SPECIFICATIONS
TABLE OF CONTENTS

SECTION 01001

GENERAL REQUIREMENTS

1.0 PROJECT LOCATION

The East Central Regional Water Reclamation Facility located in West Palm Beach, Florida in Township 43 South, Range 42 East, Section 11. The street address is 4325 N. Haverhill Road, West Palm Beach, Florida. See construction drawings (Mock•Roos Dwg. No. 43-42-11-29) for specific location of the Emergency Power Plant.

2.0 SCOPE OF WORK

A. The Work to be performed by the Contractor includes permitting, inspections, furnishing all materials, labor, tools, equipment, water, light, power, transportation, superintendence, temporary construction of every nature, and all other services and facilities of every nature whatsoever necessary to modify, construct, complete, deliver and place in operation the above referenced Project as shown on the Drawings and/or as herein described as specified. All Work to be in accordance with the Contract Documents.

3.0 REFERENCE POINTS

A. Not Used.

4.0 GRADES, DIMENSIONS, AND ELEVATIONS

A. Written dimensions have preference over scaled dimensions.

5.0 EXISTING STRUCTURES AND UTILITIES

A. All known utilities have been shown on the Drawings according to the best information available. It is the Contractor's responsibility to contact all owners of structures or utilities above ground, on the surface, or below the ground, within the Project area so that said owners may stake or otherwise mark or protect their facilities. The Contractor must provide facilities and be responsible for the protection of all structures, buildings and utilities, underground, on the surface, or above ground against trenching, dewatering, or any other activity connected with the Work throughout the entire Contract Time.

B. When structures and utilities have been properly shown or marked and are disturbed or damaged in the execution of the Work, they must be repaired immediately in conformance with best standard practice and the approval of the owner of the damaged utility or structure. In the case of structures and utilities which have not been properly shown or located as outlined above and are disturbed or damaged in the prosecution of the Work, take whatever steps are necessary for safety and notify the affected utility owner and avoid any actions which might cause further damage to the structure or utility.

C. Should the Work require repairs, changes or modifications of the Owner's utilities as well as other utilities, it is the responsibility of the Contractor to provide for the maintenance of continuous water, sewage, electric, telephone and other utility services to all present customers of such utilities, unless approval in writing is secured from the applicable utility company or Owner for interruption of such service.

D. Contractor shall be responsible for verifying all vertical and horizontal locations of existing utilities and structures, whether shown on the Drawings or not, to verify any potential conflicts prior to ordering any materials.

6.0 SHOP DRAWINGS

A. All Shop Drawings are to be carefully reviewed by the Contractor prior to submission to the Engineer. Stamp, sign, and date each sheet as being reviewed and approved. All non-approved submittals will be returned to the Contractor with out action.

B. Identify, in writing, any deviations that the Shop Drawings may have from the requirements of the Contract Documents.

C. Submit five (5) copies of all Shop drawings to the Engineer for review and approval.

D. Engineer will review the Shop Drawings with reasonable promptness.

E. Review by the Engineer will be only for conformance with the design concept of the Project and for compliance with the information given in the Contract Documents. Engineer's review will not extend to means, methods, sequences, techniques or procedures of construction, or to safety precautions or programs incident thereto.

F. Shop Drawings are defined to mean all drawings, diagrams, illustrations, schedules and other data which are specifically prepared by Contractor, a Subcontractor, manufacturer, fabricator, supplier or distributor to illustrate some portion of the Work.

7.0 QUALITY CONTROL

A. Testing Laboratory Services:

All tests, analyses and inspections, which are required in the Specifications and/or Drawings, are to be performed by a qualified independent testing laboratory and shall be at the Contractor's expense, unless otherwise specified. To qualify for acceptance, the Contractor shall demonstrate to the Engineer, based on evaluation of laboratory-submitted criteria conforming to ASTM E 699, that the independent testing laboratory has the experience and capability to conduct the required tests, analyses and inspections without delaying the progress of the Work. All tests, analyses and inspections performed by the independent testing laboratory shall be conducted under direct charge of a Registered Professional Engineer in the State of Florida. The Contractor shall be responsible for scheduling the independent testing laboratory's visits and for the coordination of the testing with the independent testing laboratory and Engineer.

B. Field Observations:

Provide twenty-four (24) hour notification to the Engineer for all specified field observations, unless otherwise noted.

8.0 MOBILIZATION

A. Consists of the preparatory Work and operations in mobilizing for beginning Work on the Project, including, but not limited to, those operations necessary for the movement of personnel, equipment, supplies and incidentals to the Project site, and for the establishment of temporary offices, buildings, safety equipment and first aid supplies, sanitary and other facilities, as required by these Specifications, and State and local laws and regulations.

The costs of bonds, insurance and any other pre-construction expenses necessary for the start of the Work, excluding the cost of construction materials, is to be included in Mobilization.

B. When the Bid Form includes a separate pay item for Mobilization, partial payments will be made in accordance with the following:

Percent of Contract Price Less Mobilization Earned	Allowable Percent of the Lump Sum Price of Mobilization
5	25
10	50
25	75
50	100

The standard retainage will be applied to these payments. Previous payments for Mobilization and unpaid amounts on Allowances will not be considered in calculating the percent of the Contract Price earned. Payments will be made in stepped increments as shown and will not be interpolated between steps.

C. When the Bid Form does not include a separate item for Mobilization, all Work and incidental costs specified as being covered under Mobilization is to be included for payment under the several scheduled items on the Bid Form, and no separate payment will be made therefor.

9.0 MAINTENANCE OF TRAFFIC

A. In the Contractor's use of streets and highways for the Work to be done under these Specifications, conform to all Municipal, County, State and Federal laws and regulations as applicable. Provide, erect and maintain effective barricades, warning lights, and signs on all intercepted streets or highways for protection of the Work and safety of the public. All barricades or obstructions which encroach on or are adjacent to the public rights of way should be provided with lights which are illuminated at all times between sunset and sunrise.

B. Contractor shall schedule Work to cause minimum disturbance of normal pedestrian and vehicular traffic and be responsible for providing suitable means of access to all public and private properties during all stages of the construction. Other than for an emergency safety condition, the Contractor must contact the Owner and Engineer for approval prior to completely blocking off any street to vehicular traffic during construction. Contractor shall provide written notification to emergency, police, fire, and other appropriate agencies at least 24 hours in advance of new work or changed work.

C. Maintain traffic in accordance with Section 102 of the Florida Department of Transportation Standard Specifications for Road and Bridge Construction, 2007 Edition, except as follows:

1. Contractor shall be responsible for preparing a Maintenance of Traffic plan. Contractor shall submit a Maintenance of Traffic Plan for Owner or roadway authority (City, County, D.O.T.) review.

2. The Maintenance of Traffic plan must be prepared by a person who is certified by an FDOT certified school or an engineer licensed in the State of Florida.

3. When the Bid Form does not include a separate item for Maintenance of Traffic, the costs are to be included for payment under the several scheduled items on the Bid Form, and no separate payment will be made.

10.0 PLACING EQUIPMENT INTO SERVICE

A. Do not operate or place into service or energize, electrical and mechanical equipment until approved by the Owner and Engineer. Such approval may be granted only after all interested parties have been duly notified, have given approval for placing the equipment into service, and

all interested parties are present or waived their right to be present. Contractor shall provide, in writing, seventy-two (72) hour notification for all items and equipment startups.

11.0 SALVAGEABLE MATERIAL

A. All salvageable material and/or equipment removed from the existing construction for which specific use, relocation or other disposal is not specifically noted on the Drawings or otherwise specified, will remain the property of the Owner and be turned over to him. All material and/or equipment not in salvageable condition as determined by the Engineer, must be disposed of by the Contractor. The actual storage site for salvageable material will be designated by the Owner.

12.0 BORING LOGS, OTHER REPORTS AND DRAWINGS UTILIZED BY ENGINEER

A. Boring Logs, other reports and Drawings utilized by Engineer, if attached at the end of these Specifications, are provided for Contractor's information only and are not a part of the Contract Documents. There is no technical data in the Boring Logs, other reports or Drawings that should be relied on by the Contractor. There also were no other reports or drawings utilized by Engineer in preparation of the Contract Documents that contained data that could be relied on by the Contractor.

13.0 DISPOSAL OF EXCAVATED MATERIALS AND DEBRIS

A. All excess excavated material and debris not required for backfill (unless otherwise noted), including but not limited to, broken pipe, sidewalks, curbs and other concrete items, together with all roots, boards and other debris, are to be disposed of by the Contractor at an appropriate legal site.

14.0 CONTRACTOR'S RESPONSIBILITIES

A. Supervise and direct the Work competently and efficiently, devoting such attention thereto and applying such skills and expertise as may be necessary to perform the Work in accordance with the Drawings and these Specifications. Be solely responsible for the means, methods, techniques, sequences and procedures of construction. Be responsible to see that the finished Work complies accurately with the Drawings and Specifications.

B. Provide competent, suitably qualified personnel to perform construction as required by the Drawings and these Specifications.

C. Be responsible for initiating, maintaining and supervising all safety precautions and programs in connection with the Work. Take all necessary precautions for the safety of, and provide the necessary protection to prevent damage, injury or loss to:

1. All employees on the Work and other persons who may be affected thereby.

2. All the Work and all materials or equipment to be incorporated therein, whether in storage on or off the site, and

3. Other property at the site or adjacent thereto, including trees, shrubs, lawns, walks, pavements, roadways, structures and utilities not designated for removal, relocation or replacement in the course of construction.

D. Comply with all applicable laws, ordinances, rules, regulations and orders of any public body having jurisdiction for the safety of persons or property or to protect them from damage, injury or loss; and erect and maintain all necessary safeguards for such safety and protection.

E. Keep one record copy of all Specifications, Drawings, Addenda, Modifications, Shop Drawings and samples at the site, in good order and annotated to show all changes made during the

construction process. These items are to be available to Owner's Representative for examination and be delivered to Owner's Representative for Owner upon completion of the Work.

15.0 VISITS TO SITE BY OWNER'S REPRESENTATIVE

A. Owner's Representative will make visits to the site at intervals appropriate to the various stages of construction to observe the progress and the quality of the executed Work and to determine, in general, if the Work is proceeding in accordance with the Contract Documents. Owner's Representative will not be required to make exhaustive or continuous on-site inspections to check the quality or quantity of the Work. Owner's Representative's efforts will be directed toward providing for Owner a greater degree of confidence that the completed Work will conform to the Drawings and these Specifications. On the basis of such visits and on-site observations, Owner's Representative will keep Owner informed of the progress of the Work and will endeavor to guard Owner against defects and deficiencies in the Work.

16.0 LIMITATIONS ON OWNER'S REPRESENTATIVE RESPONSIBILITIES

A. Neither Owner's Representative's authority to act under these Specifications and Drawings or elsewhere in other Documents nor any decision made by Owner's Representative in good faith either to exercise or not exercise such authority will give rise to any duty or responsibility of Owner's Representative to Contractor, any Subcontractor, any manufacturer, fabricator, supplier or distributor, or any of their agents or employees or any other person performing any of the Work.

B. Owner's Representative will not be responsible for Contractor's means, methods, techniques, sequences or procedures of construction, or safety precautions and programs incident thereto, and Owner's Representative will not be responsible for Contractor's failure to perform the Work in accordance with the Drawings and these Specifications.

C. Owner's Representative will not be responsible for the acts or omissions of Contractor or of any Subcontractors, or of the agents or employees of any Contractor or Subcontractor, or of any other persons at the site or otherwise performing any of the Work.

17.0 DESIGN PROFESSIONALS REPRESENTING OWNER

A. Various Design Professionals (i.e. Civil, Mechanical, Electrical, Groundwater Hydrologists, Etc.) as consultants to Owner, prepared the Drawings and Specifications for the Project. Owner may have the various Design Professionals provide services to Owner during construction phase of the Project. The Design Professionals will be representatives of the Owner and visits to the site by the Design Professionals will be on the basis of above paragraph 15.0, VISITS TO SITE BY OWNER'S REPRESENTATIVE. Also paragraph 16.0, LIMITATIONS ON OWNER'S REPRESENTATIVE RESPONSIBILITIES includes the various Design Professionals for this Project.

18.0 CONSTRUCTION MEETINGS

A. Contractor’s Project Manager and a representative of subcontractors performing work at the time of the meeting shall attend a coordination/progress meeting a minimum of once a month, as designated by the Owner, at the Owner’s office during the progress of the Work. Contractor shall submit an updated construction schedule to the Engineer at each coordination/progress meeting. Contractor shall also be required to attend additional coordination meetings as requested by Owner.

19.0 TEMPORARY CONTROLS AND FACILITIES

A. The Contractor is responsible for compliance with all NPDES regulations including submitting a Pollution Prevention Plan, submitting a Notice of Intent, conducting maintenance and inspection of controls, erosion and sediment controls and submitting a Notice of Termination.

B. As part of the Work, the Contractor shall be responsible for applying for, obtaining and complying with all required dewatering permits. Contractor shall notify South Florida Water Management District (SFWMD) prior to all dewatering activities. All dewatering shall meet SFWMD requirements.

C. Contractor shall prevent erosion of soil on the site and on adjacent properties resulting from construction activities, effective measures shall be initiated prior to commencement of clearing, grading, excavation, or other operations. Contractor shall install silt barriers or screens to capture sediments/solids from erosion.

D. Contractor shall perform dust and mud control operations to prevent construction operations from producing dust and mud in amounts harmful to persons or causing a nuisance to persons living nearby or occupying buildings in the vicinity of the Work. Use water or dust preventative to control dust during dry weather. Take necessary steps to prevent the tracking of mud onto adjacent streets and highways.

E. Contractor shall install all turbidity control devices required by SFWMD, if necessary. Contractor shall notify SFWMD for inspection of turbidity control devices prior to any construction activities.

20.0 STORAGE SITES

A. The Contractor may furnish, at his expense, properly zoned areas suitable for field offices, material storage and equipment service, and storage. The Contractor shall maintain these areas in a clean, orderly condition so as not to cause a nuisance in the area. The Contractor shall restore the storage area to its original or better condition, with all its appurtenances, in kind, to the satisfaction of the Engineer. Contractor is responsible for security of storage site.

21.0 CONTRACTOR'S SUBMITTALS

A. Contractor shall be required to submit, with a letter of transmittal to the Engineer, a minimum of eight (8) copies of each checked and approved shop drawing, mix report, laboratory results, etc., where required in the specifications, Drawings or as appropriate, in lieu of the five (5) copies specified in Article 6 of the General Conditions or as specified elsewhere in these Specifications. Of the ten copies submitted, two copies will be returned to the Contractor for the Contractor's use. If the Contractor requires any additional approved copies, the Contractor shall submit additional copies at the time of initial submission. Allow a minimum of two weeks from date of receipt for review by the Engineer. Review of shop drawings will be general and will not relieve the Contractor from any responsibility.

A. Contractor shall be required to submit, with a letter of transmittal to the Engineer, for review and approval, eight (8) hard copies and eight (8) copies in CD format of each Operation and Maintenance Manual for all equipment, regardless of the number of submittals specified elsewhere in these Specifications.

