration isolation or adjustments or flexibility is required shall be flexible steel conduit not exceeding 3′ in length. Flexible conduits in exterior locations, locations below ground level and in any damp or wet locations shall be liquid-tight flexible steel conduit.

G. Supports

1. Spacing shall be a maximum of 10′ on center for metallic conduit and 5′ on center for wire ways.
2. Supports shall be mounted to structure with:
    a. Toggle bolts on hollow masonry.
    b. Expansion shield or insets on concrete.
    c. Machine screws on metal.
    d. Nails, raw plugs or wood plugs shall not be permitted.
3. Raceway shall not be attached to machinery or equipment (e.g., air ducts) except at point of service to motors, control devices, etc.
4. Raceways shall not be supported by suspended ceiling wires or on any suspended ceiling system

but shall be separately supported by building structure, except that recessed ceiling lighting branch circuit conduits may be run on main ceiling beam members with approved standoff clamps that meet seismic requirements.

H. All flexible conduit sections shall be bypassed, either inside or outside, with insulated copper ground wire sized in relationship to the circuit in accordance with Table 250-122 of the National Electrical Code.

I. Pipe joint compounds used on raceways shall be conducting type.

J. Rigid conduits terminating at a box or enclosure without threaded hubs shall be terminated with two locknuts, one inside and one outside, and a steel bushing. Ground continuity between conduit and boxes and enclosures shall be maintained.

K. All conduit penetrating roofs shall be provided with flashing collars sealed to conduit and counter-flashed with roofing material.

L. Raceway penetrations of air plenums shall be completely sealed.

M. Raceways shall not penetrate or pass through air ducts.

N. Raceways shall be concealed in all finished areas wherever possible.

O. Empty raceways shall be provided with identification tags in each pull box and junction box showing origin of raceway run.

P. Raceway shall be cut with a hacksaw or machine saw, no wheel cutter shall be allowed. Inside cross-section area shall not be reduced due to cutting, cut ends shall be reamed to remove burrs and sharp edges.

Q. Conduit shall be bent with standard bending equipment.

R. Raceways shall be located not closer than 12" from uninsulated parallel steam or hot water lines, 6" from uninsulated crossing steam or hot water lines, and 2" from insulated steam or hot water lines; and shall be installed below such lines.

S. Conduits terminating at concentric or eccentric knockouts or oversized holes shall be bonded to box, cabinet or equipment enclosure by means of grounding bushing and bonding wire.

T. Installation of Conduit in Structures:

1. Conduit embedded in concrete structures shall not, with fittings, displace more than 4% of area of cross section of column. Embedded conduits, other than those merely passing through, shall not be larger in outside diameter than 1/3 of thickness of slab, wall or beam in which embedded, nor shall they be spaced closer than three diameters of larger conduit on center; or so located as to unduly impair strength of construction. Concrete covering of conduits and fittings shall be 1.25" minimum.

2. Conduits or sleeves passing through slabs, walls or beams shall be placed as not to unduly impair strength of construction.

3. Conduits or sleeves passing through slabs, walls or beams larger than 2" inside diameter or spaced less than three diameters of largest conduit on center, shall be installed only when

specifically permitted by the Structural Engineer.

4. Metal conduits penetrating concrete slabs, walls or beams, at or below grade level or in any damp or wet location, shall be wrapped or coated a minimum of 3" on each side of air-concrete interface.

U. Electrical raceways shall be identified by self-adhering, non-conductive markers with orange background and black letters. Lettering shall be printed or field applied by felt tip pen. Field applied lettering shall be covered with clear tape. Markers shall be placed on all exposed or accessible raceways within 18" of raceway termination, wherever raceway enters or leaves concealed space, and every 50' along raceway. Markers shall be 0.5" by 2.25" for conduits up to 1.25" nominal size; 1-1/8" by 4.5" for conduit 1.5" nominal size and larger and all other raceways. Markers shall be Brady or equal.

1. Power and lighting raceways shall be identified as to system voltage between phases, and to ground if system is grounded.
2. Emergency Raceways shall be identified "Emergency Service" in addition to system voltage.
3. Ground Raceways shall be identified "Ground."
4. Fire Alarm Raceways shall be "Fire Alarm."
5. Low Voltage Control Raceways shall be identified "Low Voltage."
6. Clock System Raceways Shall Be Identified "Clock."
7. Raceways reserved for Telephone Service Raceways shall be identified "Telephone."
8. Public Address System Raceways shall be identified "P.A."
9. Raceways reserved for Data Raceways shall be identified "Data."
10. Security Raceways shall be identified "Security Raceways."
11. Miscellaneous Communications Systems Raceways shall be identified appropriately.
12. SCADA System Raceways shall be identified "SCADA."
13. Other raceways shall be identified as directed by the Engineer.

V. Raceways located underground beyond building shall be as follows:

1. Twenty-four inch (24") minimum below finished grade for 600V and below applications or 36" minimum below finished grade for direct buried PVC coated RGS or concrete encased duct banks for higher than 600V applications; slope away from building at a minimum slope of 3" per 100'.
2. At building or equipment entry (exterior locations) and at manholes or pull boxes, terminate empty raceways with bushing plugs. Seal cables in raceways with terminators, similar to O.Z. "C" series or appropriate foam sealant as directed by the Engineer.

W. Outlet boxes; install square and true with building finish and secured to building structure.

X. Junction and Pull Boxes:
1. Install clear of other work, maintain accessibility.
2. Support from building structure independent of conduit.

3.2 INSTALLATION OF WIRE AND CABLE

A. Low Voltage Cable (600 Volts and under)

1. Raceways shall be installed complete and cleaned and mandrelled prior to pulling of wires.

2. Minimum size of conductors shall be No. 12 AWG, except that control conductors may be No. 16 AWG.

3. Conductors of different systems shall not occupy the same raceway, cable sheath outlet box, pull or junction box, fitting, cabinet, switch case, or other wiring enclosure.

4. Pulling tension on wires shall not exceed 0.008 pounds per circular mil area for copper conductors.

5. Only approved wire lubricants shall be used.

6. Care shall be taken to avoid kinks and sharp bends in pulling wires.

7. Splices shall be as follows:

   a. Wires #8 AWG and larger shall be spliced with compression sleeve connectors with tool designed so that full compression must be applied before tool released. Wires of different sizes shall be spliced with one-hole crimped lugs. Splices shall be insulated with Scotch pre-shrunk tubing or layers of Scotch 33 + tape, half lapped built up to 1-1/2 times wire insulation thickness.

   b. Wires #8 AWG and smaller for power and control circuits shall be spliced with either compression sleeve connectors as in (a) above or Scotchlok connectors (copper conductors or lighting fixtures connections only).

   c. Splices in underground or wet locations shall be Scotchcast or otherwise sealed in an approved waterproof epoxy casing.

8. All building conductors shall be identified at each junction box, outlet box, cabinet pullbox, etc., with vinyl cloth self-adhesive tags showing panel and circuit numbers, control wire numbers or other appropriate information.

9. Tests

   a. All feeders shall be tested for mechanical and electrical properties, including grounds, shorts, leakage, continuity and tightness of connections.

   b. All panel boards and branch circuits shall be tested for grounds and shorts with mains disconnected from feeders, branch circuits connected, circuit breakers closed, all fixtures in place and permanently connected (without lamps or ballasts connected), and all switches closed.

   c. The insulation resistance of each circuit, phase to phase and phase to ground shall be measured as follows:

      1) Systems rated above 240 volts shall be tested with a 1000 volt D.C. and minimum insulation resistance in 100 megohms; system rated 240 volts and below shall be tested with a 500 volt D.C. and minimum insulation resistance in 25 megohms.