END OF SECTION

SECTION 01720

RECORD DOCUMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. On site maintenance of Record Documents.

B. Required record information.

1.02 MAINTENANCE

A. Maintain on site, one set of the following Record Documents; record actual revisions to the Work:

1. Drawings.
2. Specifications.
3. Addenda.
4. Change Orders and other modifications to the Contract.
5. Shop Drawings, product data, and samples.

B. Store Record Documents separate from documents used for construction.

C. Record information concurrent with construction progress.

D. In the interest of timely detection of non-conforming Work, all Record Drawing information must be furnished to the Engineer prior to submitting for payment of that particular item. No progress payment application requests will be approved by the Engineer without satisfactory record drawings for that particular items(s).

E. Under no circumstances will roadway paving Work be allowed to start until the Engineer has reviewed the Record Drawing information for Work constructed within the roadway area that will be paved.

F. All Record Drawing information such as elevations, distances, location of underground utilities, lake cross-sections, and road cross-sections must be obtained by a Professional Surveyor and Mapper, who is licensed in the State of Florida. The Surveyor will be retained by the Contractor. Information must be signed and sealed.

G. Record Documents must be available to Engineer for examination at any time during the progress of the Work.

H. Submit completed Record Documents upon completion of the Work and prior to application for final payment.

I. Show record information in bold or boxed out to stand out from rest of Drawing.

J. Record actual revision dates of the Work.

1.03 REQUIRED RECORD DRAWING INFORMATION

A. All elevations and horizontal locations shown on the Drawings must be verified. Verification or deviation must be clearly indicated on the Drawings.

B. Drainage

1. Flow line elevation of pipe at headwalls, outfalls and structures.

2. Top elevation of headwalls, structures, and concrete caps.
3. Drainage Control Structures, Baffles, and Weirs. Obtain horizontal dimensions and vertical elevations.
4. Horizontal locations of headwalls, structures, and concrete caps.
5. Location of utilities and miscellaneous structures encountered which are different from or not shown on the Drawings.

C. Lakes, Canals, and Pump Station Intake Channels

1. Cross section at each design cross section shown on the Drawings and at a minimum 100 foot intervals. Obtain elevations at all grade breaks and across bottom from 20 foot beyond top of bank (each side).
2. Determine side slopes.
3. Locate top of bank and the edge of water at the control elevation and plot location on a drawing at the same scale as the construction drawings.

D. Roadways

1. Cross-section elevations at the profile grade line (centerline or edge of median) and at the edge of pavement at the following frequencies:
   a. Major Roads (collector or higher): At high and low points of the profile grade and at even 100 foot stations in-between.
   b. Local Roads: At high and low points of the profile grade.
2. Location of utilities and miscellaneous structures encountered which are different from or not shown on the Drawings.
3. Spot elevations in parking lots and access roads.

E. Wastewater

1. Invert elevations in manholes and at end of stubouts.
2. Distance between manholes.
3. Top of manhole elevations.
4. Location of manholes, based on stationing system on Drawings.
5. Calculate slope of gravity mains.
6. Locate end of stubouts and services by stationing and offsetting from the gravity main and downstream manholes.
7. Length of stubouts.
8. Elevations of the top slab, wet well invert, influent pipe inverts, and driveway for lift stations.
9. Details of any design changes.
10. Location of utilities and miscellaneous structures encountered which are different from or not shown on the Drawings.
11. Top of force main elevations and finished grade at 100 foot intervals and at high and low points.
12. Locate force main fittings, valves, air release structures, etc. by stationing and offsetting from gravity wastewater manholes. If manholes are not located nearby, use reference points shown on the Drawings.
13. Elevation and clearances when wastewater mains cross either water mains or drainage pipe.
14. Changes in pipe material.
15. Bottom of wastewater service pipe elevation and top of drainage pipe elevation at all crossings.
16. Top of wastewater service pipe elevation and bottom of watermain elevation at all crossings.
17. Lift station electrical controls and FPL service to control panel.

F. Water

1. Top of pipe elevations at 100 foot intervals.
2. Distance from the reference points shown on the Drawings.
3. Horizontal location at 100 foot intervals.

4. Location of water services, valves, fittings, hydrants, blowoff points, etc. by stationing and offsetting from wastewater manholes. If wastewater manholes are not located nearby, use reference points shown on the Drawings.
5. Details of any design changes.
6. Location of utilities and miscellaneous structures encountered which are different from or not shown on the Drawings.
7. Elevations and clearances when water mains cross either wastewater or drainage pipe.
8. Changes in pipe material.

G. Conduit Sleeves

1. Horizontal location and size of conduit.

H. Structural

1. Obtain horizontal and vertical locations and elevations for all structural components, including but not limited to, intake structure including piles and cap, slabs, building and building features, grating, trash rack, etc.

I. General Site

1. Spot elevations shall be taken at a reasonable grid interval for finished grade verification. Obtain spot elevations at all grade or contours (as shown on the Drawings), grade breaks, property lines, and limits of construction.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 CONTRACTOR'S SURVEYOR RESPONSIBILITIES

A. Engineer will provide the Contractor with electronic files of the construction drawings at the pre-construction conference. One copy of the electronic files will be provided on CD/DVD media in AutoDesk Civil 3D 2010 format. No warranty of the usability of the electronic files provided is expressed or implied. The cost of any required conversion or duplication of the electronic files from the format specified herein shall be the responsibility of the Contractor.

B. The Owner and Engineer will advise the Contractor at the pre-construction conference of the acceptable method and file format by which the interim and final Record Drawing information will be provided to the Owner and/or Engineer.

C. Record Drawing information shall be prepared electronically. The Record Drawing information shall be placed on a separate layer so that it is isolated from all other layers in the drawing file. This layer must be prepared in such a manner that it can be exported as a separate AutoCad file and subsequently inserted into an AutoCad drawing containing the approved design information. The AutoCad files shall be accompanied by an Adobe Acrobat portable document format (.pdf) file of the Record Drawings.

D. Place information in the Drawings in a manner that indicates which elevations and dimensions have been checked. This is to be done by crossing through the design elevation or dimension and placing the Record information next to it. If an elevation or dimension has not changed, the same procedures should be followed to confirm that it has been checked. Add new information in a manner to indicate that it is Record information and not design information.

E. Each Record Drawing sheet must include the surveyor's name, company, address, license number, and date of field survey.

F. Signed and sealed Record Drawings shall be submitted with all pay applications and at the conclusion of the Project.

3.02 CONTRACTOR RESPONSIBILITIES

A. Record document information not required to be obtained by a Professional Surveyor and Mapper must be obtained by the Contractor.

B. Mark Record information on one clean set of prints of the Contract Documents.

C. Each Drawing must be stamped indicating that the information has been reviewed by the Contractor.

D. Contractor's Surveyor will transfer Contractor supplied information to the record drawing.

END OF SECTION

SECTION 02072

MINOR DEMOLITION FOR REMODELING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Remove designated building equipment and fixtures.

B. Remove designated partitions and components.

C. Cap and identify utilities.

D. Temporary partitions to allow building occupancy.

1.02 EXISTING CONDITIONS

A. Conduct demolition to minimize interference with adjacent areas. Provide temporary office and laboratory areas required for continuous plant operation.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 PREPARATION

A. Erect and maintain weatherproof closures for exterior openings.

B. Protect existing items which are not indicated to be altered.

C. Disconnect, remove, and cap designated utility services within demolition areas.

3.02 EXECUTION

A. Demolish in an orderly manner.

B. Except where noted otherwise, immediately remove demolished materials from site.

C. Remove materials to be re-installed or retained in manner to prevent damage.

D. Remove, store and protect for re-installation the following materials and equipment:

1. Owner designated furniture.
2. Blower for lime conveying equipment.
3. Kitchen appliances.
4. Water coolers.

E. Remove the following material and equipment to be retained by Owner.

1. Owner designated lab furniture.
2. Materials stored in areas designated for imprints.

F. Remove demolished materials from site as Work progresses. Upon completion of Work, leave areas of Work in clear condition.

END OF SECTION

SECTION 02108

VIDEO-TAPING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Video-taping the pre-construction conditions of the surface features within the construction area and post construction (clean-out) dive inspection video of wetwells.

1.02 SUBMITTALS

A. Pre Construction: Submit two completed DVD media that is playable on standard DVD players to Engineer at least seven calendar days prior to commencing construction and delivery of any materials and/or equipment.

B. Post Construction: Submit two completed DVD media that is playable on standard DVD players to Engineer for review prior to substantial completion.

1.03 QUALITY ASSURANCE

A. Video-taping must be done by a responsible commercial firm known to be skilled and regularly engaged in the business of pre-construction video documentation.

PART 2 PRODUCTS

2.01 MATERIALS

A. DVD Media: Standard name-brand high quality write-once media. New, not previously used.

PART 3 EXECUTION

3.01 PRE CONSTRUCTION VIDEO-TAPING

A. Video-taping shall be performed and submitted at least seven calendar days prior to the commencement of construction and delivery of any materials and/or equipment. Upon review by the Engineer, and prior to commencement of construction and delivery of any materials and/or equipment, additional video-taping of any portions of the construction areas that are not adequately documented on the initial video-tapes may be required.

B. Video-tape the pre-construction conditions of the surface features within the construction area.

C. The video-tape will serve as a record of the pre-construction conditions for disputes arising from restoration, and should, therefore, be taken within the construction area in sufficient detail as necessary to clearly depict pre-construction conditions.

D. Indicate the date and time (hour, minutes and seconds) on which the video-tapes were recorded.

E. Video-tapes shall record video with simultaneous audio to assist viewer orientation with any needed identification, differentiation, clarification, or objective description of the features being shown with audio recording of commentary by the camera operator. The audio recording shall be free of any conversations between the camera operator and other production technicians.

F. Camera Height and Stability: Do not exceed 10 feet vertical distance between camera lens and the ground when conventional wheeled vehicles are used as conveyances for the recording system.

G. Camera Control: Control camera pan, tilt, zoom-in and zoom-out rates such that recorded objects will be clearly viewed during video tape playback. Control or adjust camera and recording system controls such as lens focus, aperture, light, and white balance to maximize picture quality.

H. Viewer Orientation Techniques: Use existing landmarks including but not limited to, all visible house and business addresses, to maintain viewer orientation.

I. Video Tape Log: Provide a written log of each video tape's contents including but not limited to, the names of the streets or easements, coverage beginning and ending, directions of coverage, and the date upon which the recording was made.

J. All video-tapes and DVD's become the property of the Owner.

3.02 POST CONSTRUCTIN VIDEO TAPING

A. Video-tape the post-construction conditions of the surface of the wetwells to verify miscellaneous materials have adequately been removed.

END OF SECTION

SECTION 03001

CONCRETE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Formwork.

B. Concrete reinforcement and accessories.

C. Cast-in-place concrete.

D. Pre-cast concrete.

1.02 REFERENCES

A. ACI 301-96 - Specifications for Structural Concrete.

B. ACI 318-99 - Building Code Requirements for Structural Concrete.

C. ACI SP-4 (95) – Formwork for Concrete.

D. ASTM A185-97 – Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.

E. ASTM A615-01 - Deformed and Plain Billet Steel for Concrete Reinforcement.

F. ASTM A775-01 – Epoxy - Coated Reinforcing Steel Bars.

G. ASTM C31-00 - Making and Curing Concrete Test Specimens in the Field.

H. ASTM C33-01 - Concrete Aggregates.

I. ASTM C39-01 - Compressive Strength of Cylindrical Concrete Specimens.

J. ASTM C42-99 - Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

K. ASTM C94-00 - Ready-Mixed Concrete.

L. ASTM C143-00 - Slump of Hydraulic Cement Concrete.

M. ASTM C150-00 - Portland Cement.

N. ASTM C192-90 - Making and Curing Concrete Test Specimens in the Laboratory.

O. ASTM C260-01 - Air-Entraining Admixtures for Concrete.

P. ASTM C309-98 - Liquid Membrane - Forming Compounds for Curing Concrete.

Q. ASTM D1751-99 - Preformed Expansion Joint Filler for Concrete Paving and Structural Construction.

1.03 SUBMITTALS

A. Four copies of the test mix report showing the proportions of cement, aggregate, fine aggregate, water and admixtures.

B. Shop Drawings of pre-cast structures for review prior to fabrication.

PART 2 PRODUCTS

2.01 FORM MATERIALS

A. Conform to ACI 347.

2.02 REINFORCING STEEL

A. Reinforcing Bars: ASTM A615, Grade 60, new deformed billet steel.

B. Welded Wire Fabric: Plain type, ASTM A185.

C. Stirrups and Ties: ASTM A615, Grade 40 or Grade 60.

D. Bar Supports and Spacers: Steel wire with upturned legs. Mortar cubes.

E. Epoxy - Coated Reinforcing Bars: ASTM A775, Grade 60, new deformed billet steel.

2.03 CONCRETE MATERIALS

A. Cement: ASTM C150, Type I. Type II cement for wastewater structures.

B. Fine and Coarse Aggregates: ASTM C33.

Nominal maximum size of coarse aggregate not larger than:

1 The narrowest dimension between sides of forms, nor
2. 1/3 the depth of slabs, nor
3. 3/4 the minimum clear spacing between individual reinforcing bars or wires, bundles of bars, or ducts.
4. 4 inches.

C. Water: Clean, fresh, and free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances that may be deleterious to concrete or reinforcement.

D. Air Entrainment Admixtures: ASTM C260. 'Darex' by the W. R. Grace Company or approved equal.

E. Curing Compound: ASTM C309, Type 1 or Type 1-D, Class A.

2.04 CONCRETE MIX

A. Mix concrete in accordance with ASTM C94.

B. Compressive Strength: 3000 psi minimum at 28 days for cast-in-place concrete and 4000 psi minimum at 28 days for pre-cast concrete (unless otherwise noted on Drawings).

C. Slump: 5 inches maximum (Vertical Pours)
3 inches maximum (Horizontal Pours)
2 inches minimum (Unless noted otherwise i.e. tremie, curb machine)

D. Mixing water not to exceed 6 gallons per sack of Portland Cement. This includes water entering the batches as surface moisture on the aggregates, which must be deducted from the specified 6 gallons to determine the amount of mixing water for each batch.

E. Contain not less than 5 sacks of cement per cubic yard of concrete for 3000 psi concrete and not less than 6 sacks of cement per cubic yard of concrete for 4000 psi concrete.

F. Air-Entraining admixture to produce 5 percent (+/- 1.5%) entrained air.

PART 3 EXECUTION

3.01 FORMWORK ERECTION

A. Conforms to the shapes, lines, and dimensions of the members as called for on the Drawings.

B. Provide bracing to ensure stability of formwork.

C. Design and construct forms, bracing, and supports to withstand the pressure of freshly placed concrete without bow or deflection.

D. Hand trim sides and bottom of earth forms; remove loose dirt.

E. Coordinate Work on Drawings in forming and setting openings, recesses, chases, sleeves, bolts, anchors, and other inserts.

F. Substantial and sufficiently tight to prevent leakage of mortar. Check forms prior to placing concrete and tighten as required to produce flush surfaces.