      2) Motor feeders shall be measured with motor disconnected.

      3) Line voltage control circuits shall be measured with pushbutton, interlocking relays, instruments, overcurrent devices and the like connected.

4) All measurements shall be recorded on standard test forms. Any measurement of less than 10 megohms shall be immediately called to the attention of the Engineer for final decision of acceptability.

5) A written report of the test results shall be submitted and approved by the Engineer before the systems are placed in service. Each circuit at the panel board shall be tested for proper operation with its normal load connected.

3.3 INSTALLATION OF FASTENERS

A. All inserts, expansion bolts, and other type stud fasteners installed in concrete shall withstand 30′ pounds torque without loosening. No fasteners shall be installed in concrete fireproofing of steel members. Installation of fasteners in precast members shall be under direction of the Engineer. Powder-actuated fasteners shall not be permitted. Hanger rods shall be a minimum diameter of 3/8″. Seismic bracing shall be installed under NUSIG guidelines.

END OF SECTION 26 05 01

SECTION 26 05 73 - POWER SYSTEM STUDY

PART 1 – GENERAL

1.1 SUMMARY

A. Section includes short circuit, computer-based, fault-current, and protective device coordination study encompassing portions of electrical distribution system from normal power source or sources up to and including breakers in service entrance switchboard, fuses in service entrance switchboard, main breaker in sub-distribution panels, fuses in sub-distribution panels and main breaker in each panel board.

1. Protective devices shall be set based on results of the protective device coordination study.
    a. Coordination of series-rated devices is permitted where indicated on Drawings.

B. Related Sections:

1. Division 26 sections pertaining to Low-Voltage Electrical Power Conductors and Cables.
2. Division 26 sections pertaining to Switches and Circuit Breakers.
3. Drawings, documents, and general provisions of the Contract, including but not limited to General Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers:

1. IEEE 3000 Standard: Fundamentals
2. IEEE 3001 Standards: Power Systems Design
3. IEEE 3002 Standards: Power Systems Analysis
4. IEEE 3003 Standards: Power Systems Grounding
5. IEEE 3004 Standards: Protection & Coordination
6. IEEE 3005 Standards: Energy & Standby Power Systems
7. IEEE 3006 Standards: Power Systems Reliability
8. IEEE 3007 Standards: Maintenance, Operation & Safety

B. National Fire Protection Association:

1. NFPA 70 - National Electrical Code, latest edition.\
2. NFPA 70E – Standard for Electrical Safety in the Workplace

1.3 DESIGN REQUIREMENTS

A. Complete Power System Study to include Short Circuit, Protective Device Coordination and Arc Flash Study to accordance to IEEE and NFPA.

B. The scope of the studies shall include all electrical distribution equipment and protection as identified by the Airport on the single-line diagram.

C. Report Preparation:

1. Prepare study prior to ordering distribution equipment to verify equipment ratings required.

2. Perform electrical coordination study and analysis with aid of the most up to date version of Airport Engineering approved computer software program.

3. Contractor shall be responsible for obtaining actual settings for all equipment incorporated into work. The qualified (as defined by NFPA 70E) technician will ensure an accurate equipment modeling. The technician shall have completed an 8-hour instructor-led Electrical Safety Training Course. The course shall include NFPA 70E training which includes the selection and use of personal protective equipment.

4. The contractor will visually inspect to verify the electrical equipment ratings, conductor ratings relays and device data by removing panels, covers and doors where required to document the necessary data used in the analysis. The contractor can perform these inspections with the equipment energized provided the incident energy values are less than 40cal/cm^2, greater values or unusual site conditions will require an equipment shutdown so the equipment can be inspected de-energized.

5. Data collection shall begin downstream from the utility service and continue down through the Airport's electrical distribution system as defined under scope of work. The study shall not include any single phase AC circuits or DC distribution systems as these types of circuits and systems are excluded from IEEE 1584 Arc Flash calculation guidelines.

6. Calculate short circuit interrupting and, when applicable, momentary duties for assumed 3-phase bolted fault short circuit current and phase to ground fault short circuit current at each of the following:

   a. Utility supply bus.
   b. Medium voltage air interrupter switchgear.
   c. Medium voltage circuit breaker switchgear.
   d. Secondary unit substations.
   e. Automatic transfer switch.
   f. Manual transfer switch.
   g. Engine generator.
   h. Medium voltage motor controllers.
   i. Low-voltage switchgear.
   j. Switchboards.
   k. Motor control centers.
   l. Distribution panel boards.
   m. Branch circuit panel boards.
   n. Bus way.
   o. Each other significant equipment location throughout system.

D. Short Circuit Study Report Contents:

1. Use actual conductor impedances if known. If unknown, use typical conductor impedances based

on IEEE Standard 141.

2. Transformer design impedances shall be used when test impedances are not available.

3. Provide the following:

   a. Calculation methods and assumptions

   b. Selected base per unit quantities

   c. One-line diagram of the system being evaluated that clearly identifies individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location and other information pertinent to the computer analysis

   d. The study shall include input circuit data including electric utility system characteristics, source impedance data, conductor lengths, number of conductors per phase, conductor impedance values, insulation types, transformer impedances and X/R ratios, motor contributions, and other circuit information as related to the short-circuit calculations.

   e. Tabulations of calculated quantities including short-circuit currents, X/R ratios, equipment short-circuit interrupting or withstand current ratings and notes regarding adequacy or inadequacy of the equipment rating.

   f. Results, conclusions, and recommendations. A comprehensive discussion section evaluating the adequacy or inadequacy of the equipment must be provided and include recommendations as appropriate for improvements to the system.

4. For solidly-grounded systems, provide a bolted line-to-ground fault current study for applicable buses as determined by the engineer performing the study.

5. Protective Device Evaluation:

   a. Evaluate equipment and protective devices and compare to short circuit ratings.

   b. Adequacy of switchgear, motor control centers, and panel board bus bars to withstand short-circuit stresses.

   c. Notify the Airport in writing, of any circuit protective devices improperly rated for the calculated available fault current.

E. Protective Device Time-Current Coordination Study Report Contents:

1. Protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs.

2. Include on each TCC graph, a complete title and one-line diagram with legend identifying the specific portion of the system covered.

3. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.

4. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

5. Plot the following characteristics on the TCC graphs, where applicable:

   a. Electric utility's overcurrent protective device

   b. Medium voltage equipment overcurrent relays

c. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands

d. Low-voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands

e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves

f. Medium voltage conductor damage curves

g. Ground fault protective devices, as applicable

h. Pertinent motor starting characteristics and motor damage points, where applicable

i. Pertinent generator short-circuit decrement curve and generator damage point

j. The largest feeder circuit breaker in each motor control center and applicable panel board.

6. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

a. A one-line diagram shall be provided which clearly identifies individual equipment buses, bus numbers, device identification numbers and the maximum available short-circuit current at each bus when known.

b. A sufficient number of log-log plots shall be provided to indicate the degree of system protection and coordination by displaying the time-current characteristics of series connected overcurrent devices and other pertinent system parameters.

c. Computer printouts shall accompany the log-log plots and will contain descriptions for each of the devices shown, settings of the adjustable devices, and device identification numbers to aid in locating the devices on the log-log plots and the system one-line diagram.

d. The study shall include a separate, tabular printout containing the recommended settings of all adjustable overcurrent protective devices, the equipment designation where the device is located, and the device number corresponding to the device on the system one-line diagram

e. A discussion section which evaluates the degree of system protection and service continuity with overcurrent devices, along with recommendations as required for addressing system protection or device coordination deficiencies.

f. The contractor shall notify the Airport in writing of any significant deficiencies in protection and/or coordination. Provide recommendations for improvements.

F. Arc Flash Hazard Study Report Contents:

1. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E, Annex D. The arc flash hazard analysis shall be performed in conjunction with the short-circuit analysis and the protective device time-current coordination analysis.

2. The Arc Flash Hazard Analysis shall be performed utilizing a typical Airport operational condition, if applicable. When a typical Airport's operation condition can't be determine, the contractor shall be responsible for performing the Arc Flash Hazard Analysis utilizing the worst operation conditions and describing what methodology was utilized to calculate these values.

3. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panel boards, bus way and splitters) where work could be performed on energized parts.

4. Working distances shall be based on IEEE 1584. The calculated arc flash protection boundary shall be determined using those working distances.

5. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations

6. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location in a single table. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum. Conversely, the maximum calculation will assume a maximum contribution from the utility. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable as well as any stand-by generator applications.

7. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors should be decremented as follows:

    a. Fault contribution from induction motors should not be considered beyond 5 cycles.

    b. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

1.4 SUBMITTALS

A. As per Division 1 sections pertaining to Submittals.

B. Qualifications Data: Submit the following for review prior to starting study.

1. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the responsible charge and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies.

2. The Registered Professional Electrical Engineer shall be a full-time employee of the approved engineering firm.

3. The Registered Professional Electrical Engineer shall have a minimum of 5 years of experience in performing power system studies. Submit documentations for the Registered Professional Electrical Engineer which documents their qualifications.

4. The approved engineering firm shall demonstrate experience with Short Circuit, Protective Device Coordination and Arc Flash Hazard Analysis by submitting the project name, project location, project information and etc. of at least 10 actual Short Circuit, Protective Device Coordination and Arc Flash Hazard analyses it has performed in the past 3 years. The scope of these Short Circuit, Protective Device Coordination and Arc Flash Hazard Analysis shall be for 12KV and 480V devices with minimum of 40 medium-voltage devices and 40 low-voltage devices or comparable to the Airport's system.

5. The engineering firm shall have a minimum of 10 years of documented experience in performing power system studies.

6. Prior to the start of the study, contractor shall submit all qualification requirements as specified here in to Project Manager.

C. Software: The studies shall be performed using the most up to date version of Airport Engineering approved Windows based electrical power systems analysis computer software program.

D. Product Data: Submit the following:

1. Report: Summarize results of study in report format including the following:

a. Descriptions, purpose, basis, and scope of study.

b. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short-circuit duties, and commentary regarding same.

c. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection, and commentary regarding same.

d. Fault current calculations including definition of terms and guide for interpretation of computer printout.

e. Results of the Arc-Flash Hazard Analysis shall be submitted in tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, working distances, personal-protective equipment classes and AFIE (Arc Flash Incident Energy) levels. The tables shall be for existing and recommended device settings.

f. Product data for computer software program to be used for studies.

E. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

F. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals may be in digital form.

1. Coordination-study input data, including completed computer program input data sheets.

2. Study and Equipment Evaluation Reports.

3. Coordination-Study Report.

4. Submit to Airport Electrical Engineering the final electronic scenario or program files utilized for Coordination Analysis and Arc Flash Studies.

G. Submit one (1) hard copy and one (1) electronic copy of the final report signed by the Registered Professional Electrical Engineer in California. Make additions or changes required by review comments.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with IEEE, NFPA and all applicable standards.

B. Maintain one copy of each document on site.

C. Perform study in accordance with IEEE and NFPA.

D. Studies shall use computer programs that are distributed nationally and are in wide use. Software

algorithms shall comply with requirements of standards and guides specified in this section. Manual calculations are not acceptable.

E. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. Professional engineer, licensed in the state of California, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.

F. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

G. Comply with IEEE 399 for general study procedures.

1.6 QUALIFICATIONS

A. Study Preparer: Company specializing in performing work of this section with a minimum of 10 years of documented experience and having completed 10 projects of similar size and complexity within the past 3 years.

B. Perform study under direct supervision of Professional Engineer experienced in design of this work and licensed in State of California with minimum of 5 years of documented experience in power system analysis.

C. Demonstrate company performing study has capability and experience to provide assistance during system start up.

1.7 PRE-INSTALLATION MEETINGS

A. As per Division 1 sections pertaining to Project Meetings.

B. Convene a minimum of 2 weeks prior to commencing work of this section.

1.8 SEQUENCING

A. As per Division 1 sections pertaining to Summary of Work.

B. Complete study within 4 weeks after pre-construction meeting.

C. Allow a minimum of 4 weeks for review of completed study by the Airport.

D. Submit short circuit, protective device coordination and arc flash study to Airport Electrical Engineer or Airport Project Manager 4 weeks prior to receiving final approval of distribution equipment shop drawings and prior to releasing equipment for manufacturing.

E. When formal completion of study will cause delay in equipment manufacturing, obtain approval from Engineer or Project Manager for preliminary submittal of study data sufficient in scope to ensure selection of device ratings and characteristics will be satisfactory.

1.9 SCHEDULING

A. As per Division 1 sections pertaining to Work Schedule.

B. Schedule work to expedite collection of data to ensure completion of study for final approval of distribution equipment shop drawings prior to release of equipment for manufacturing.

1.10 COORDINATION

A. As per Division 1 sections pertaining to Work Coordination.

B. Coordinate work with local power company as required.

PART 2 – PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Computer Software Developers: Subject to compliance with requirements, provide products by one of the following:

1. SKM Systems Analysis, Inc. compatible with Airport system or Airport Electrical Engineering approved electrical power system analysis software, latest version.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

PART 3 – EXECUTION

3.1 FIELD QUALITY CONTROL

A. As per Division 1 sections pertaining to Quality Control and Contract Closeout.

B. Provide assistance to electrical distribution system equipment manufacturer during startup of electrical system and equipment.

C. Select each primary protective device for delta-wye connected transformer so device's characteristic or operating band is within transformer characteristics, including point equal to 58% of ANSI withstand point to provide secondary line-to-ground fault protection.

D. Separate transformer primary protective device characteristic curves from associated secondary device characteristics by 16% current margin to provide proper coordination and protection in event of secondary line-to-line faults.

E. Separate medium-voltage relay characteristic curves from curves for other devices by at least 0.4 second time margin.

3.2 FIELD ADJUSTMENT

A. As per Division 1 sections pertaining to Contract Closeout.

B. The contractor shall perform field adjustments of electrical equipment, relays and protective device settings according to the recommended settings table provided by the coordination study as approved by the Engineer. Field adjustments to be completed by the contractor under the Startup and Acceptance Testing portion of project specifications.

C. The contractor shall make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

D. The contractor shall notify the Airport in writing of any required major equipment modifications.

3.3 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.4 POWER SYSTEMS DATA

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.

2. Impedance of utility service entrance.

3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:

a. Circuit-breaker and fuse-current ratings and types.

b. Relays and associated power and current transformer ratings and ratios.

c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.

d. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.

e. Motor horsepower and code letter designation according to NEMA MG

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

a. Special load considerations, including starting inrush currents and frequent starting and stopping.

b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.

c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.

d. Time-current-characteristic curves of devices indicated to be coordinated.

e. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.

f. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for Panel board relays.

g. Panel boards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

3.5 FAULT-CURRENT STUDY

A. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit- breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a 3-phase bolted short circuit at each of the following:

1. Switchgear and switchboard bus.
2. Distribution panel board.
3. Branch circuit panel board

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 241 and IEEE 242.

1. Transformers:

a. ANSI C57.12.22.

b. IEEE C57.12.00.

c. IEEE C57.96.

2. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.

3. Low-Voltage Fuses: IEEE C37.46.

E. Study Report:

1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.

F. Equipment Evaluation Report:

1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.

3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

3.6 COORDINATION STUDY

A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.

1. Calculate the maximum and minimum 1/2-cycle short-circuits currents.

2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short- circuit currents.

3. Calculate the maximum and minimum ground-fault currents.

B. Comply with IEEE 241 and IEEE 242 recommendations for fault currents and time intervals.

C. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

a. Inrush current when first energized.

b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.

c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

D. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

E. Coordination-Study Report: Prepare a written report indicating the following results of coordination

study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
    a. Device tag.
    b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
    c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
    d. Fuse-current rating and type.
    e. Ground-fault relay-pickup and time-delay settings.
2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
    a. Device tag.
    b. Voltage and current ratio for curves.
    c. Three-phase and single-phase damage points for each transformer.
    d. No damage, melting, and clearing curves for fuses.
    e. Cable damage curves.
    f. Transformer inrush points.
    g. Maximum fault-current cutoff point.

3.7 ARC FLASH LABELS & REPORT

A. The contractor shall furnish and install Arc Flash labels.

B. The labels should be self-adhesive, be UV resistant 4 mil thick vinyl labels conforming to ANSI-Z535 and approximately 4" x 6" thermal transfer type label of high adhesion polyester for each equipment analyzed as noted within this report with large print.

C. Warning labels should be white with orange warning strip and black letters for category 0, 1, 2, 3 and 4. "WARNING Arc Flash and Shock Hazard Appropriate PPE Required."

D. Danger labels should be white with red danger strip and black letters for equipment above category 4. "DANGER No Safe PPE Exists Energized Work Prohibited."

E. The label shall include the following information:
    1. Arc Flash Hazard Boundary Distance
    2. Arc Flash Incident Energy value (cal/cm^2) Flash Hazard in inches
    3. Flash Hazard Category
    4. PPE Level Class Required
    5. Glove Class Requirement
    6. System Voltage
    7. Limited, restricted, and prohibited shock approach boundaries
    8. Facility Equipment Name

9. Study report number and date of the assessment on the label

F. Arc flash labels should be field applied by the Contractor for the equipment as identified in the study and the respective equipment access areas per the following:

1. Floor Standing Equipment: Labels shall be provided on the front of each individual section. Equipment requiring rear and/or side access shall have labels provided on each individual section access area.

2. Wall Mounted Equipment: Labels shall be provided on the front cover or a nearby adjacent surface, depending upon equipment configuration.

3. Arc flash labels will be provided in the following manner:

a. For each medium voltage switchgear, one (1) arc flash label should be field applied for each vertical section on the front and rear of the switchgear only when there is possible access in the rear of the equipment.

b. For each medium voltage motor control center, one (1) arc flash label should be field applied for each vertical section.

c. For each facility transformer, one (1) arc flash label should be field applied to each "access panel."

d. For each enclosed medium voltage load interrupter switch or circuit breaker external to electrical distribution equipment, one (1) arc flash label should be field applied.

e. For each low voltage equipment (1000V or below), one (1) arc flash label should be field applied for each "access panel."

G. Arc Flash Study Report: Prepare a written report indicating:

1. Arc flash incident energy values at all electrical distribution equipment.

2. Indicate proper PPE required at each location.

3. Determine Arc Flash boundary limits.

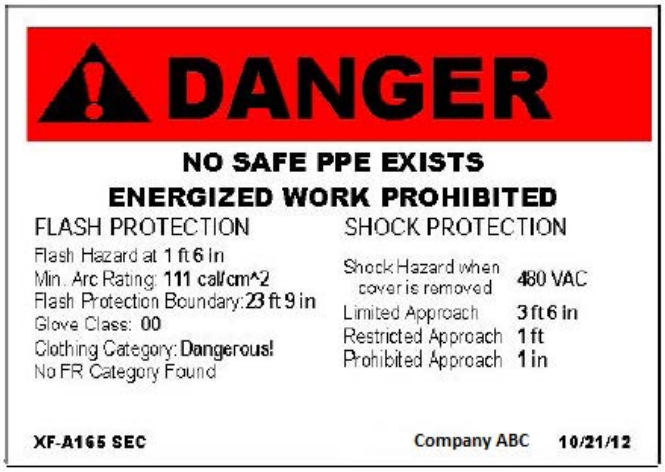
4. Furnish and install arc flash labels with an arc flash rating per NEC on all electrical equipment.

H. Completed data sheets for setting of overcurrent protective devices.

I. The coordination study report shall be submitted to the Airport Authority for review and approval. Adjustment to protective relay settings may be required and shall be performed.

J. Arc Flash Label Sample

1. The following are a typical samples of arc flash labeled that should be applied.



END OF SECTION 26 05 7

SECTION 26 05 05 – SELECTIVE DEMOLITION FOR ELECTRICAL

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:

1. Removal of existing electrical equipment, wiring, and conduit duct bank; removal of designated construction; dismantling, cutting and alterations for completion of the Work.
2. Disposal of materials.
3. Storage of removed materials.
4. Identification of utilities.
5. Salvaged items.
6. Protection of items to remain as indicated on Drawings.
7. Relocate existing equipment to accommodate construction.

1.2 SUBMITTALS

A. As per Division 1 requirements for submittals.

B. Shop Drawings: Indicate location and construction of temporary work. Describe demolition removal procedures and schedule.

1.3 CLOSEOUT SUBMITTALS

A. As per Division 1 Contract Closeout Requirements for submittals.

B. Project Record Documents: Record actual locations of capped conduits and equipment abandoned in place.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with the latest edition of the National Electric Code (NEC) and the Airport Building Regulations (ABR).

1.5 SEQUENCING

A. As per Division 1 Summary: Requirements for sequencing.

B. Sequence work as shown on the Architectural Drawings.

1.6 SCHEDULING

A. As per Division 1 Administrative Requirements: Requirements for scheduling.

B. Schedule work to coincide with other plans.

C. Cease operations immediately when structure appears to be in danger and notify Architect/Engineer. Do not resume operations until directed.

1.7 COORDINATION

A. Conduct demolition to minimize interference with adjacent building areas.

B. Coordinate demolition work with other departments.

C. Coordinate and sequence demolition so as not to cause shutdown of operation of surrounding areas.

D. Shut-down Periods:

1. Arrange timing of shut-down periods of in service panels with Airport Project Manager. Do not shut down any utility without prior written approval.