G. Tie metal remaining in the concrete to be at least 3 inches back of the concrete face. Plug holes left by the tie ends with grout.

H. Chamfer corners of beams, columns, walls and exposed edges or corners of concrete with 3/4 inch by 3/4 inch wood chamfer strips unless otherwise shown on Drawings.

I. Clean forms and apply form release agents or wet forms prior to concrete placement.

J. Remove forms in such a manner as to insure the complete safety of the structure. Where the structure as a whole is supported on shores, the removable floor forms, beams and girder sides, columns and similar vertical forms may be removed only after concrete has reached 2/3 of its design strength by test and is sufficiently hard not to be injured during form removal. In no case should supporting forms or shoring be removed until the members have acquired sufficient strength to support their weight and the load safely thereon.

3.02 REINFORCEMENT

A. Before placing concrete, clean reinforcement of foreign particles or coatings.

B. Place, support, and secure reinforcement against displacement.

C. Lap welded wire mesh at least one full mesh and lace splices with wire. Offset end laps in adjacent widths to prevent continuous laps in either direction.

D. Avoid splices at points of maximum stress. Provide sufficient lap to transfer the stress between bars by bond and shear.

E. Make bends for stirrups and ties on bars 5/8 inches in diameter and less, around a pin having a diameter not less than four times the thickness of the bar. Make bends for other bars around a pin having a diameter not less than six times the minimum thickness of the bar, except that for bars larger than one inch but less than 1-3/4 inches, the pin can not be less than eight times the minimum thickness of the bar. Bend all bars cold.

F. Splices and Offsets in Reinforcement: In slabs, beams, and girders, avoid splices of reinforcement at points of maximum stress. Provide sufficient lap to transfer the stress between bars by bond and shear and meet the requirements of ACI 318.

Where changes in the cross section of a column occur, offset the longitudinal bars in a region where lateral support is afforded. Where offset, the slope of the inclined portion should not be more than one in six, and in the case of tied columns, space the ties not more than 3 inches on center for a distance of one foot below the actual point of offset.

G. Protection of Reinforcement: Protect the metal reinforcement by the thickness of concrete indicated on the Drawings. Where not otherwise shown, the thickness of concrete over the reinforcement should be as follows:

Where concrete is deposited against ground without the use of forms, not less than 3 inches for beams and slabs.

Where concrete is exposed to the weather or exposed to the ground but placed in forms, not less than 2 inches for bars more than 5/8 inch in diameter and 1-1/2 inches for bars 5/8 inch or less in diameter.

In slabs and walls not exposed to the ground or to the weather, not less than 1-1/2 inches.
In beams, girders and columns not exposed to the ground or to the weather, not less than 1-1/2 inches.

In all cases, the thickness of concrete over the reinforcement must be at least 1-1/2 inches.

H. Protect reinforcement bars, intended for bonding with future extensions, with approved adequate covering.

3.03 JOINTS

A. Expansion and Contraction Joints: Provide expansion joints when slabs on grade join other construction and elsewhere as indicated. Expansion joints are to be one-half (1/2) inch thick when not otherwise noted. Tool edges of slabs at expansion and contraction joints to a one-fourth (1/4) inch radius.

B. Construction Joints: In jointing fresh concrete to that which has already set, the surface of the concrete in place must be thoroughly cleaned and have all laitance removed by cutting with a suitable tool. In addition, wet and slush with a coat of grout, no leaner than one (1) part cement to two (2) parts sand.

3.04 CONCRETE MIXING

A. Mix until there is a uniform distribution of the materials and discharge completely before the mixer is recharged.

B. For job-mixed concrete, rotate the mixer at a speed recommended by the manufacturer and mix continuously for at least one minute after all materials are in the mixer.

C. Mix and deliver ready-mixed concrete in accordance with ASTM C-94.

D. Wet batches of concrete may be transported in either agitating or nonagitating trucks. When non-agitator trucks are used, the elapsed time between the addition of water to the mix and depositing the concrete in place must not exceed 45 minutes except that when a retardant admixture is used such elapsed time must not exceed 75 minutes. When the handling is done in truck agitators, such elapsed time must not exceed 60 minutes, except that when a retardant admixture is used a maximum elapsed time of 90 minutes will be permitted.

E. When concrete arrives on site with slump below that suitable for placing, as indicated by the Specifications, water may be added only if neither the maximum permissible water-cement ratio nor the maximum slump is exceeded.

3.05 PLACING CONCRETE

A. Notify Engineer a minimum of 24 hours prior to commencement of concreting operations.

B. Equipment for chuting, pumping and pneumatically conveying concrete must be sized and designed as to insure a practically continuous flow of concrete at the delivery end without separation of the materials.

C. Prevent separation or loss of materials when conveying concrete from mixer to place of final deposit.

D. No concrete that has partially hardened or been contaminated by foreign material may be deposited on the Work nor retempered.

E. Deposit as nearly as practicable to its final position to avoid segregation due to rehandling or flowing.

F. During placement, thoroughly work concrete around reinforcement and embedded fixtures and into the corners of the forms.

G. At all times, concrete is to be plastic and flow readily into the space between the bars.

When concreting is once started, carry on as a continuous operation until the placing of the panel or section is completed. The top surface to be generally level.

H. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand-spading, rodding or tamping. Use vibrators designed to operate with vibratory element submerged in concrete.

3.06 UNDER-WATER PLACING (Done only on approval of Engineer)

A. When conditions require placing through water, a tremie or drop-bottom bucket should be used and the Work must be well supervised. Every precaution must be taken to prevent the cement from washing out of the concrete. The tremie is to be water-tight and large enough to allow a free flow of concrete. It must be kept filled with concrete at all times while depositing. Discharge concrete and spread by moving the tremie as to maintain as nearly as practicable a uniform flow and avoid dropping the concrete through water. If the charge is lost while depositing, the tremie must be withdrawn and refilled. Maintain concrete slump between 6 and 7 inches. Tremie concrete must be pumped into place instead of gravity placed.

3.07 COLD WEATHER PLACEMENT

A. Provide adequate equipment for heating the concrete materials and protecting the concrete during freezing or near-freezing weather. No frozen materials or materials containing ice can be used.

B. All concrete materials and all reinforcement, forms, fillers and ground with which the concrete is to come in contact must be free from frost. Whenever the temperature of the surrounding air is below 40 degrees F, all concrete placed in the forms must have a temperature of between 70 degrees F and 80 degrees F, and adequate means to provide for maintaining a temperature of not less than 70 degrees F for 3 days or 50 degrees F for 5 days. The housing covering or other protection used in connection with curing must remain in place and intact at least 24 hours after the artificial heating is discontinued. No dependence can be placed on salt or other chemicals for the prevention of freezing.

3.08 HOT WEATHER PLACEMENT

A. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90 degrees F. Mixing water may be chilled, or chopped ice may be used to control the concrete

temperature, provided the water equivalent of the ice is calculated to the total amount of mixing water.

B. A shorter mixing time than specified in ASTM C94 may be required. When the air temperature is between 85 and 90 degrees F, reduce the mixing and delivery time from 90 minutes to 75 minutes, and when the air temperature is above 90 degrees F, reduce the mixing and delivery time to 60 minutes.

Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that the steel temperature will not exceed the ambient air temperatures immediately before embedment in concrete. Wet forms thoroughly before placing concrete.

Do not use retarding admixtures without the written approval of the Engineer.

3.09 FINISHING CONCRETE

A. Rough finish for concrete surfaces not exposed to view in the finish Work or covered by other construction.

B. Strike - off smooth and finish with a texture matching adjacent formed surfaces at tops of walls, horizontal offsets and similar unformed surfaces occurring adjacent to formed surfaces.

C. Provide a uniform smooth rubbed finish on exposed formed concrete walls, columns, and beams.

D. Float finish monolithic slab surfaces that are to receive trowel finish or other finish.

1. Trowel Finish: After floating, begin first trowel finish operation using a power-driven trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand-troweling operation, free of trowel marks, uniform in texture and appearance, and with a surface plane tolerance not exceeding 1/4" in 10 feet when tested with a 10 foot straight-edge. Grind smooth surface defects which would show through applied floor covering system.

2. Non-slip Broom Finish: Apply non-slip fine-hair broom finish to sidewalks, driveways, handicap ramps, curbs, or other items as noted on the Drawings.

3.10 CURING

A. Protect freshly placed concrete from premature drying or heat, and maintain without drying at a relatively constant temperature for a period of time necessary for hydration of cement and proper hardening.

B. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting, keep continuously moist for not less than 72 hours.

C. Continue curing for a least 7 days and in accordance with ACI 301 procedures. Avoid rapid drying at end of final curing period.

D. In lieu of moist curing, spray a clear liquid membrane curing compound on all new concrete immediately after initial set. Rate of application to be 200 square feet per gallon or as recommended by the manufacturer.

3.11 TESTS

A. Testing and analysis of concrete will be performed by an independent testing laboratory.

B. Test firm will take cylinders and perform compression tests in accordance with ASTM C31, ASTM C39, and ASTM C192.

C. Number of cylinders and frequency of tests will be designated by the Engineer.

D. One slump test will be performed per ASTM C143 for each set of test cylinders taken.

E. Cure specimens under laboratory conditions except that when in the opinion of the Engineer, there is a possibility of the surrounding air temperature falling below 40 degrees F., additional specimens may be required and cured under job conditions.

F. If the average strength of the laboratory control cylinders for any portion of the structure falls below the compressive strengths called for on the Drawings, the Engineer has the right to order a change in the proportions or the water content for the remaining portion of the structure. If the average strength of the job-cured cylinders falls below the required strength the Engineer has the right to require conditions of temperature and moisture necessary to secure the required strength and may require tests in accordance with ASTM C42, or order load tests to be made on the portions of the structure so affected. Remove or replace failing concrete if directed by the Engineer.

3.12 PROTECTION

A. Protect concrete from damage until final acceptance of Work.

END OF SECTION

SECTION 04220

CONCRETE UNIT MASONRY

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Concrete masonry units.

B. Mortar.

C. Grout.

D. Reinforcement.

E. Lintels.

1.02 REFERENCES

A. ASTM A82-88 - Steel Wire, Plain, for Concrete Reinforcement.

B. ASTM C90-85 - Hollow Load-Bearing Concrete Masonry Units.

C. ASTM C387-87 - Packaged, Dry, Combined Materials for Mortar and Concrete.

D. ASTM C476-83 - Grout for Masonry.

E. ASTM C1019-89 - Sampling and Testing Grout.

1.03 RELATED SECTIONS

A. Section 03001 - Concrete.

PART 2 PRODUCTS

2.01 MATERIALS

A. Premix Mortar: ASTM C387, Type M or S.

B. Grout: ASTM C476. f'm > 2000 psi Slump between 8 and 11 inches.

C. Hollow Load Bearing Block Units: ASTM C90, Grade N, Type II, normal weight.

D. Joint Reinforcement: ASTM A82, welded construction. Two, nine gage wires running parallel to each other.

E. Water: Potable. Clean and free of amounts of oils, acids, alkalies, salts, organic materials, or other substances that may be deleterious to mortar or any metal in the wall.

2.02 LINTELS

A. Construct with reinforced concrete per Section 03001.

B. Provide minimum 2 - #5 reinforcing bars or equivalent in bottom with 2 inches cover.

C. If lintels are precast, designate top and bottom.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that field conditions are acceptable and are ready to receive Work.

B. Verify items provided by other Sections of Work are properly sized and located.

C. Verify that built-in items are in proper location and ready for roughing into masonry.

3.02 INSTALLATION

A. Mix mortar and place in accordance with the premix mortar manufacturer's instructions.

B. Mix mortar materials mechanically for not less than five minutes after all ingredients are in the mixer.

C. Do not use mortar that has begun to set or that has been mixed for more than two hours. Retempering will not be allowed.

D. Maintain masonry courses to uniform dimension. Form vertical and horizontal joints of uniform thickness. Lay block plumb, level, and true to line.

E. Install horizontal joint reinforcement in the first course above the footing or floor level, and in every second course thereafter. Do not displace reinforcement while placing mortar.

F. Bond each course at corners and intersections.

G. Do not shift or tap masonry units after mortar has achieved initial set. Where adjustment must be made, remove mortar and replace.

H. Masonry partitions are to be isolated from vertical structural framing members with a control joint where indicated on the Drawings.

I. Lintels are to be provided over all openings in concrete block walls not spanned by beams. Provide minimum 8 inches bearing on each side of opening.

J. All masonry units are to be handled carefully. Use of chipped or broken units is not acceptable.

K. Saw-cut all partial masonry units to fit.

L. Masonry to be plastered or permanently concealed are to have all joints trowel- struck flush.

M. Exposed Masonry: Point joints and tool before mortar is set. Jointing tools must be of high-grade steel that will not blacken joints. Brush with a clean fiber brush after tooling.

3.03 CLEANING

A. Remove excess mortar and mortar smears.

B. Replace defective mortar. Match adjacent Work.

C. Use non-metallic tools in cleaning operations.

END OF SECTION

SECTION 09220

PORTLAND CEMENT STUCCO

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Portland cement stucco system.

1.02 REFERENCES

A. ASTM C150-85 - Portland Cement.

B. ASTM C207-79 - Hydrated Lime for Masonry Purposes.

C. ASTM C631-81 - Bonding Compounds for Interior Plastering.

D. ASTM C897-83 - Aggregate for Job-Mixed Portland Cement-Based Plasters.

1.03 SUBMITTALS

A. Submit manufacturer's product specifications and installation instructions.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the site in sealed containers fully identified with manufacturer's name, brand, type and grade.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cement: ASTM C150, Type I.

B. Water: Clean, fresh, potable and free of mineral or organic matter which can affect stucco.

C. Aggregate: ASTM C897.

D. Hydrated Lime: ASTM C207, Type S.

E. Bonding Agent: ASTM C631. Thorobond by Thoro System Products or approved equal.

F. Premixed Finishing Coat: Thoro Stucco by Thoro System Products or approved equal.

2.02 STUCCO MIXES

A. Scratch Coat - One part cement, three parts sand, with hydrated lime not more than 1/4 part by volume. Cement and hydrated lime after being thoroughly mixed dry to uniform color, added to dry sand and whole thoroughly mixed. Water added to secure proper working consistency.

B. Finish Coat - Mix in accordance with the manufacturer's instructions.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that surfaces and site conditions are ready to receive Work.

B. Verify joints are cut flush and surface is ready to receive Work of this Section. Verify no bituminous or water repellent coatings exist on masonry surface.

C. Verify all flashing, wall vents, drains, fastenings or projections of any kind are in place.

3.02 PREPARATION

A. Brush clean masonry surface. Surface must be free from dirt, dust or loose particles.

B. Dampen masonry surfaces to reduce excessive suction. Do not saturate.

C. Apply bonding agent on concrete surfaces for direct application of stucco.

3.03 APPLICATION

A. Apply scratch coat to a nominal thickness of 5/8 inch. Scratching to be done with a wire tool. Apply within thirty minutes from time of mixing. Use of retempered stucco is not allowed.