2. Keep shut-down period to minimum or use intermittent period as directed by Project Manager.

3. Maintain life-safety systems in full operation in occupied facilities.

4. All shutdowns shall be in accordance with Specification Section 26 05 00.

E. Identify salvage items in cooperation with the Engineer or Airport Project Manager.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

3.1 EXAMINATION

A. As per Division 1 Administrative Requirements: Verification of existing conditions before starting work.

B. Verify wiring and equipment indicated to be demolished serve only abandoned facilities.

C. Verify termination points for demolished services.

3.2 PREPARATION

A. Erect, and maintain temporary safeguards, including warning signs and lights, barricades, and similar measures, for protection of the public, Contractor's employees, and existing improvements to remain.

B. Temporary egress signage and emergency lighting

3.3 DEMOLITION

A. Demolition Drawings are based on casual field observation and existing record documents. Report discrepancies to Architect/Engineer before disturbing existing installation.

B. Remove exposed abandoned conduit, including abandoned conduit. Cut conduit flush with walls and floors, and patch surfaces and paint to match existing.

C. Remove conduit, wire, boxes, and fastening devices to avoid any interference with new installation. Remove abandoned wiring back to source of supply.

D. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.

E. Reconnect equipment being disturbed by renovation work and required for continued service.

F. Disconnect or shut off service to areas where electrical work is to be removed. Remove electrical fixtures, equipment, and related switches, outlets, conduit and wiring that are not part of final project.

G. Install temporary wiring and connections to maintain existing systems in service during construction.

H. Perform work on energized equipment or circuits with experienced and trained personnel.

I. Remove, relocate, and extend existing installations to accommodate new construction.

J. Repair adjacent construction and finishes damaged during demolition and extension work.

K. Remove exposed abandoned grounding and bonding components, fasteners and supports, electrical identification and abandoned components.

L. Clean and repair existing equipment to remain or to be reinstalled.

M. Protect and retain power to existing active equipment remaining.

N. Cap abandoned empty conduit at both ends.

3.4 EXISTING PANELBOARDS

A. Ring out circuits in existing panel affected by the Work. Where additional circuits are needed, reuse circuits available for reuse. Install new breakers to match existing in type and manufacturer when required.

B. Tag unused circuits as spare.

C. Where existing circuits are indicated to be reused, use sensing measuring devices to verify circuits feeding Project area or are not in use.

D. Remove existing wire no longer in use from panel to equipment.

E. Provide new updated directories where more than three circuits have been modified or rewired.

3.5 SALVAGE ITEMS

A. Remove and protect items indicated on Drawings to be salvaged and return to Owner.

B. Items of salvageable value may be removed as work progresses.

3.6 REUSABLE ELECTRICAL EQUIPMENT

A. Carefully remove equipment, materials, or fixtures that are to be reused.

B. Disconnect, remove, or relocate existing electrical material and equipment interfering with new installation.

C. Relocate existing CCTV camera and fire alarm devices as indicated on drawings. Clean devices and test to ensure good working condition before installation at new location.

3.7 CLEANING

A. As per Division 1 Contract Closeout: Requirements for cleaning.

B. Remove demolished materials as work progresses. Legally dispose.

C. Keep workplace neat at all times.

3.8 PROTECTION OF FINISHED WORK

A. As per Division 1 – Contract Closeout: Requirements for protecting finished Work.

3.9 SCHEDULE

A. Protect all other equipment not marked for demolition as shown on the plans.

END OF SECTION 26 07 00

SECTION 26 08 00 – COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 26.

B. This project will have selected building systems commissioned.

1.2 SUMMARY

A. This Section includes requirements for commissioning the electrical systems, subsystems and equipment.

B. The commissioning activities have been developed to support the SFO requirements to meet guidelines for Federal Leadership in Environmental, Energy, and Economic Performance.

1.3 COMMISSIONED SYSTEMS

A. Commissioning of a system or systems specified in this Division is part of the construction process. Documentation and testing of these systems, as well as training of the SFO's Operation and Maintenance personnel, is required in cooperation with the SFO and the Commissioning Agent.

B. The following Electrical systems will be commissioned:

1. Utility Service Entrance Switchgear – fuses and circuit breaker settings, metering, mimic diagram, gages, and controls.

2. Standby Generator Systems – automatic transfer switches, fuel delivery pumps and motors, battery charging and instrumentation, muffler and exhaust system, and vibration isolation.

3. Generator Power Distribution Systems – fuses and circuit breaker settings, metering, gages, and controls.

4. Automatic Transfer Switches – test with associated generator.

5. Normal Power Distribution Systems – grounding tests, coordination study review, major circuit breaker settings, meters and gages, and controls.

6. Emergency Power Distribution Systems – automatic transfer on loss of normal power, grounding tests, coordination study review, major circuit breaker settings, meters and gages, and controls.

7. Lighting Controls – control system hardware and software, scene settings, zone settings, occupancy sensor interface, and unoccupied cycle control.

8. Uninterruptible Power Supply Systems and UPS Power Distribution Systems – battery chargers, static and dynamic power generators, system power displays, and distribution panel circuit breakers.

9. 400 Hertz System – equipment, fuses and circuit breaker settings, metering, gages, and controls.
10. Obstruction Lighting System – fuses and circuit breaker and time control.
11. Area and Apron Lighting Systems – fuses and circuit breaker and time control.
12. Normal Power Distribution Systems – grounding tests, insulation resistance test, coordination study review, major circuit breaker settings, meters and gage, and controls.

1.4 SUBMITTALS

A. As per Submittals requirements.

B. General:

1. The commissioning process requires review of selected Submittals. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the Resident Engineer prior to forwarding to the Contractor.
2. The commissioning process requires Submittal review simultaneously with engineering review.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

3.1 PRE-FUNCTIONAL CHECKLISTS

A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. The Contractor shall complete the checklists. Completed checklists shall be submitted to the SFO and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission.

3.2 CONTRACTORS TESTS

A. Contractor tests as required by other sections of Division 26 shall be scheduled and documented. The Commissioning Agent will witness selected Contractor tests. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.3 SYSTEMS FUNCTIONAL PERFORMANCE TESTING

A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test

systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the Resident Engineer. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed.

3.4 TRAINING OF SFO PERSONNEL

A. Training of the SFO's operation and maintenance personnel is required in cooperation with the Resident Engineer and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Engineer or Project Manager after submission and approval of formal training plans.

END OF SECTION 26 08 00

SECTION 26 09 13 – POWER MONITORING AND CONTROL SYSTEMS (PMCS)

PART 1 – GENERAL

1.1 SUMMARY

A. Section includes the following for monitoring of electrical power system:

1. PC-based workstation(s) and software.
2. Interface modules for RS-232, RS-485, Modbus TCP/IP, IEEE 802.3 data transmission protocols.

1.2 DESCRIPTION

A. Furnish and install a complete Power Monitoring and Control System (PMCS) as shown on the drawings and as described in this specification. The system is defined to include, but not be limited to, remote devices for monitoring, control and protection, device communication interface hardware, inter-communication wiring, and ancillary equipment. The PMCS shall utilize Ethernet as the high-speed backbone network that supports direct connection of an unlimited number of personal computer workstations anywhere on the network.

1.3 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.4 DEFINITIONS

A. Ethernet: Local area network based on IEEE 802.3 standards.

B. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

C. HTML: Hypertext markup language.

D. I/O: Input/output.

E. KY Pulse: A term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay changing status in response to the rotation of the disk in the meter.

F. LAN: Local area network; sometimes plural as “LANs.”

G. LCD: Liquid crystal display.

H. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.

I. Modbus TCP/IP: An open protocol for exchange of process data.

J. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered

electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

K. PC: Personal computer; sometimes plural as "PCs."

L. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

M. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.

N. RS-485: A TIA standard for multipoint communications using two twisted-pairs.

O. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

P. THD: Total harmonic distortion.

Q. UPS: Uninterruptible power supply; used both in singular and plural context.

R. WAN: Wide area network.

1.5 SUBMITTALS

A. PMCS Drawings: Drawings shall show all field monitoring devices, key networking components, and cabling required to complete the system. Drawings shall identify network connections and protocols. Drawings shall identify device room location and recommended installation notations. Specific locations and mounting details are subject to the discretion and responsibilities of the installation Contractor.

B. Shop Drawings: For power monitoring and control equipment. Include plans, elevations, sections, details, and attachments to other work.

1. Outline Drawings: Indicate arrangement of components and clearance and access requirements.

2. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.

3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

4. Wiring Diagrams: For power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.

C. Product Data:

1. Attach copies of approved Product Data submittals for products (such as switchboards and switchgear) that describe power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.

2. Provide catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements of each device supplied under the PMCS scope of work.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer and manufacturer.

B. Field quality-control reports.

C. Other Informational Submittal:

1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.

1.7 CLOSEOUT SUBMITTALS

A. Operations and Maintenance Data: For power monitoring and control units, to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 sections pertaining to "Operation and Maintenance Data," include the following:

1. Operating and applications software documentation.

2. Software licenses.

3. Software service agreement.

4. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.

5. A hard copy of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and an electronic copy of the hard-copy submittal.

B. Software and Firmware Operational Documentation:

1. Self-study guide describing the process for setting equipment's network address; setting Owner's options; procedures to ensure data access from any PC on the network, using a standard Web browser; and recommended firewall setup.

2. Software operating and upgrade manuals.

3. Software Backup: On a magnetic media or compact disc, complete with Owner-selected options.

4. Device address list and the set point of each device and operator option, as set in applications software.

5. Graphic file and print out of graphic screens and related icons, with legend.

1.8 MAINENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Addressable Relays: One for every 10 installed. Furnish at least one of each type.

2. Data Line Surge Suppressors: One for every 10 of each type installed. Furnish at least one of each type.

1.9 QUALITY ASSURANCE

A. Installer qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Manufacturer Qualifications: A firm experienced in manufacturing power monitoring and control equipment similar to that indicated for this Project and with a record of successful in-service performance.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.10 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.

1. Match components and interconnections for optimum performance of specified functions.

B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

1.11 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within 2 years from date of Substantial Completion. Upgrading software shall include the operating systems. Upgrade shall include new or revised licenses for use of software.

C. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers: System shall be PowerLogic by Schneider Electric or approved equal.

B. Basis of Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Schneider Electric – PowerLogic ION system.

2.2 FUNCTIONAL DESCRIPTION

A. Instrumentation and Recording Devices: Monitor and record load profiles and chart energy consumption patterns.

1. Calculate and Record the Following:

a. Load factor.

b. Peak demand periods.

2. Measure and Record Metering Data for the Following:

    a. Electricity.

B. Power Quality Monitoring: Identify power system anomalies and measure, display, and record trends and alarms of the following power quality parameters.

1. Voltage regulation and unbalance.
2. Continuous 3-phase rms voltage.
3. Periodic max/min/avg. voltage samples.
4. Harmonics.
5. Voltage excursions.

C. System: Report equipment status and power system control.

2.3 SYSTEM HARDWARE AND SOFTWARE

A. PMCS metering hardware requirements. Refer to Table 1 for PMCS Requirements by electrical system.

B. All tenant meters shall be Square D PowerLogic ION7650 and installed in a pre-wired PowerLogic High Density Metering Cabinet capable of housing 16 m in each cabinet or equal.

C. Basic Requirements:

1. Fully compatible with and based on the approved operating system
2. Password-protected operator login and access; 3 levels, minimum.
3. Password-protected setup functions.
4. Context-sensitive online help.
5. Capability of creating, deleting, and copying files; and automatically maintaining a directory of all files, including size and location of each sequential and random-ordered record.
6. Capability for importing custom icons into graphic views to represent alarms and I/O devices.
7. Automatic and encrypted backups for database and history; automatically stored at central control PC and encrypted with a nine-character alphanumeric password, which must be used to restore or read data contained in backup.
8. Operator audit trail for recording and reporting all changes made to user-defined system options

D. Workstation Server Functions:

1. Support other client PCs on the LAN and WAN.
2. Maintain recorded data in databases accessible from other PCs on the LAN and WAN.

E. Data Formats:

1. User-programmable export and import of data to and from commonly used Microsoft Windows spreadsheet, database, billing, and other applications; using dynamic data exchange technology.

2. Option to convert reports and graphics to HTML format.
3. Interactive graphics.
4. Option to send preprogrammed or operator designed e-mail reports.

F. Remote Control:

1. Display circuit-breaker status and allow breaker control.
2. User defined with load-shedding automatically initiated and executed schemes responding to programmed time schedules, set points of metered demands, utility contracted load shedding, or combinations of these.

G. Graphics: Interactive color-graphics platform with pull-down menus and mouse-driven generation of power system graphics, in formats widely used for such drafting, to include the following:

1. Site plan.
2. Floor plans.
3. Equipment elevations.
4. Single-line diagrams.

H. User-Defined Monitoring and Control Events: Display and record with date and time stamps accurate to 0.1 second, including the following:

1. Operator log on/off.
2. Attempted operator log on/off.
3. All alarms.
4. Equipment operation counters.
5. Out-of-limit, pickup, trip, and no-response events.

I. Trading Reports: Display data acquired in real-time from different meters or devices, in historical format over user-defined time; unlimited as to interval, duration, or quantity of trends.

J. Alarms: Display and record alarm messages from discrete input and controls outputs, according to user programmable protocol.

1. Functions requiring user acknowledgement shall run in background during computer use for other applications and override other presentations when they occur.

K. Waveform Data: Display and record waveforms on demand or automatically on an alarm or programmed event. Include the graphic displays of the following, based on user-specified criteria:

1. Phase voltages, phase currents, and residual current.
2. Overlay of 3-phase currents, and overlay each phase voltage and current.
3. Waveforms ranging in length from 2 cycles to 5 minutes.
4. Disturbance and steady-state waveforms up to 512 points per cycle.
5. Transient waveforms up to 83,333 points per cycle on 60-Hz base.
6. Calculated waveform, based on recorded data, on a minimum of 4 cycles of data of the following:
   a. THD.

b. rms magnitudes.
c. Peak values.
d. Crest factors.
e. Magnitude of individual harmonics.

L. Data Sharing: Allow export of recorded displays and tabular data to third-party applications software.
1. Tabular data shall be in the comma-separated values.

M. Activity Billing Software:
1. Automatically compute and prepare activity demand and energy-use statements based on metering of energy use and peak demand integrated over user-defined interval.
2. Intervals shall be same as used by electric utilities, including current vendor.
3. Import metered data from saved records that were generated by metering and monitoring software.
4. Maintain separate directory for each activity's historical billing information.
5. Prepare summary reports in user-defined formats and time intervals.

N. Reporting: User commands initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
1. Print a record of user-defined alarm, supervisory, and trouble events on workstation printer.
2. Sort and report by device name and by function.
3. Report type of signal (alarm, supervisory, or trouble), description, date, and time of occurrence.
4. Differentiate alarm signals from other indications.
5. When system is reset, report reset event with same information concerning device, location, date and time.