B. Moist cure scratch coat.

C. After curing, dampen scratch coat prior to applying finish coat.

D. Apply finish coat to a nominal thickness of 1/8 inch and wood float to a smooth and consistent finish.

E. Avoid excessive working of surface. Delay trowelling as long as possible to avoid drawing excess fines to surface.

F. Moist cure finish coat.

END OF SECTION

SECTION 09900

PAINTING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Surface preparation and application of protective coatings.

B. Interior and exterior coating systems.

1.02 REFERENCES

A. ASTM B117-90 - Salt Spray (Fog) Testing.

B. ASTM D2247-87 - Testing Water Resistance of Coatings in 100% Relative Humidity.

C. ASTM D3359-87 - Measuring Adhesion by Tape Test.

D. ASTM D3363-74 - Film Hardness by Pencil Test.

E. ASTM D4060-84 - Abrasion Resistance of Organic Coatings by the Taber Abraser.

F. ASTM D4541-85 - Pull-Off Strength of Coatings Using Portable Adhesion-Testers.

G. ASTM D4585-87 - Testing the Water Resistance of Coatings Using Controlled Condensation.

H. AWWA C210-84 - Liquid Epoxy Coating System for the Interior and Exterior of Steel Water Pipelines.

I. AWWA D102-78 - Painting Steel Water-Storage Tanks.

J. Steel Structures Painting Council (SSPC) Specifications.

1. SP-1 Solvent Cleaning: Remove all grease,oil, salt, acid, alkali, dirt, dust, wax, fat, foreign matter and contaminates, etc. by one of the following methods: steam cleaning, alkaline cleaning, or volatile solvent cleaning.

2. SP-2 Hand Tool Cleaning: Removal of loose rust, loose mill scale and loose paint to a clean sound substrate by hand chipping, scraping, sanding and wire brushing.

3. SP-3 Power Tool Cleaning: Removal of loose mill scale and loose paint to a clean sound substrate by power tool chipping, descaling, sanding, wire brushing and grinding.

4. SP-5 White Metal Blast Cleaning: Complete removal of all mill scale, rust, rust scale, previous coating, etc., leaving the surface a uniform gray-white color.

5. SP-6 Commercial Blast Cleaning: Complete removal of all dirt, rust scale, mill scale, foreign matter and previous coating, etc., leaving only shadows and/or streaks caused by rust stain and mill scale oxides. At least 66% of each square inch of surface area is to be free of all visible residues, except slight discoloration.
6. SP-7 Brush-Off Blast Cleaning: Removal of rust scale, loose mill scale, loose rust and loose coatings, leaving tightly-bonded mill scale, rust and previous coatings. On concrete surfaces, brush-off blast clean to remove all laitance, form oils and solid contaminates. Blasting should be performed sufficiently close to the surface so as to open up surface voids, bugholes, air pockets and other subsurface irregularities, but so as not to expose underlying aggregate.

7. SP-8 Shop Pickled: Complete removal of rust and mill scale by acid pickling, duplex pickling or electrolytic pickling (may reduce the resistance of the surface to corrosion, if not to be primed immediately).

8. SP-10 Near-White Metal Blast Cleaning: Removal of all rust scale, mill scale, previous coating, etc., leaving only light stains from rust, mill scale and small specks of previous coating. At least 95% of each square inch of surface area is to be free of all visible residues and the remainder limited to slight discoloration.

9. VIS-1 Pictorial Surface Preparation Standards for Painting Steel Surfaces

1.03 ABBREVIATIONS

A. ASTM - American Society of Testing Materials

B. AWWA - American Water Works Association

C. DFT - Dry film thickness.

D. Exterior - Outside, exposed to weather.

E. Interior Dry - Inside, concealed or protected from weather.

F. Interior Wet - Inside, subject to immersion service.

G. NACE - National Association of Corrosion Engineers

H. SSPC - Steel Structures Painting Council

1.04 SUBMITTALS

A. Product data sheets and application instructions.

B. Color samples for selection by the Owner.

C. For each coating application, submit an affidavit from the manufacturer stating that the paint selected is recommended for its intended use.

D. When removal of lead containing paint is part of the Work, submit qualifications such as a copy of a Certification of Training, demonstrating that the person supervising the Work has been trained in removing lead containing paint. In addition, submit a plan for the methods to be employed for surface preparation, containment and ventilation, and collection of debris.

1.05 QUALITY ASSURANCE

A. All Work to be done by skilled and experienced craftsmen.

B. When removal of lead containing paint is part of the Work, the person supervising the Work must be trained in lead paint removal by a nationally recognized training organization. A minimum of 16 hours classroom training is required.

C. The following instruments must be available on the job site for Engineer's use, during all painting activities:

1. Moisture meter.
2. 'Tape' type mill profile micrometer.
3. 'Nordson-Mikrotest' dry film gauge.
4. Tooke - gauge.
5. Sponge type holiday detector.

D. Primers and other undercoat paint must be produced by same manufacturer as finish coats.

E. Use only thinners approved by the paint manufacturer, and use only within recommended limits.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site in sealed and labeled containers.

B. Container labeling to include manufacturer's name, type of paint, brand name, brand code, batch number, date of manufacturer, shelf life, coverage, surface preparation, drying time, cleanup, color designation, and instructions for mixing and reducing.

C. Store painting materials in a clean, dry, well ventilated place, protected from sparks, flame, direct rays of the sun or from excessive heat.

1.07 REGULATORY REQUIREMENTS

A. All coatings used for potable water service must be approved and certified for use by the National Sanitation Foundation (NSF) Standard 61 and conform to AWWA D-102 and AWWA C-210.

B. All coatings must meet the requirements for volatile organic compounds (VOC) of not more than 3.5 lbs/gallon after thinning.

C. Contain, handle, and dispose of all hazardous materials, including but not limited to lead containing paint, resulting from surface preparation and painting, in accordance with all applicable local, state and federal requirements.

1.08 ENVIRONMENTAL REQUIREMENTS

A. Apply paint only on thoroughly dry surfaces and during periods of favorable weather, unless otherwise allowed by the paint manufacturer. Except as provided below, painting is not permitted when the atmospheric temperature is below 50° F, or when freshly painted surfaces may be damaged by rain, fog, dust, or condensation, and/or when it can be anticipated that these conditions will prevail during the drying period.

B. Do not apply coatings unless the surface temperature is a minimum of 5° above the dew point; temperature must be maintained during curing.

C. Dew Point Calculation Chart

Ambient Air Temperature - Fahrenheit

Relative Humidity	20	30	40	50	60	70	80	90	100	110	120
90%	18	28	37	47	57	67	77	87	97	107	117
85%	17	26	36	45	55	65	76	84	95	104	113
80%	16	25	34	44	54	63	73	82	93	102	110
75%	15	24	33	42	52	62	71	80	91	100	108
70%	13	22	31	40	50	60	68	78	88	96	105
65%	12	20	29	38	47	57	66	76	85	93	103
60%	11	29	27	36	45	55	64	73	83	92	101
55%	9	17	25	34	43	53	61	70	80	89	98
50%	6	15	23	31	40	50	59	67	77	86	94

45%	4	13	21	29	37	47	56	64	73	82	91
40%	1	11	18	26	35	43	52	61	69	78	87
35%	-2	8	16	23	31	40	48	57	65	74	83
30%	-6	4	13	20	28	36	44	52	61	69	77

SURFACE TEMPERATURE AT WHICH CONDENSATION OCCURS

D. Suitable enclosures to permit painting during inclement weather may be used if provisions are made to control atmospheric conditions artificially inside the enclosure, within limits suitable for painting throughout the painting operations.

1.09 EXISTING CONDITIONS

A. When unable to inspect the interior surfaces of existing tanks during bidding, assume 25 percent of the area is pitted as defined by the Steel Structures Painting Council.

1.10 EXTRA MATERIALS

A. Provide a one gallon container of each color and surface texture to Owner.

B. Label each container with color, texture, location used, in addition to the manufacturer's label.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. All materials specified herein are manufactured by the Tnemec Company, Inc., North Kansas City, Missouri, unless noted otherwise. These products are specified to establish standards of quality and are approved for use on this Project.

B. Equivalent materials of other manufacturers may be substituted on approval of the Engineer. Requests for substitution must include manufacturer's literature for each product giving the name, generic type, descriptive information and evidence of satisfactory past performance and an independent laboratory certification that their product meets the performance criteria of the specified materials.

C. Performance Criteria

1. Abrasion - ASTM D4060, CS-17 Wheel, 1,000 grams load.

2. Adhesion - ASTM D3359, Method B or ASTM D4541.

3. Exterior Exposure - Exposed at 45 degrees facing the ocean (South Florida Marine Exposure).

4. Hardness - ASTM D3363.

5. Humidity - ASTM D2247 or ASTM D4585.

6. Salt Spray (Fog) - ASTM B117.

D. Substitutions which decrease the film thickness, the number of coats applied, change the generic type of coating, or fail to meet the performance criteria of the specified materials will not be approved. Primer and finish coats on all surfaces must be furnished by the same manufacturer.

2.02 MATERIALS

A. Coatings: Ready mixed, except field catalyzed coatings. Process pigments to a soft paste consistency, capable of being readily and uniformly dispersed to a homogeneous coating. Good flow and brushing properties; capable of drying or curing free of streaks or sags.

B. Accessory Materials: Linseed oil, shellac, turpentine, paint thinners and other materials not specifically indicated but required to achieve the finishes specified. Of commercial quality.

C. Cement - Base Patching: Thorite by Thoro System Products of Miami, Florida.

D. Colors: When not specified, as selected by the Owner.

2.03 EQUIPMENT

A. Use effective oil/water separators on all compressed air lines serving spray painting and sandblasting operations to remove oil or moisture from the air before it is used. Place separators as far as practicable from the compressor.

B. All equipment for application of the paint and the completion of the Work must be in first-class condition and comply with recommendations of the paint manufacturer.

PART 3 EXECUTION

3.01 INSPECTION

A. Applicator must examine areas and conditions under which painting Work is to be completed and notify Engineer in writing of conditions detrimental to proper and timely completion of Work.

B. Inspect the substrate and report any unsatisfactory conditions. Contractor is not responsible for latent defects in the substrate which can not be detected during a reasonable visual inspection. Starting the Work indicates acceptance of the substrate as constructed.

C. All surfaces to be painted are subject to review by the Engineer before application of the prime coat and each succeeding coat. Any defects or deficiencies are to be corrected by the Contractor before application of any subsequent coat.

D. When any appreciable time has elapsed between coats, previously coated areas are to be reviewed by the Engineer. Where surfaces are damaged or contaminated, they are to be cleaned and recoated. Adhere to recoating times of manufacturer's printed instructions.

3.02 SURFACE PREPARATION

A. General: Clean surfaces as specified and in accordance with the manufacturer's recommendation for the coating being used. If surfaces are subject to contamination other than mill scale or normal atmospheric rusting, the surfaces are to be pressure washed, and acid or caustic pH residues neutralized, in addition to the specified surface preparation.

B. Concrete and Masonry: Remove all oil, grease, dirt, laitance and other foreign materials. Blast remove all existing coatings using equipment rated at 3500 psi. Acid etch with a solution of muriatic acid and then rinse with clean water. Verify required acid-alkali balance is achieved. Surface must be dry and free of dust prior to painting. New concrete and masonry must be cured a minimum of 28 days before treating and coating.

Repair damaged concrete using a cement base patching system. Use in strict accordance with the manufacturer's recommendations.

C. Plaster: Remove dirt, loose mortar, scale, chalk, salt or alkali powder, and other foreign matter. Remove oil and grease with a solution of tri-sodium phosphate; rinse well and allow to dry.

Remove stains caused by weathering of corroding metals with a solution of sodium metasilicate after thoroughly wetting with water. Allow to dry. Fill hairline cracks, small holes, and imperfections with a latex patching plaster.

D. Gypsum Drywall: Latex fill minor defects. Spot prime after repair. Remove dust from surface by wiping with clean rags or other means.

E. Carbon Steel: Remove all oily and greasy residues in accordance with SSPC-SP1. Blast clean using Dupont's 'Starblast' as the blasting media in accordance with SSPC-SP10. 'Starblast' is the only blasting media allowed to be used. Apply primer coat before any rust bloom forms.

F. Galvanized Steel and Other Non-Ferrous Metals: Surface to be clean and dry. Remove oil, grease, and protective mill coatings by solvent cleaning per SSPC-SP1. Remove white rust from galvanized steel by hand or power brushing. Take care not to damage or remove the galvanizing. Remove rust from old galvanized steel by hand or power tool cleaning in accordance with SSPC-SP2 or SSPC-SP3.

G. PVC Pipe: Remove surface contaminants. Roughen surface by sanding to provide adhesion for primer coat.

H. Wood: Remove dust, grit and foreign matter. Seal knots, pitch streaks, and sappy sections. Fill nail holes and cracks. Wood must be clean and dry before application of coating.

I. Fiberglass Reinforced Plastic: Roughen by brush blasting to provide adhesion for primer coat.

3.03 PROTECTION

A. Protect elements surrounding the Work of this Section from damage or disfiguration.

B. Repair damage to other surfaces caused by Work of this Section.

C. Furnish drop cloths, shields, and protective methods to prevent spray or droppings from disfiguring other surfaces.

D. Erect, maintain, and dismantle scaffolding without damage to structures, machinery, equipment or pipe. Use drop cloths to protect buildings and equipment.

E. Construct a temporary shroud or cover to contain and collect all spent abrasives and old paint. Dispose of spent abrasives and old paint in accordance with all local, state and federal requirements.

3.04 APPLICATION

A. Apply products in strict accordance with the coating manufacturer's instructions.

B. Apply coating uniformly at the prescribed thickness. Prevent film defects that would adversely affect the appearance or performance.

C. Apply prime coat immediately following surface preparation and in no case later than the same working day. Apply by brushing, paint mitt and roller, conventional spraying, or airless spraying, using equipment approved by the coatings manufacturer.

D. Recoat as per the manufacturer's instructions. Coating is considered recoatable when an additional coat can be applied without any detrimental film irregularities such as lifting or loss of adhesion.

E. Surfaces that will be inaccessible after assembly are to receive either the full specified paint system or three shop coats of the specified primer before assembly.

F. Brushing or rolling is to be done so that a smooth coat as nearly uniform in thickness as possible is obtained. Smooth the film so as not to leave detrimental marks.

G. When using an air, airless or hot spray, apply paint in a uniform layer, with a 50 percent overlap pattern. Brush out all runs and sags immediately or the paint will have to be removed and the surface resprayed.

H. High build coatings should be applied by a cross-hatch method of spray application to ensure proper film thickness of the coating.

I. Surfaces not accessible to brushes, rollers or sprays may be painted by a dauber, sheepskin, or paint mitt.

J. Sand lightly between each succeeding alkyd enamel or varnish coat.

3.05 FINISHING MECHANICAL AND ELECTRICAL EQUIPMENT

A. Approval from the Owner is required prior to field painting in the vicinity of, or on, energized electrical and rotating equipment, and equipment and/or pipes in service.

B. Exercise extreme care in the painting of operable equipment, such as valves, electric motors, etc., so that the proper functioning of the equipment will not be affected.

C. Degloss factory finish.

D. Do not paint identification markings or code required labels.

E. Match associated piping color with finished paint color. See piping color code.

3.06 CLEANING

A. Contain paint overspray and debris by suitable means, including but not limited to, full shrouding of the area.

B. As Work proceeds, promptly remove paint where spilled, splashed or splattered.

C. During progress of Work maintain premises free of unnecessary accumulation of tools, equipment, surplus materials, and debris.

3.07 COATING SYSTEMS - INTERIOR SURFACES

A. Concrete Floors

1. One coat of Tnemec Series 287 Enviro-Tread (Waterborne Epoxy) applied at 3.0 mils DFT (273 SF/Gal).
2. A second coat of Tnemec Series 287 Enviro-Tread applied at 3.0 mils (273 SF/Gal).
3. Where requested by Owner add or broadcast Series S287-300C (sand) to the 1st coat for a non-slip finish.

B. Masonry Block Walls

1. One coat Tnemec 54-WB surface coat masonry filler. Apply at a minimum rate of 80-100 square feet per gallon to concrete block surfaces only.
2. One coat Series 113 H.B. Tnemec-Tufcoat water-base acrylic epoxy. Apply at a minimum rate of 120-170 square feet per gallon. Two coats will be required if applied by roller.

C. Concrete (including exposed ceilings)

1. Two coats Series 113 H.B. Tnemec-Tufcoat water base acrylic epoxy. Apply at a minimum rate of 120-170 square feet per gallon.

D. Gypsum Drywall

1. One coat Tnemec-cryl Sealer (thinned 10%). Apply at a minimum rate of 400 square feet per gallon.
2. One coat Series 113 H.B. Tneme-Tufcoat water-base acrylic-epoxy. Apply at a minimum rate of 120-170 square feet per gallon. Two coats will be required if applied by roller.

E. Carbon Steel, Ductile Iron, or Cast Iron

1. Prime coat Tnemec Series N69-1211 Epoxoline Primer epoxy-polyamide, 3-5 mils DFT.
2. Finish coat Tnemec Series N69 Hi-Build Epoxoline II epoxy-polyamide, 4-6 mils DFT.

F. Fuel Oil Tanks

1. Prime coat Series 61-5002 Tneme-Liner high solids catalyzed epoxy, 8-12 mils DFT.
2. Finish coat Series 61-5001 Tneme-Liner high solids catalyzed epoxy, 8-12 mils DFT.

G. Galvanized Steel and Other Non-Ferrous Metals

1. One coat Tnemec Series N69 Hi-Build Epoxoline epoxy-polyamide, 4-6 mils DFT.

H. PVC Piping

1. Two coats Tnemec Series N69 Hi-Build Epoxoline epoxy-polyamide. Apply at a minimum rate of 300 square feet per gallon per coat.

I. Shop Finished Electrical and Mechanical Equipment

1. One coat Tnemec Series 27 F/C/ Tu[ppxu (Fast Cire E[pxu), 2-6 mils DFT.
2. One coat Tnemec Series N69 Hi-Build Epoxoline epoxy-polyamide, 4-6 mils DFT.

J. Wood Trim and Doors - Painted

1. Prime coat of Tenemec Series 10-99 W Tnemec primer applied at 2.5 mils DFT (350± SF/Gal)..
2. Two coats of Tnemec Series 23 Enduratone (Semi-Gloss Alkyd Ename) applied at 2.0 mils DFT per coat.

3.08 COATING SYSTEMS - EXTERIOR SURFACES

A. Carbon Steel, Ductile, or Cast Iron

1. Prime coat Tnemec Series 135 (Chembuild Surface Tolerant Epxy), 3-5 mils DFT.
2. Finish coat Tnemec Series 73 Endura-Shield III high build acrylic polyurethane, 2-5 mils DFT.

B. Galvanized Steel and Other Non-Ferrous Metals

1. Prime coat Tnemec Series N69 Hi-Build Epoxoline epoxy-polyamide, 2-3 mils DFT.
2. Finish coat Tnemec Series 73 Endura-Shield III high build acrylic poly- urethane, 2-5 mils DFT.

C. Above Ground Fuel Storage Tanks

1. Shop Primer: One coat Series 90-97 Tneme-Zinc zinc-rich urethane, 2.5-3.5 mils DFT.
2. Field Touch-Up: Series 90-97 Tneme-Zinc, 2.5-3.5 mils DFT.

3. Full first coat Tnemec Series N69 Hi-Build Epoxoline epoxy polyamide, 2-3 mils DFT.
4. Finish coat Tnemec Series 73 Endura-Shield III high-build acrylic polyurethane, 2-5 mils DFT.

D. PVC Piping

1. One coat Tnemec Series N69 Hi-Build Epoxoline epoxy polyamide. Apply at a minimum rate of 300 square feet per gallon.
2. One coat Tnemec Series 73 Endura-Shield III high-build acrylic polyurethane. Apply at a minimum rate of 300 square feet per gallon.

E. Fiberglass Reinforced Plastic

1. One coat Tnemec Series N69 Hi-Build Epoxoline epoxy polyamide. Apply at a minimum rate of 300 square feet per gallon.
2. One coat Tnemec Series 73 Endura-Shield III high-build acrylic polyurethane. Apply at a minimum rate of 300 square feet per gallon.

F. Shop Finished Electrical and Mechanical Equipment

1. Prime coat Tnemec Series 27 F.C. Typoxy (fast cure epoxy), 2-3 mils DFT.
2. Finish coat Tnemec Series 73 Endura-Shield III high-build acrylic polyurethane, 2-5 mils DFT.

G. Masonry Block Walls
1. Block Filler – Tnemec Series 54WB surface coat Masonry Filler applied at 80± SF/Gal.
2. Finish per requirements below.

H. Precast and Cast In Place Concrete
1. Above Grade Coating – Finish per requirements below.
2. Below Grade Coating – Apply one coat Series 46H-413 Hi-Build Theme-Tar (Coal Tar Epoxy), 14.0 to 20.0 mils DFT.

I. Plaster, Above Grade Concrete, and Stucco
1. Prime Coat: Thoro Primer 2K by Thoro System Products of Miami, Florida. Apply at the minimum rate of 200 square feet per gallon.
2. Finish Coats: Two coast Thorosheen by Thoro System Products of Miami, Florida. Apply at the minimum rate of 200 square feet per gallon.
3. See Section 07145 for additional requirements for new or repaired concrete and masonary surfaces.

3.09 PIPING COLOR CODE

Water Lines

Raw	Olive Green
Settled or Clarified	Aqua
Finished or Potable	Dark Blue

Chemical Lines

Alum or Primary Coagulant	Orange
Ammonia	White
Carbon Slurry	Black
Caustic	Yellow with Green Band
Chlorine (Gas and Solution)	Yellow
Fluoride	Light Blue and Red Band
Lime Slurry	Light Green
Ozone	Yellow with Orange Band
Phosphate Compounds	Light Green with Red Band

Polymers or Coagulant Aids	Orange with Green Band
Potassium Permanganate	Violet
Soda Ash	Light Green with Orange Band
Sulfuric Acid	Yellow with Red Band
Sulfur Dioxide	Light Green with Yellow Band

Fuel Oil Lines

Black Oil	Yellow
Diesel	Yellow

Waste Lines

Backwash Waste	Light Brown
Sludge	Dark Brown
Sewer (Sanitary and Other)	Dark Gray

Other

Compressed Air	Dark Green
Gas	Red
Other Lines	Light Gray

3.10 PAINTING SCHEDULE

END OF SECTION

SECTION 16201

DIESEL STANDBY GENERATOR

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Work included:

1. The work covered by this portion of the specifications consists of supplying one diesel electric generator for standby continuous use. All necessary equipment and accessories as specified shall be provided and any additional equipment required for a completely functional system shall be supplied.

2. See also the drawings.

1.02 MANFACTURER

A. The unit shall be completely built, tested and shipped by one manufacturer who has been regularly engaged in the manufacturing of such equipment. The manufacturer and local dealer shall be limited to the following, no equal.

1. Caterpillar/Pantropic Power Products, Inc.
Robert Butt
8205 N.W. 58th Street
Miami, FL 33166
FL Watts: 1-800-237-2945
Dade: (305) 592-4944
Fax: (305) 477-1943

2. Cummins /Power South, LLC
Stephen L. Towle
9220 S.W. 14th Street, Apt. #3502
Boca Raton, FL 33428
Phone: (561) 451-8887
Fax: (561) 451-8831

3. Detroit Diesel/ Florida Detroit Diesel
2277 N.W. 14th Street
Miami, FL 33125
Phone: (305) 637-1574
Fax: (305) 637-1582

1.03 CODES

A. All equipment shall be provided per the requirements of the following codes as applicable for the intended use and installation:

1. NFPA 70, latest edition (National Electrical Code).

2. NFPA 110, Emergency and Standby Power Systems, latest edition.

3. UL 2200, the complete generator set shall be UL listed.

B. Emissions

1. Supplier shall be responsible to meet all EPA and other similar codes.

1.04 SUBMITTALS

A. Submittals for approval shall be provided for any and all materials. No materials shall be used without approval from the Engineer

B. Refer to the General Requirements for documentation of Shop Drawings and O&M Manuals.

C. Provide additional submittal information:

1. Engine manufacturer, model number, power output parameters, Drawings and elevations of the units, entrance points for power, control, fuel, storage and foundation requirements.

2. Engine Generator/Exciter control cubical.

3. Fuel consumption rate curves at ¼, 2/4, ¾, 4/4 loads.

4. Exhaust mufflers and vibration isolators.

5. Battery charger, batteries and battery racks.

6. Diesel Storage Tank, day tank and fuel connection points.

7. Cooling water requirements of radiator.

8. Engine cooling air requirements and radiator fan capacity.

9. Electrical diagrams including schematic and interconnection wiring diagrams for all equipment to be provided.

10. Legends for all devices on all diagrams.

11. Sequence of operation, explanations of all portions of schematic wiring diagrams.

12. Provide load calculations including starting and running kVA.

13. Transient voltage response calculation, no voltage transient shall dip below 25%.

D. The specified kW shall be for continuous electrical service during interruption of the normal utility source. These ratings must be substantiated by manufacturer's standard published curves. Special ratings or maximum ratings are not acceptable.

E. O&M Manuals

1. Refer to the General Requirements.

F. Warranty

1. The Installing Contractor shall be responsible to generate and provide to the Engineer scaled layout Drawings of the generator room clearly depicting detailed dimensions of the mechanical installation of all generator equipment including generator set, vibration isolators, day tank and associated piping, exhaust flex and muffler and associated piping as intended to be physically located and installed within the generator room. Include detailed and dimensioned elevation Drawings depicting the installation mounting height of all equipment and piping, including the exhaust system with the required insulation system installed within the generator room. The scaled installation Drawings provided shall indicate satisfactory installation and appropriate clearances for all installed equipment and piping systems.

1.05 WARRANTY

A. Equipment furnished under this section shall be guaranteed against defective parts and workmanship under terms of the manufacturer's and dealer's standard warranty for a period of no less than five (5) years from the date of the Owner's acceptance of the unit.

PART 2 PRODUCTS

2.01 ENGINE

A. Engine shall be watercooled 4 cycle inline or vee type compression ignition diesel. It shall meet specifications when operating on No. 2 domestic burner oil. The engine shall be equipped with fuel, lube oil, coolant, exhaust system, silencer, fuel transfer pump, fuel priming pump, fuel water separator, service run time meter, engine driven water pump, engine driven alternator for batteries, batteries, instrument/control panel including: lube oil pressure gauge, tachometer, system voltage, jacket water temperature gauge, system diagnostics code display, other auxiliary equipment as may be required for proper operation of the units. Provide jacket water heater. Provide one at 3 kW each, 208 volts.

B. An electronic governor system shall provide automatic isochronous frequency regulation. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous or parallel states.

C. The engine/generator set shall be mounted on a structural steel sub-base and shall be provided with suitable quad spring vibration isolators.

D. Safety devices for protection of the units shall be provided as per the generator Supplier and shall minimally include: shutoffs for high water temperature, low oil pressure, overspeed and engine overcrank.

E. Guards shall be provided over all exposed moving parts per OSHA.

2.02 ALTERNATOR

A. The AC generator shall be synchronous, four pole, 2/3 pitch, revolving field, drip-proof construction, single pre-lubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc. All insulation system components shall meet NEMA MG1 temperature limits for Class H insulation system. Actual temperature rise measured by resistance method at full load shall not exceed 80 degrees Centrigrade. Supplier shall supply the alternator suitable for the load. If a lower temperature rise alternator is required then it shall be provided.

B. The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor at any voltage not more than 5 percent above or below rated voltage.

C. A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of rated current for not more than 10 seconds.

D. The subtransient reactance of the alternator shall not exceed 12 percent based on the standby rating of the generator set.

E. Space Heater – Alternator shall be provided with 120V, 100W max. space heater interlocked with generator run relay.

2.03 COOLING SYSTEM

A. Radiator – An engine mounted radiator with blower type fan shall be sized to maintain safe operation at 122 degrees Fahrenheit maximum ambient temperature.

B. The engine cooling system shall be pretreated by the Engine Supplier for the inhibiting of internal corrosion.

C. The radiator shall exhaust through the building.

2.04 EXHAUST SYSTEM

A. The engine exhaust system shall be installed to discharge combustion gases quickly and silently with minimum restriction. The exhaust system including the generator exhaust silencer shall be designed for minimum restriction and in no case shall the total exhaust system (including piping system as installed) backpressure restriction imposed on the engine at full operating load exceed the engine manufacturer's maximum allowable exhaust backpressure.

B. All exhaust piping shall be Schedule 40 heavy walled steel piping. The generator exhaust muffler and all exhaust piping located within the generator room shall be covered with appropriate insulation and shielding. Piping shall be installed with 16 inches minimum clearance from combustible materials.

C. The generator exhaust silencer shall be installed inside of the generator room and exhaust piping terminated as shown on the Contract Drawings. The exhaust silencer and associated piping shall be installation supported

and braced to prevent weight or thermal growth from being transferred to the engine. Flexible expansion fittings shall be provided to accommodate thermal growth. Support dampers and springs shall be included where necessary to isolate damaging vibrations. All exhaust system piping, installation hardware and materials, insulation materials and installation of the entire exhaust system shall be provided by the Installing Contractor.

D. The exhaust silencer (muffler) shall be "hospital" grade to provide extreme noise attenuation for environments with low background noise where slight noise emissions would be objectionable. The silencer shall be aluminized steel body construction, prime painted with high temperature finish coating and manufacturer rated and capable of up to 35-40 dBA attenuation at between 125 and 2000 Hz octave band center frequencies. The silencer shall incorporate installed inlet and outlet ASA flanges and configured as shown on the Contract Drawings. The silencer shall also be furnished with inlet and outlet weld on type ANSI companion flanges with gaskets and bolts/nuts and an appropriately sized stainless steel bellows type engine expansion flex connector for connection to the engine. Any required extension/spool piece piping connection from the exhaust flex to the installed muffler shall be furnished and installed by the Installing Contractor. The silencer's exhaust inlet flange location on the silencer shall be configured so as to fit and be properly installed in the generator room space available.