O. Display Monitor:
1. Backlighted LCD to display metered date with touch-pad selecting device.
2. Touch-screen display shall be a minimum of 12" diagonal, resolution of 800 by 600 RGB pixels, 256 colors; NEMA 250, Type 1 displays enclosure.
3. Display 4 values on one screen at same time.

TABLE 1 – Monitoring Device Matrix

Electrical Equipment	ION7650	ION7650	ION6200	Micrologic H Trip Unit	Micrologic P Trip Unit	Model 98 Xfmr Monitor	PM 820
12 kV Switchgear – Mains	X						
Substation Transformer						X	
480 Volt Main Switchgear		X					
480 Volt Main Breakers		X		X			
480 Volt Feeder breakers			X		X		
Distribution Switchboard Mains			X		X		
Distribution Switchboard Feeder Breakers					X		
Tenant Feeder Breakers			X		X		
On Board HTML Web Server	X	X	X				
Modbus TCP Ethernet Communications–	X	X	X				
Modbus RTU Serial Communications	X	X	X	X	X	X	
400 Hz Distribution Feeder Breakers							X

2.4 SYSTEM REQUIREMENTS

A. Monitoring and Control System: Include PC-based workstations with graphics capability and Web access, with its operating system and application software, connected to data transmission network.

B. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.

1. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.

C. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.

D. BAS Interface: Provide factory-installed hardware and software to enable the BAS to monitor, display, and record data for use in processing reports.

1. Hardwired Monitoring Points: Electrical power demand (kilowatts), electrical power consumption (kilowatt-hours), power factor, alarms.

2. Industry-accepted, open-protocol communication interface with the BAS shall enable the BAS operator to remotely monitor meter information from a BAS operator workstation. Control features and monitoring points displayed locally at metering panel shall be available through the BAS.

2.5 OPERATING SYSTEM

A. Software: Configured to run on a portable laptop computer, a single PC, or a palm computer, with capability for accessing a single meter at a time. System is not connected to a LAN. Modbus TCP/IP, RS-232, and RS-485 digital communications.

B. Software: Configured to run on a single PC, with capability for accessing multiple devices simultaneously. Modbus TCP/IP, RS-232, and RS-485 digital communications.

C. Software: Configured for a server and multiple client PCs, each with capability for accessing multiple devices simultaneously. Ethernet, Modbus TCP/IP, RS-232, and RS-485 digital communications.

D. Software: Configured for a server and multiple client PCs, each with capability for accessing multiple devices simultaneously. Software shall include interactive graphics client and shall be Web enabled. Workstations and portable computers shall not require any software except for an Internet browser to provide connectivity and full functionality. Include a firewall recommended by manufacturer. 100 Base-T Ethernet, Modbus TCP/IP RS-232, and RS-485 digital communications.

E. Operating System Software: Based on 32-bit, Microsoft Windows workstation operating system. Software shall have the following features:

1. Multiuser and multitasking to allow independent activities and monitoring to occur simultaneously at different workstations.

2. Graphical user interface to show pull-down menus and a menu tree format.

3. Capability for future additions within the indicated system size limits.

2.6 ETHERNET SOLUTIONS

A. Network Configuration: High-speed, multi-access, open nonproprietary, industry standard communication protocol; LANs complying with EIA 485, 100 Base-T Ethernet, and Modbus TCP/IP.

B. Basic (Ethernet Communications Card - ECC-21)

C. The Ethernet communication card shall have an embedded web server inside the unit, capable of serving HTML pages with dynamic meter data displays.

D. The Ethernet communication card shall connect to the Ethernet backbone via standard RJ-45 port for connection of unshielded twisted pair cable (UTP) or LC fiber optic connection for multimode fiber (100BaseFX).

E. There shall be indicating LED's for the Ethernet connections to assist in trouble-shooting. Indicators are required for TRANSMIT, RECIEVE, and LINK status for Ethernet, and TRANSMIT, RECEIVE for the RS-485 communications.

F. The Ethernet communication card shall support Circuit Monitors, Power Meters, and other POWERLOGIC-compatible devices through one 2 wire or 4-wire RS-485 communication port via standard daisy-chain connections. The RS-485 serial port shall operate up to 38.4k baud.

G. The Ethernet communication card shall allow protocol conversion between standard Ethernet network protocols and PowerLogic (SY/MAX and Modbus/Jbus devices on the same daisy chain).

H. The Ethernet communication card shall be fully TCP/IP compliant thereby allowing the power monitoring software access to power monitoring information from anywhere on the local area network (LAN) or via the Wide Area Network (WAN).

I. The protocol used over Ethernet by the Ethernet communication card shall be Modbus/TCP an international industry standard which is an open and well-defined protocol.

J. Setup of the Ethernet communication card shall be accomplished via the on-board Ethernet port and a web browser. It shall also be possible via the Ethernet port to upgrade the firmware of the Ethernet communication card in the field to accommodate new system features.

K. Web Pages shall be configurable to display data from all devices connected to the Ethernet Communication Card.

L. Data shall be displayed in tabular or trend chart format.

M. The Ethernet card shall be capable of initiating an e-mail based on alarms or custom user logic programming in the host Circuit Monitor.

N. Fifteen (15) unique addresses shall be user configurable to receive e-mail notification from the Ethernet communication card.

O. Each address shall have a user-configurable schedule assignment to only page during specific days of the week and hours of the day.

P. E-mail shall be initiated based on user configurable alarm priority.

Q. E-mail shall be sent in the user-selected language of the Circuit Monitor Display (English, French, Spanish, etc.)

R. The Ethernet Communication Card shall have 4 e-mail buffers.

S. To prevent nuisance E-mails during repetitive alarms, an e-mail will only be sent on a buffered basis when one of the following conditions is met:

T. One of the alarm buffers fills to 38 events OR a predetermined amount of time elapses.

U. A dedicated Ethernet communication card shall be used which requires no hardware adjustments or modifications. Standard personal computers (PCs) or programmable logic controllers (PLCs) are not acceptable as gateways to the power monitoring and control devices.

V. The Ethernet communication card shall derive control power directly from the Circuit Monitor.

W. The Ethernet communication card shall be UL Listed, NOM and CE and CSA certified.

X. All Ethernet cabling shall be installed by a qualified data communications cable installer or the electrical contractor qualified to install data communications equipment. All communications cabling shall be Category 5 rated for 100baseT, or Fiber Optics rated for 100baseFX.

Y. SNMP (Simple Network Management Protocol) shall be supported by the circuit monitor according to the industry standard MIB2.

Z. SNTP (Simple Network Management Protocol) shall be supported to allow date and time to synchronize to within one (1) second between monitors.

AA. A tool shall be provided with the ECC (Ethernet Communications Card) that allows a user to create web pages for the host meter and other monitoring and protection devices from Schneider Electric that are connected to the ECC's serial port. The tool shall be wizard based allowing the user to specify the name and address for each device and create web pages with no knowledge of HTML or Java scripting.

PART 3 – EXECUTION

3.1 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 sections pertaining to "Identification for Electrical Systems."

B. Label each power monitoring and control module with a unique designation.

3.2 GROUNDING

A. Comply with IEEE 1100, "Recommended Practice for Powering and Grounding Electronic Equipment."

3.3 ON-SITE START-UP AND training of the PMCS shall be included in the project bid.

A. Start-up shall include a complete working demonstration of the PMCS with simulation of possible operating conditions that may be encountered.