E. The silencer shall be furnished with a N.P.T. drain fitting. The exhaust piping from the muffler shall be extended horizontally and with a slight pitch downward and away from the generator to discharge engine exhaust gases and to facilitate exhaust silencer and piping drainage. The Installing Contractor shall provide and install stainless steel construction manual isolation shutoff drain valves and carbon steel piping drain lines in the end of the muffler and at the low point in the exhaust piping and piped by the Installing Contractor to a readily accessible location beneath the muffler. Appropriately rated high temperature resistant gaskets shall be utilized for all exhaust system flanged connections.

F. The Installation Contractor shall be responsible to confirm and provide documentation indicating that the physical size and construction of muffler to be furnished shall be adequate to properly locate and install the muffler and associated exhaust piping system, including insulation in the generator room with the generator set in its installed location. The exhaust muffler installed inlet shall be relocated as necessary and shall be constructed with manufacturer approved physical locations of the muffler's inlet and outlet location on the muffler.

G. Exhaust piping from the muffler shall be extended to outside of the building as shown on the Contract Drawings. The exhaust piping shall be routed through the building structure through an industrial pre-

manufactured stainless steel construction exhaust piping thimble to be installed at the point of generator room penetration. The exhaust pipe termination point shall incorporate a 45 degree angle cut with bird screen installed in the opening for horizontal discharge, or with an exhaust aluminum counter weighted rain cap with brass collar for vertical discharge of the exhaust gases.

H. The entire generator set equipment exhaust system, including each engine exhaust muffler and all exhaust piping installed inside of the generator room from the top of the engine installed exhaust flexible connector(s) to the point of generator room exhaust piping penetration(s) shall be covered with insulation of a non-combustible type and jacketed with an aluminum jacket. The insulation shall be minimum of 4 inch thick, Fibrex Industrial Flexible Batt Insulation IF1260, or equal, and for the piping shall be Coreplus 1200 insulation, or equal, held in place with stainless steel banding and covered with 0.020 inch aluminum jacket, secured with stainless steel screws and jacketing overlapped a minimum of 3 inches. The exhaust system insulation materials and aluminum jacket shall be separately applied and completely installed on site after the exhaust system is installed within the generator room. All exhaust system fittings from the top of the engine exhaust flexible connector to the point exhaust piping penetration out of the generator room shall be insulated with secured MF pipe covering material, cut to fit, and must be field removable for flange inspections. No asbestos or asbestos bearing products shall be used, no exceptions. Any other flexible sections of the exhaust piping system shall be protected by a removable suitable metal guard, constructed so as to prevent personal injury from a burn if in contact with bare flesh.

2.05 AUTOMATIC STARTING SYSTEM

A. Starting Motor – A DC electric starting system with positive engagement drive shall be provided. The motor voltage shall be as recommended by the engine manufacturer.

B. Automatic control – Fully automatic generator start/stop controls in the generator control panel shall be provided. Controls shall provide shutdowns for low oil pressure, emergency stop, high water temp, engine overspeed, low coolant level, overcrank, internal fault shutdown. Controls shall include a 30 second cranking cycle with lock out. Lock out shall have remote reset capability.

C. Batteries – A lead acid storage battery set of the heavy duty special starting type shall be provided. Battery voltage shall be compatible with the starting system. Battery set shall be rated for no less than 172 amp hours. Free standing corrosion resistant battery racks and necessary cables shall be provided. Batteries shall be unit mounted.

D. Battery Charger – Current limiting battery charger shall be furnished to automatically recharge the batteries. Charger shall be the float charging type furnished to properly charge the batteries. It shall include overload protection, silicone diode full wave rectifiers, voltage surge suppressor, DC ampmeter, DC voltmeter, fused AC input. Input power shall be 120V single phase. A battery charger fail alarm contact shall be provided.

2.06 GENERATOR CONTROL PANEL

A. Generator Set Control

1. The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set and remote monitoring and control as described in this specification.

2. The control shall be mounted on the generator set. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.

B. Generator set A/C output metering

1. The generator set shall be provided with a metering set including the following features and functions:

a. Digital metering set, 0.5% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display all three phase voltages (line to neutral or line to line) simultaneously.

C. Generator Set Alarm and Status Display

1. The generator set shall be provided with alarm and status indicating lamps to indicate non-automatic generator status and existing warning and shutdown conditions. The lamps shall be high intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of the following alarm and shutdown conditions on an alphanumeric digital display panel:

ALARM
Low oil pressure
Oil pressure sender failure
Low coolant temperature
High coolant temperature
Engine temperature sender failure
Low DC voltage
High DC voltage
Weak battery
Low fuel-daytank
Ground fault
Over load
Low coolant level

SHUTDOWN
Low oil pressure (shutdown)
High coolant temperature (shutdown)
Fail to crank (shutdown)
Fail to start/overcrank (shutdown)
Overspeed (shutdown)
High AC voltage (shutdown)
Low AC voltage (shutdown)
Under frequency (shutdown)
Over current (shutdown)
Short circuit (shutdown)
Emergency stop (shutdown)
Low coolant level

WARNING
Over current (warning)

2. Provide form "A" contacts for each of the above to be used in SCADA system.

3. Provide common fault alarm.

D. Unit shall work with ATS. All labor and material shall be provided to coordinate the installation with the ATS.

2.07 GENERATOR RATINGS

A. The size of the generator shall be **350 kW** or as minimally indicated in the drawings and be rated .8 PF. Increase generator size as may be required. All loads are considered fully loaded.

2.08 MAIN LINE CIRCUIT BREAKER

A. Unit shall be provided as an integral main line circuit breaker, 480V, 3 phase, rated as indicated in the Drawings with an interrupting rating exceeding the generator output.

B. Provide circuit breaker unit mounted in oversized circuit breaker enclosure.

C. Unit shall be provided with 100% rated circuit breaker with ground fault indication.

2.09 FLUIDS

A. Unit shall be provided with all fluids, fully fuelled and ready for immediate use.

2.10 SPECIAL FEATURES

A. Refer to the drawings. Provide and receive signals as indicated.

B. Provide output from Gen.CP to SCADA for the following:

1. Battery system failure

2. Generator run status

3. Generator shutdown

C. Receive input from the plant control system for the following:

1. Low fuel in main tank shutdown.

2. Provide manual reset.

D. From the ATS, provide and receive the following signals:

1. Start/stop the generator based upon loss of normal power.

E. Provide fused 24 VDC source to shunt trip the main breaker based upon break glass control station operation. Prohibit engine start based on break glass operation.

2.11 BREAK GLASS CONTROL STATION

A. Provide unit to shunt trip the remote main breaker and prohibit engine start or run. The excitation voltage for the shunt trip shall come from the DC battery circuit. See the drawings.

1. Shunt trip the main remote breaker. Provide contacts on main breaker to remove excitation voltage.

2. Shunt trip the mainline circuit breaker. Provide contacts on main line breaker to remove excitation voltage.

3. Stop engine and prohibit restart.

4. Lock out generator and allow reset via the engine control panel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Unit shall be installed in accordance with Manufacturer's instructions.

3.02 TESTS

A. The unit shall be tested at rated frequency and voltage.

B. Following installation, the following tests shall be performed by the system manufacturer's local dealer representative(s) in the presence of the Engineer:

1. Pre-start checks:

a. Oil level

b. Water level

c. Tank fuel level

d. Battery connection and charge condition

e. Engine to control interconnects

f. Engine generator intake/exhaust obstructions

C. Supplier shall provide onsite operation tests

1. Load – One hour operation at 80% of full load rating. Two hours operation at 100% of full load rating. After the first half hour stabilization period at full load, the following shall be recorded at fifteen minute intervals:

a. Voltage, amps and frequency.

b. Fuel pressure, oil pressure and water temperature.

c. Exhaust gas temperature at engine exhaust outlet.

d. Ambient temperature

e. Kilowatts

f. Power factor

g. kVARS

h. Generator temperature

2. Test shall utilize resistive load banks for the full load. Minimum load shall be equal to the nameplate rating of the engine/generator set in kW. Generator Supplier shall supply all load banks equipment necessary for connecting generator to load banks. Supplier shall provide all labor and material to perform test.

3. Proper operation of controls, engine shutdown and safety devices shall be demonstrated.

4. Should these tests indicate that the equipment does not meet the specified performance requirements, National Electrical Code and local codes, the cost of all corrective measures shall be borne by the Supplier.

3.03 STARTUP AND INSTRUCTION

A. Before start up, the Supplier shall provide the services of an on site technician to confirm proper connection of external equipment. If acceptable to the Supplier and the Owner, the unit may be start up tested.

B. The Owner, the generator Supplier shall provide start up assistance and coordination as required.

C. Operating and maintenance procedures shall be explained to the Owner's personnel by the Supplier's factory trained representative.

D. A minimum of one manday shall be provided for instructing the Owner's staff in the care and maintenance of the unit. Training shall be provided by the Supplier.

E. Proper operation of controls, engine shutdown and safety devices shall be demonstrated.

3.04 SYSTEM SERVICE CONTRACT

A. Supplier shall make available to the Owner, this standard service contract which the Owner may or may not choose to exercise. This contract is separate from the warranty requirements contained herein.

3.05 SCHEDULE OIL SAMPLING

A. The Supplier of the equipment must provide a quarterly oil sampling analysis for a period of one year form the date of acceptance. This scheduled oil sampling shall be of the atomic absorption spectrophotometry method as opposed to the spectrographic analysis method and shall be accurate to within a fraction of one part per million for the following elements:

1. Iron
2. Chromium
3. Copper
4. Aluminum
5. Silicon
6. In addition the sample shall be tested for the presence of water, fuel dilution, and antifreeze.

B. All equipment needed to take oil samples shall be provided in a kit at the time of acceptance and shall include the following:

1. Sample gun kit (1)
2. Bottles (4)
3. Mailers (4)
4. Written instructions (1)

C. Immediate notification shall be provided to the Owner when analysis results shows any critical reading. If readings are normal, a report stating that the equipment is operating within established requirements shall be provided.

D. This scheduled oil sampling program shall be made available to the Owner beyond the mandatory one (1) year specified above and shall be optional for the Owner to continue that program after that time period has elapsed.

3.06 TRAINING

A. Provide training of ATS and generator systems.

B. Provide a minimum of 4 hours training. Training shall be at a time convenient to the Owner.

C. Operation and maintenance training shall be provided.

END OF SECTION

SECTION 16621
CONTROLS, STARTING AND FUEL SYSTEMS RETROFIT FOR GAS TURBINE PACKAGE

1.01 SCOPE: The work and material described in these Specifications and accompanying plans is for the following primary tasks:

- Retrofit and testing of four (4) Solar Centaur 40GS gas turbine control systems including replacement of existing load management system
- Replacement and testing of two (2) gas turbine starting systems
- Retrofit and testing of two (2) gas turbine liquid fuel controls
- Replacement of one (1) 480V substation
- Installation of new 350kW diesel generator and transfer switch

All work will be performed at the emergency power facility of the East Central Regional Wastewater Treatment Plant in West Palm Beach, Florida. All work shall be performed by the Contractor unless otherwise specified. Each new system shall go "on line" as soon as it is installed, tested and approved by the Engineer subject to the schedule provided. Each new controls system will be installed in the existing controls system cabinet and load management cabinet as required (removal of old system components as required). All existing components removed are the property of the Owner unless otherwise specified. A control room layout is presented as Figure 1 showing the current layout and controls cabinet(s) locations.

The following Specifications reference one gas turbine package controls system retrofit, however the requirements apply to each of four (4) gas turbine packages under the Contract. Unit 1 and Unit 2 will receive replacement of start system and retrofit of fuel control. It is anticipated that Unit 3 and Unit 4 will receive replacement start system and retrofit fuel control at a later date. Unit 3 and Unit 4 new controls must be interfaced with existing Titan start system and liquid fuel system.

Each retrofit system shall be installed individually and isolated from the remaining three systems. Each retrofit system must be installed in the existing control consoles and load management panel. The installation must be completed, tested and placed in operation prior to commencing retrofit of additional systems. Three (3) gas turbine packages must be operational at all times. In the event of any unusual occurrences during installation activities, the Contractor shall inform the Engineer immediately. Manual operation of the gas turbine packages is acceptable during construction.

After completion of installation and testing, the Contractor shall remove any temporary equipment and/or systems that are not part of the completed retrofit and leave the site in good condition, acceptable to the Owner.

1.02 MINIMUM CREW REQUIREMENTS: The Contractor shall have the following minimum crew on site at all times during any construction activity on the gas turbine controls system:

1 – Project Manager
2 – Installation Technicians

The above crew members shall have the following minimum experience:

Project Manager – Shall have a minimum of 10 years experience in the installation and retrofit of gas turbine controls and acted as project manager on a minimum of five (5) gas turbine controls retrofit projects with at least two (2) projects including Solar gas turbines.

Installation Technicians – Shall have a minimum of five (5) years experience in the installation and retrofit of gas turbine controls and a minimum two (2) projects including Solar gas turbines.

1.03 CONSTRUCTION SCHEDULE: The Contractor shall submit a detailed construction schedule prior to commencement of any site work. The construction schedule shall include proposed down-time for each unit and a testing schedule for each unit. The Contractor shall note that the proposal contemplates the submittal of a Lump Sum Bid Amount established on the basis of a certain construction schedule.

Within the Lump Sum Bid Amount, the Contractor shall perform construction and testing activities at the site 12 hours per day, 7 days per week. The Contractor shall schedule all work or tests, which will be attended by Owner and/or Engineer, during regular working hours. All other tests not requiring Owner or Engineer attendance shall be performed during daylight hours (7:00 a.m. to 7:00 p.m.), unless prior approval from the Engineer has been obtained. It is understood that certain tests may extend into the evening and cannot be stopped when in progress.

Contractor will perform work and testing as to minimize unit down-time. At no time will fewer than three (3) gas turbine packages be operational.

1.04 OUTLINE SPECIFICATION FOR WORK: After a Contractor has been selected, a pre-construction meeting will be held at the Plant prior to commencement of work. The following items represent and identify the general outline of work to be performed by the Contractor; additional details regarding specific work items are included in subsequent Parts of this Section.

A. Site Preparation, Mobilization and Demobilization:

1. Review current site conditions and record as necessary.
2. Mobilization to site.
3. Review of schedule and down-time plan.
4. Inventory of equipment.
5. Equipment set up for first unit and each subsequent unit.
6. Coordinate work-scope with Owner and Engineer.
7. Demobilization

B. Replacement of Existing 480V Substation

1. Isolate temporary power feed from existing emergency diesel generator to MCC5A.
2. Operate emergency diesel generator to provide power to MCC5A.
3. Disconnect 4160V feed to Substation 6A.
4. Remove existing Substation 6A.
5. Install new Substation 6A (equipment as specified).
6. Commission and test as required.