B. Training shall include any documentation and hands-on exercises necessary to enable electrical operations personnel to assume full operating responsibility for the PMCS after completion of the training period.

C. The project bid shall include 3 days start-up assistance and 2 days training.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect

components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Electrical Tests: Use caution when testing devices containing solid-state components.

2. Continuity tests of circuits.

3. Operational Tests: Set and operate controls at workstation and at monitored and controlled devices to demonstrate their functions and capabilities. Use a methodical sequence that cues and reproduces actual operating functions as recommended by manufacturer. Submit sequences for approval. Note response to each test command and operation. Note time intervals between initiation of alarm conditions and registration of alarms at central-processing workstation.

a. Coordinate testing required by this Section with that required by Sections specifying equipment being monitored and controlled.

b. Metering Test: Load feeders, measure loads on feeder conductor with an rms reading clamp-on ammeter, and simultaneously read indicated current on the same phase at central-processing workstation. Record and compare values measured at the 2 locations. Resolve discrepancies greater than 5% and record resolution method and results.

c. Record metered values, control settings, operations, cues, time intervals, and functional observations and submit test reports printed by workstation printer.

E. Power monitoring and control equipment will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

H. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

I. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

J. Remove and replace malfunctioning devices and circuits and retest as specified above.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems. See Division 26 sections pertaining to “Commissioning of Electrical Systems.”

1. Train Owner's management and maintenance personnel in interpreting and using monitoring displays and in configuring and using software and reports. Include troubleshooting, servicing, adjusting, and maintaining equipment. Provide a minimum of 12 hours’ training.

2. Training Aid: Use approved final versions of software and maintenance manuals as training aids.

3.6 ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other-than-normal occupancy hours for this purpose.

3.7 PRIOR TO STARTUP

A. The manufacturer's engineer responsible for executing the project will submit a prestart up checklist. The prestart up checklist is a list of actions which the installing contractor must complete at the project site prior to startup. If necessary, the engineer will also submit a preliminary network diagram with the prestart up checklist. The preliminary network diagram details the arrangement and networking parameters for the devices that are relevant to the current project.

3.8 THE STARTUP

A. Configuration of meter wiring and CT and PT ratios: The engineer will check the instrument transformer connections to the meters. He or she will make any changes necessary to ensure that your meters are properly recording voltage and current from the power system. The engineer may require the assistance of site maintenance personnel if any instrument transformer installation must be corrected. All meters will be programmed with the proper CT and PT ratio.

END OF SECTION 26 09 13

SECTION 26 41 13 – LIGHTNING PROTECTION FOR STRUCTURES

PART 1 – GENERAL

1.1 DESCRIPTION

A. When deemed necessary provide: Air terminals, down leads, ground rods, and other miscellaneous materials, as specified and as required for a complete lighting protection system.

1.2 RELATED DOCUMENTS

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

1.3 SUMMARY

A. Section includes lightning protection for structures.

1.4 REFERENCES

A. Comply with the latest versions of the following standards:

1. National Fire Protection Association (NFPA)
2. Underwriters Laboratories (UL)

1.5 SUBMITTALS

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

B. Shop Drawings: For air terminals and mounting accessories.

1. Layout of the lightning protection system, along with details of the components to be used in the installation.
2. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.

C. Qualification Data: For qualified Installer and manufacturer. Include data on listing or certification by UL.

D. Certification, signed by Contractor, that roof adhesive is approved by manufacturer of roofing material.

E. Field quality-control reports.

F. Comply with recommendations in NFPA 780, Annex D, "Inspection and Maintenance of Lightning Protection Systems," for maintenance of the lightning protection system.

G. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features, including the following:

1. Ground rods.
2. Ground loop conductor.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Certified by UL, trained and approved for installation of units required for this Project.

B. System Certificate:

1. UL Master Label.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

D. The system to be provided shall be the standard product of a manufacturer regularly engaged in the production of lightning protection systems and shall be the manufacturer's latest approved design. The equipment manufacturer shall be a UL listed and approved manufacturer.

1.7 COORDINATION

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

C. Flashings of through-roof assemblies shall comply with roofing manufacturers' specifications and approved by Airport's Architecture Section.

PART 2 – PRODUCTS

2.1 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Comply with UL 96 and NFPA 780.

B. Roof-Mounted Air Terminals: NFPA 780, Class I unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. East Coast Lightning Equipment Inc.
   b. ERICO International Corporation.
   c. Harger.
   d. Heary Bros. Lightning Protection Co. Inc.
   e. Independent Protection Co.
   f. Preferred Lightning Protection.

g. Robbins Lightning, Inc.

h. Thompson Lightning Protection, Inc.

i. Or Equal

2. Air Terminals More than 24" Long: With brace attached to the terminal at not less than half the height of the terminal.

3. Single-Membrane, Roof-Mounted Air Terminals: Designed specifically for single- membrane roof system materials. Comply with requirements in roofing Sections.

C. Main and Bonding Conductors: Copper.

D. Ground Loop Conductor: Same size and type as the main conductor except tinned.

E. Ground Rods: Copper-clad steel; 0.75" in diameter by 10' long.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to UL 96A and NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends.

C. Conceal the following conductors:

1. System conductors.
2. Down conductors.
3. Interior conductors.
4. Conductors within normal view of exterior locations at grade within 200' of building.

D. Cable Connections: Use crimped or bolted connections for all conductor splices and connections between conductors and other components. Use exothermic-welded connections in underground portions of the system.

1. Exception: In single-ply membrane roofing, exothermic-welded connections may be used only below the roof level.

E. Air Terminals on Single-Ply Membrane Roofing: Comply with roofing membrane and adhesive manufacturer's written instructions.

F. Bond extremities of vertical metal bodies exceeding 60' in length to lightning protection components.

G. Lightning protection system down leads shall be exothermic-welded to the existing ground ring (if any). Provide ground rod at 50' maximum on center bonded to the ring.

3.2 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.

3.3 FIELD QUALITY CONTROL

A. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.

B. UL Inspection: Meet requirements to obtain a UL Master Label for system.

C. LPI System Inspection: Meet requirements to obtain an LPI System Certificate.

END OF SECTION 26 41 13

APPENDIX A – MASTER LIST OF MANUFACTURERS

This section provides the Master List of Manufacturers for Electrical Basic Requirements approved by SFO organized by section and subsection. Contractors are responsible for any extra cost incurred when evaluating products by manufacturers that are not listed are approved equals.

26 09 13 – POWER MONITORING AND CONTROL SYSTEMS

1. PowerLogic by Schneider Electric.
2. Or approved equal.

26 41 13 – LIGHTNING PROTECTION FOR STRUCTURES

ROOF-MOUNTED AIR TERMINALS

1. East Cost Lightning Equipment Inc.
2. ERICO International Protection Co. Inc.
3. Harger.
4. Heary Bros. Lightning Protection Co. Inc
5. Independent Protection co.
6. Preferred Lightning Protection.
7. Robbins Lightning, Inc.
8. Thompson Lightning Protection, Inc.
9. Or approved equal.

SFO San Francisco International Airport

Standards Adoption

The "Electrical – Basic Requirements" Version 3.1, March 2018 standards were adopted by the Standards Committee on April 5th, 2018, and are effective immediately.

Confirmed:

Geoffrey W. Neumayr, Standards Committee Chair