C. Installation of New 350kW Diesel Generator and Transfer Switch

1. Install diesel generator and electrical disconnect at specified location inside emergency power plant.
2. Install liquid fuel line from supply manifold to generator.
3. Install exhaust piping.
4. Install cooling system ductwork.
5. Install transfer switch and 480V distribution panel at specified location inside control room.
6. Install conduit from disconnect to transfer switch inside control room.
7. Pull and terminate 3-phase AC power wiring from disconnect to transfer switch.

D. Retrofit of Gas Turbine Controls (Start Systems and Fuel Module as required)

1. Install new Variable Frequency Drive (VFD) MCC cabinet at specified location (back-to-back with corresponding controls cabinet).
2. Install conduits from Substation 6A to 350kW emergency generator transfer switch.
3. Install conduits from transfer switch distribution panel to MCC5A and VFD MCC.
4. Pull and terminate 3-phase AC power wiring from Substation 6A to 350kW emergency generator transfer switch.
5. Pull and terminate 3-phase AC power wiring from transfer switch distribution panel to MCC5A and VFD MCC.
6. Identify existing control system components inside control cabinet and load management cabinet to be removed.
7. Prepare existing control and load management panel/door/cabinet for modifications.
8. Assist Owner to insure unit is isolated from remaining units of Plant.
9. Modify existing turbine control panel and load management panel as required to accept/interface with new controls.
10. Install new turbine control panel and load management panel hardware including any required conduits.
11. Provide engineering and software support for installation of new controls system including any required logic modifications and additional I/O or communications modules required for this specific application.
12. Provide engineering and software support for installation of new load management system including changes to standard logic and any required additional communications modules.
13. Prepare turbine package skid including any demolition of old components.
14. Install controls retrofit kit for package controls, starting system and liquid fuel module as required.
15. Modify existing package fuel and oil system manifolds and electrical conduits as required.
16. Install start system A/C motor and conduit (Note: Stack up measurement of AC motor and adapter must be taken and reported to Engineer prior to installation. The electrical generator must be uncoupled from the main gearbox and pushed back several inches to allow clearance for motor and adapter installation onto gearbox).
17. Re-install and align electrical generator.
18. Install liquid fuel module.
19. Install new package instrumentation.
20. Pull and terminate all internal turbine package skid wiring.

21. Pull and terminate 3-phase AC power wiring from starter motor to VFD MCC cabinet.
22. Pull and terminate starter motor to VFD control wiring for thermal protection thermostats.
23. Pull and terminate control BNC cables from PLC to VFD (ControlNet).
24. Pull all turbine package to turbine control panel wiring. Includes all necessary conduit installation.
25. Terminate all turbine package to turbine control panel wiring in the control console. Includes all instrument and control interconnect wiring for PLC and fuel module.
26. Terminate balance-of-plant wiring in existing turbine control panel and load management panel.
27. Pull and terminate remaining wiring into turbine control panel (switchgear, MCC, motor power).

28. Start-up and re-commission unit and place back on line, including all necessary package testing. Contractor re-commissioning scope will include:

    a. Check-out and test of all components including PLC
    b. Review of equipment operation with site personnel
    c. Package safety shutdown set point sequence
    d. Package start-up and shutdown sequence
    e. Package back-up relay shutdown sequence

29. Provide as-installed drawings.

1.05 DAILY LOG: The Contractor shall maintain a detailed daily log of the construction and testing operations activity for the duration of the project. The logs shall be maintained in an organized ledger and shall give a detailed description of the daily activity as well as daily starting and stopping points. The logs shall include a record of all down time due to planned and unplanned activity and any other pertinent data as may be required by the Engineer. All Contractor and subContractor activity shall be recorded in a single log for submission to the Engineer. Two copies of the daily log shall be submitted to the Engineer (or Engineer's representative) on a daily basis.

1.06 AS-INSTALLED DRAWINGS: Upon completion of the work, the Contractor shall supply the Engineer with accurate and reproducible as-installed drawings of all electrical and mechanical installations. The drawings shall show conduit sizes, wire sizes, electrical specifications and ratings, installed components, mechanical dimensions and

other information that may be required by the Engineer and regulatory agencies, including deviations from the proposed construction details noted.

1.07 STANDBY TIME: The Owner may order the Contractor to stop operations so that extra work not included in these Specifications, such as testing and additional data collection, can be performed. The Owner and Engineer shall schedule the request so it causes a minimum of delay. The Contractor shall be reimbursed at hourly rates listed in the unit price bid form. All standby time for which extra payment will be made shall be approved by the Engineer in writing in advance.

1.08 GUARANTEE: The Contractor guarantees that the work and service to be performed under the Contract and all workmanship, materials, equipment performed, furnished, used or installed in the work shall be free from defect and flaws, and shall be performed and furnished in strict accordance with the Contract documents; that the strength of all parts of all manufactured equipment shall be adequate and as specified; and that the performance test requirements of the Contract documents shall be fulfilled. The Contractor shall repair, correct or replace all damage to the work resulting from failures covered by the guarantee. The guarantee shall remain in effect for one year from the final date of final acceptance by the Owner.

1.09 PERMITS: The Contractor shall be responsible for securing any permits, licenses, or approvals that must be obtained from City of West Palm Beach, Palm Beach County, the State of Florida, or any other local regulatory entity.

1.10 DEMOBILIZATION: Upon completion of the work, the Contractor shall disassemble all temporary equipment modifications from the site and demobilize. The Contractor shall remove all equipment which is not part of the plant and leave the site in a condition acceptable to the Owner. The Contractor shall broom clean interior surfaces. The Contractor shall utilize videotape record of Site conditions and shall return the Site to original or better condition as defined by the Engineer. The cost for demobilization shall be included in the lump-sum price for mobilization, site preparation and demobilization.

PART 2 – EQUIPMENT SPECIFICATION

2.01 480V SUBSTATION: The Contractor will provide and install a new 480V substation to replace the existing Substation 6A inside the control room. The substation will have these minimum specifications:

1. One (1) 5kV Single Load Interrupter Switch

    a. (Copper-silver Bus) single 60 kV BIL 600 Amps/40kA Mom/40kA Fault closing
    b. NEMA 1 unit
    c. Front and rear access
    d. Full vertical barrier
    e. Horizontal barrier
    f. 60” depth
    g. Bus boots
    h. Ground Bus
2. Single 600A Switch
    a. Cable transition to VPI Dry Type; Standard (XF – HV on left)
    b. Distribution class arrestor
    c. Current limiting fuse
    d. Spare fuses
    e. One (1) cable size 500 kcmil Enter at top w/o loop to NEMA drill only
    f. Spare fuse holder
    g. Run back Bus
3. 500 kVA SST Transformer, Dry (VPI)
    a. Primary 4160V
    b. Secondary 480Y/277V
    c. Copper windings
    d. NEMA 1, 150 deg C rise
4. One (1) Spectra Bolt-on AV1 Swb (108A)
    a. One service entrance with labeling
    b. 3P,4W/480/277V/60Hz; 600A 42kAIC Fully Rated
    c. Type 1 enclosure, front access only
    d. One group mounted feeder section 35W
    e. One Bus bracing 65000 AIC
    f. One tapered copper Bus heat rated
    g. Dry transformer transition at left end; full height side barriers
5. Service Disconnects
    a. One (1) 500A 3 pole SGLA6 (600A Frame)
    b. One padlock provision
    c. One mechanical copper load lugs
6. Other
    a. One fan control power
    b. Lifting brackets
    c. One Spectra Bolt-on (C/B feeders only) 18X
    d. 1 neutral lugs

2.02 TRANSFER SWITCH AND 480V POWER DISTRIBUTION PANEL: The Contractor will provide a suitable transfer switch in accordance with PIP ELSAP20. The switch will transfer supply power source from Substation 6A (normal operation mode) to the 350kW generator (emergency back-up mode). The transfer switch will feed a 480V distribution panel. The distribution panel will provide 480V power to MCC5A and the VFD MCC. The transfer switch will have a manual bypass feature.

2.03 MAIN GAS TURBINE PACKAGE CONTROL SYSTEM: The Contractor will provide a retrofit controls system and load management system suitable for operating the Solar Centaur 40GS (Solar Turbines Turbotronic™ 4 or equivalent) and interfacing with the existing systems as outlined in PART 1. All components will be new and unused, suitable for the intended use. All components will be mounted in existing control cabinet and load management cabinet inside the control room with the exception of package-mounted instrumentation and transmitters. The system will include these minimum requirements**:**

1. All enclosures inside the generator room will be NEMA 4X.
2. Allen Bradley 5561 Control Logix Processor utilizing RSLogix 5000 Windows XP based software, Communicating through ControlNet architecture and related Flex I/O modules. Equivalent PLC systems may be offered for review.
3. PC/Windows XP based graphic display system (Solar Turbines TT4000 or equivalent); English language.
4. Control, protection and monitoring module such as the Basler Electric/Allen-Bradley Combination Generator Control Module (CGCM) or equivalent.
5. Redundant Relay shutdown system.
6. Operator panel including switches and indicator lights for start/stop operation, back-up system, off/local/auto/remote, malfunction alarm, reset and emergency shutdown.
7. Discrete Input/Output end device monitoring.
8. Discrete output control for solenoids.
9. Analog Input/Output monitoring and control of end devices.
10. Replacement load management system (PLC based) and interface with control system PLC.
11. Wiring from package to new console and from new console to balance of plant.
12. Replacement wiring and terminal boards, rails and strips per NEC code.
13. Rosemount smart-type transmitters for lube oil pressure, fuel pressure and PCD.
14. 100 Ohm platinum w/Thermo-wells RTD’s for Turbine air inlet temperature, lube oil temperature, ambient temperature.

15. Over-speed protection.
16. High start flow switch.
17. High speed thermocouple module for engine hot section temperature (TT5) or exhaust temperature (TT7).

The Contractor shall provide the Owner with all applicable source code, documentation, and development tools to allow for non-restricted access to make future modifications and/or upgrades to the turbine control system, load management system or HMI. No areas of the delivered control system logic and associated functions shall have password restrictions applied unless otherwise specified by the Owner as part of an Owner managed access and security system scheme.

2.04 START SYSTEM: Contractor will provide a direct drive AC motor driven start system to replace the existing Titan gas turbine system. Unit 1 and Unit 2 will be replaced under this contract, Unit 3 and Unit 4 will be replaced at a later date. The replacement start system will be new and unused and specifically designed for starting the Solar Turbines Centaur 40 GS gas turbine package. The system will meet the following specifications:

1. AC direct drive, three-phase induction motor with Rockwell Automation Powerflex 700 solid-state variable frequency drive (VFD) specifically designed for starting a gas turbine generating set.
2. Starter motor must mount directly to existing pad on gas turbine package main gearbox (required motor mount and shaft adapters must be provided by Solar Turbines, see Note in Section 1.04, item 16).
3. Location of MCC cabinet provided by Engineer.
4. MCC minimum specifications:
    a. One (1) Main 3-Pole Circuit Breaker (MCB)
        i. 600A rating
        ii. Top mounted, 500A trip; 65k at 480V (HLD Frame)
        iii. Standard type line lugs for copper wire, 250-350 kcmil size wire, 2 cables per phase
    b. Two (2) Feeder 3-Pole Circuit Breaker (FCB)
        i. 150A rating
        ii. Plug-in unit, 100A trip, 65k at 480V (I6C Frame)
        iii. Standard type load lugs for copper/aluminum wire, #14-1/0 AWG size wire, 1 cable per phase
    c. Four (4) Powerflex 700 Variable Frequency AC Drive
        i. 150 HP rating
        ii. Wiring: A – no terminal blocks

iii. Output current rating 180A
iv. HMI interface module: LCD display, full numeric keypad – door mounted control: Transformer with secondary fuse, standard capacity, primary fusing, 120V/60Hz
v. Control wiring: #16 AWG copper, Type MTW
vi. Line reactor
vii. 24VDC control voltage interface with Vector Control

d. Dimensions: 90" height; 20" depth; MCB/FCB section 20" width, VFD sections 25" width

5. VFD must interface with ControlNet architecture to communicate with new package controls system.
6. System must interface with existing relay console and PLC monitoring system (required only if controls upgrade is not performed).
7. System must interface with existing load management panel (required only if controls upgrade is not performed).
8. System must be capable of providing three consecutive full-speed start attempts at 10-minute motor rest periods.
9. Motor and VFD protection circuit breakers are required.
10. Alternative systems will be considered but must have historically demonstrated performance.

2.05 LIQUID FUEL CONTROL MODULE: Contractor will provide and install a fuel system control to replace existing fuel system (servo/hydraulic actuator, mechanical loader and butterfly valve). The new module will be designed specifically for the Centaur 40 GS gas turbine package and will meet the following specifications:

1. All components to be assembled into a single module.
2. Module will utilize an electronically controlled 24VDC fuel control valve.
3. Module will interface with new package controls.
4. Module will include fast action primary fuel shutoff valves and feedback control circuits.
5. Module will incorporate the following components:
    a. Electronic Fuel Valve – PECC (VL)
    b. Primary shutoff valve and control solenoid
    c. Liquid fuel purge drain solenoid
    d. Liquid Fuel pressure transmitter
    e. Liquid Fuel Boost pressure transmitter
    f. PCD Pressure Transmitter
    g. Flame out switch
    h. Air Inlet Temperature RTD

i. Fuel valve check switch
j. Torch Solenoids
k. Torch drain back orifice
l. Torch Check Valve
m. Safety Relief valve
n. Air Assist Solenoid
o. Back Pressure Switch
p. By Pass valve

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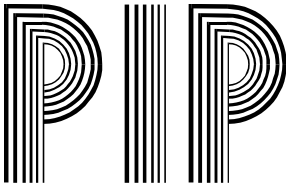

Process Industry Practices
Electrical

PIP ELCGL01
Electrical Design Criteria

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time by the responsible Function Team and will be reviewed every 5 years. This Practice will be revised, reaffirmed, or withdrawn. Information on whether this Practice has been revised may be found at www.pip.org.

PIP will not consider requests for interpretations (inquiries) for this Practice.

Process Industry Practices
Electrical

PIP ELCGL01
Electrical Design Criteria

Table of Contents

1. Introduction

1.1 Purpose

This Practice defines general requirements and the basis for the design of the electrical system for a process industry facility.

1.2 Scope

This Practice is limited to the definition of general design requirements for electrical systems. It shall be used along with other design specifications provided by the owner for the project and shall be used with the referenced documentation to develop the detailed system design.

2. References

Applicable requirements in the latest edition (or the edition indicated) of the following industry standards and Process Industry Practices shall be considered an integral part of this Practice. Revision (or edition) of codes, standards, and specifications in effect at the inception of the project shall apply for the duration of the project. Short titles will be used herein if appropriate.

2.1 Process Industry Practices (PIP)

Note: - Where a company has adopted a PIP Practice with changes, deletions, or additions, such modifications shall take precedence over the base PIP Practice.

- PIP ELEHA01 - *Engineering Procedure for Developing Electrical Area Classifications*
- PIP ELIGD000 - *Grounding Installation Details*
- PIP ELIMT000 - *Motor Installation Details*
- PIP ELIMTN00 - *Motor Installation Details - Nameplate*
- PIP ELIMTS00 - *Motor Installation Details - Stand*
- PIP ELIMTT00 - *Motor Installation Details - Terminal Box*
- PIP ELSAP01 - *Battery Chargers for Station Batteries*
- PIP ELSAP03 - *Design and Fabrication of Online Ferroresonant Uninterruptible Power Supply System*
- PIP ELSAP04 - *Design and Fabrication of Online Pulse Width Modulated Uninterruptible Power Supply System*
- PIP ELSAP11 - *Design and Fabrication of Flooded-Cell Lead-Acid Batteries for Electrical Stations*
- PIP ELSAP12 - *Design and Fabrication of Valve Regulated Lead-Acid Batteries for Station Application*
- PIP ELSAP15 - *Design and Fabrication of Flooded-Cell Lead-Acid Batteries for Uninterruptible Power Supply (UPS) Application*

- PIP ELSAP16 - *Design and Fabrication of Valve Regulated Lead-Acid Batteries for Uninterruptible Power Supply (UPS) Application*
- PIP ELSGS01 - *Design and Fabrication of High Resistance Grounding System (Wye System, 600 Volts or below)*
- PIP ELSGS02 - *Design and Fabrication of High Resistance Grounding System (Delta System, 600 Volts or below)*
- PIP ELSGS03 - *Design and Fabrication of High Resistance Grounding System (Wye System, 2400 Volts)*
- PIP ELSG04 - *Design and Fabrication of High Resistance Grounding System (Delta System, 2400 Volts)*
- PIP ELSGS05 - *Design and Fabrication of High Resistance Grounding System (Wye System, 4160 Volts)*
- PIP ELSGS06 - *Design and Fabrication of High Resistance Grounding System (Delta System, 4160 Volts)*
- PIP ELSGS11 - *Design and Fabrication of Low Resistance Neutral Grounding Resistor 2.4 to 15kV*
- PIP ELSMC12 - *Low-Voltage Fused Switch Motor Control Centers*
- PIP ELSMC13 - *Low-Voltage Circuit Breaker Motor Control Centers*
- PIP ELSMC20 - *Specification for Procurement of Low-Voltage AC Adjustable Speed Drive*
- PIP ELSMC21 - *Medium-Voltage AC Adjustable Speed Drives*
- PIP ELSMT01 - *AC Squirrel Cage Induction Motors (200 HP and below up to 600 Volts)*
- PIP ELSMT02 - *General Purpose Application of API 541 "Form-Wound Squirrel-Cage Induction Motors 250 Horsepower and Larger"*
- PIP ELSMT03 - *Special Purpose Application of API 541 "Form-Wound Squirrel-Cage Induction Motors 250 Horsepower and Larger*"
- PIP ELSMT04 - *AC Synchronous Motors with Brushless Excitation Systems*
- PIP ELSPS01 - *Electrical Requirements for Packaged Equipment*
- PIP ELSSG01 - *Design and Fabrication of Low-Voltage Metal Enclosed AC Power Circuit Breaker Switchgear*
- PIP ELSSG02 - *Medium-Voltage Metal-Clad Switchgear from 2.4 kV to 34.5 kV*
- PIP ELSSG03 - *Design and Fabrication of Medium-Voltage Metal-Enclosed Interrupter Switchgear with Air Break Switches*
- PIP ELSSG11 - *Design and Fabrication of Electrical Power Center*
- PIP ELSSG12 - *Design and Fabrication of Outdoor Enclosures for Motor Controllers and Switchgear*
- PIP ELSTR01 - *Design and Manufacture of Liquid-Immersed Power Transformers of 500 kVA through 10,000 kVA up to 34.5 kV High-Voltage Winding*

- PIP ELSTR03 - *Design and Fabrication of Ventilated Dry-Type Power Transformers of 500 kVA through 5,000 kVA to 34.5 kV High-Voltage Winding*
- PIP ELSTR04 - *Design and Fabrication of Cast-Resin Dry-Type Outdoor Power Transformers of 500 kVA through 5,000 kVA to 34.5 kV High-Voltage Winding*
- PIP ELSWC01 - *Medium-Voltage Cable - XLPE*
- PIP ELSWC02 - *Medium-Voltage Power Cable - EPR*
- PIP ELSWC03 - *600-Volt Power and Control Cable*
- PIP ELSWC05 - *300-Volt Instrumentation Tray Cable*
- PIP ELTFT01 - *Electrical Field Inspection and Testing of New Electrical Equipment*
- PIP PCCEL001 - *Instrumentation Electrical Requirements*

2.2 Industry Codes and Standards

- American National Standards Institute (ANSI)
  - ANSI C2 - *National Electrical Safety Code (NESC)*
- American Petroleum Institute (API)
  - API RP500 - *Recommended Practice for Classification of Locations for Electrical Installations as Class I, Division 1 and Division 2*
  - API RP505 - *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2*
  - API RP540 - *Electrical Installations in Petroleum Processing Plants*
  - API RP2003 - *Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents*
- American Society for Testing and Materials (ASTM)
  - ASTM C94 - *Standard Specification for Ready-Mixed Concrete*
- Institute of Electrical and Electronic Engineers (IEEE)
  - IEEE 80 - *IEEE Guide for Safety in AC Substation Grounding*
  - IEEE 141 - *Recommended Practice for Electrical Power Distribution in Industrial Plants (IEEE Red Book)*
  - IEEE 515 - *IEEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications*
  - IEEE 519 - *Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*
  - IEEE 979 - *IEEE Guide for Substation Fire Protection*
  - IEEE 980 - *IEEE Guide for Containment and Control of Oil Spills in Substations*

- National Electrical Manufacturers Association (NEMA)
  - NEMA VE1 - *Cable Tray Systems*
- National Fire Prevention Association (NFPA)
  - NFPA 70 - *National Electrical Code (NEC)*
  - NFPA 70E - *Standard for Electrical Safety Requirements for Employee Workplaces*
  - NFPA 77 - *Recommended Practice on Static Electricity*
  - NFPA 496 - *Purged and Pressurized Enclosures for Electrical Equipment in Hazardous (Classified) Locations for Electrical Installations*
  - NFPA 497 - *Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installation in Chemical Process Areas*
  - NFPA 499 - *Classification of Combustible Dust and of Hazardous (Classified) Locations for Electrical Installation in Chemical Process Areas*
  - NFPA 780 - *Standard for the Installation of Lightning Protection Systems*

3. System Design Criteria

3.1 General

The complete electrical system shall be designed to enhance personnel safety and to minimize environmental exposure of the electrical equipment. In addition, the electrical systems shall be designed for lowest life cycle cost, continuous and reliable service, equipment protection, ease of maintenance and operation, mechanical protection of equipment, interchangeability of equipment, and the addition of future loads. Equipment listed or labeled by a nationally recognized testing laboratory (NRTL) shall be used when available.

3.2 Electrical Code Compliance

All electrical systems and installations shall conform to the *NFPA 70 (NEC), NFPA 70E,* and *NESC* as applicable and to any other applicable codes that are listed on the **Data Sheet**.

3.3 System Protection and Coordination

3.3.1 Incident energy for three-phase arcing faults shall be calculated for all new electrical facilities per *NFPA 70E*. Other electrical system studies shall be provided when required on the **Data Sheet**. Software program(s) as specified on the **Data Sheet** shall be used for any required studies. Any files and libraries created in such studies shall be provided to the owner. Such files include paper files, electronic files, and native files required to run system studies.

3.3.2 System protective devices (relays, fuses, etc.) shall be selected and coordinated to ensure that the upstream-interrupting device nearest the point of fault (or overload) will open first and minimize system disturbance.

3.4 Utility Interface Parameters

Utility interface parameters shall be as specified on the **Data Sheet**.

3.5 System Parameters

System voltage levels, motor hp range for each voltage level, and system grounding methods shall be as specified on the **Data Sheet**. System voltages shall be within the tolerances as set forth in *IEEE 141-1993*, Chapter 3, unless modified otherwise as shown below in Section 3.6.

3.6 Steady State Voltage

3.6.1 Voltage drop from the substation bus to the loads supplied from the substation shall not exceed 5%, typically split as 2% feeder and 3% branch circuit.

3.6.2 Transformer secondary side no-load voltage shall rise no more than 8% above the nominal system voltage at the transformer secondary terminals.

3.7 Motor-Starting Voltage Drop

3.7.1 Motor-starting conditions shall be evaluated based on system and process conditions that result in the minimum motor acceleration torque.

3.7.2 Acceleration studies shall be made for motors 250 hp and larger, unless otherwise specified on the **Data Sheet**. Acceleration studies shall assure adequate motor acceleration torque and acceptable system voltage drops for defined system configurations and defined process conditions. Refer to *PIP ELSMT03*.

3.7.3 For motors of ≤600-volt rating, the system shall be designed to provide, as a minimum, 90% nominal system voltage at the substation bus during starting unless specified otherwise on the **Data Sheet**.

3.7.4 For motors of ≤600-volt rating, the system shall be designed to provide, as a minimum, 85% of nominal motor-rated terminal voltage at the motor terminals during starting.

3.7.5 For motors of ≤600-volt rating that cannot be started across the line, electronic soft starters shall be used unless specified otherwise on the **Data Sheet**.

3.7.6 For motors of >600-volt rating, the system shall be designed to provide, as a minimum, 85% nominal system voltage at the substation bus during starting unless specified otherwise on the **Data Sheet**.

3.7.7 For motors of >600-volt rating, the system shall be designed to provide, as a minimum, 80% of system nominal voltage at the motor terminals during starting unless specified otherwise on the **Data Sheet**.

3.7.8 For motors of >600-volt rating that cannot be started across the line because of system voltage drop requirements, a captive transformer shall be used unless specified otherwise on the **Data Sheet**.

3.8 Design Allowance

3.8.1 New electrical systems shall be designed with a minimum spare capacity as specified on the **Data Sheet**. Design allowances beyond the minimum requirements of the *NEC* shall be applied in sizing feeder circuits, transformers, switchgear buses, and motor control center (MCC) buses to allow for future load growth.

3.8.2 Spare devices as specified on the **Data Sheet** shall be included with the following equipment:

a. medium-voltage (MV) switchgear, motor starters, and switch lineups

b. low-voltage (LV) switchgear

c. LV MCC branch breakers, fused switches, and starters

3.8.3 Equipped and unequipped spaces as specified on the **Data Sheet** shall be included in the following equipment:

a. MV switchgear and motor starters

b. LV switchgear

3.8.4 Future unit spaces as specified on the **Data Sheet** shall be included in LV MCCs.

3.8.5 Adequate space shall be provided to accommodate electrical equipment to effectively use the capacity of the system.

3.8.6 Equipped spaces shall be furnished with all hardware, wiring, doors, and miscellaneous equipment, including current transformers and monitoring devices required to permit completion of the unit by the addition of only a circuit breaker or medium-voltage starter. Equipped spaces shall be capable of being safely placed in service without shutdown of switchgear or motor control center lineup. Unequipped spaces shall be provided with doors but with no other equipment for future use except the power stabs. Unequipped spaces shall not be used for mounting control switches and other auxiliary equipment. Power stabs (both line and load side) shall be provided with covers to prevent accidental contact with live parts when door is opened. For MCCs, future unit spaces shall be provided with bus and a blank door.

3.9 Power Factor

Power factor shall be corrected as specified on the **Data Sheet**.

3.10 Harmonics

Power systems that include electronic switching devices shall be designed so that the total harmonic distortion meets the requirements of *IEEE 519*.

3.11 Electrical Equipment Rooms

3.11.1 Electrical equipment rooms or walk-in enclosures shall have a minimum of two doors at opposite ends of the room unless specified otherwise on the **Data Sheet**.

3.11.2 Doors shall be equipped with panic hardware and shall be self closing.

3.11.3 When specified on the **Data Sheet**, doors shall be lockable and equipped with "night latch action (self locking)."

4. Electrical Area Classification

4.1 Electrical area classification shall be defined using *PIP ELEHA01* unless specified otherwise on the **Data Sheet**. *PIP ELEHA01* must be used in conjunction with other standards that define the basis for area classification, such as *NFPA 497*, *NFPA 499*, *API RP500*, and *API RP505*.

4.2 See **Data Sheet** for the classification method to be used.

4.3 Area classification drawings shall be submitted to the owner for review and approval. Drawings shall be approved by the owner before purchase of electrical equipment.

4.4 In general, all buildings containing only electrical equipment, such as electric rooms and control rooms, shall be located in unclassified areas. With specific written approval by the owner for each application, air pressurization may be used to maintain the interior of a building as an unclassified area. These applications shall be designed in accordance with *NFPA 496*.

5. Power Distribution

5.1 System Configuration

The plant distribution system configuration shall be as specified on the **Data Sheet**.

5.2 Utility Interface and Unit Substations

5.2.1 Unit substations shall be centrally located in the area where the loads to be served are situated.

5.2.2 Unit substations shall be located in unclassified areas.

5.2.3 Utility interface and unit substations shall be designed as specified on the **Data Sheet**. When specified on the **Data Sheet**, HVAC and pressurization systems shall be provided.

5.2.4 Unless specified otherwise on the **Data Sheet**, single-ended unit substations shall be designed for expansion in at least one direction. In this case, floor space shall be reserved for the addition of one or more vertical sections as specified on the **Data Sheet**.

5.2.5 If specified on the **Data Sheet**, design of single-ended substations shall allow for future conversion to double-ended (secondary selective) substations.

5.2.6 If specified on the **Data Sheet**, design of double-ended substations shall allow for future expansion.

5.3 Transformers

5.3.1 The system power transformers shall be selected as specified on the **Data Sheet**.

5.3.2 Transformers shall be sized according to the designed operating load on the substation. Liquid-filled transformers shall be sized based on their 65°C rating, unless otherwise specified on the **Data Sheet**. Dry type transformers shall be sized based on their 80°C rating. If the forced-cooled rating will be required for future load growth, provisions shall be made for the future addition of fans.

5.3.3 For double-ended substations (or similar arrangements having more than one transformer serving interconnected buses), in which one transformer is out of service, the remaining transformer(s) shall have sufficient capacity at the highest temperature rise FA rating to serve the maximum designed operating load on the substation.

5.3.4 Liquid-filled transformers shall be filled with mineral-based dielectric oil unless specified otherwise on the **Data Sheet**.

5.3.5 System power transformers shall be located outdoors unless indicated otherwise on the **Data Sheet**. Outdoor transformers shall be specified per *PIP ELSTR01* unless specified otherwise on the **Data Sheet**. Indoor transformers shall be specified per *PIP ELSTR03* unless specified otherwise on the **Data Sheet**.

5.3.6 Unless specified otherwise on the **Data Sheet**, control power and lighting transformers shall be indoor, 80°C rise with 220°C insulation.

5.3.7 If specified on the **Data Sheet**, outdoor control power and lighting transformers shall be epoxy-encapsulated.

5.3.8 Fire protection for mineral-oil-filled transformers shall conform to the requirements of *IEEE 979-1994*, Sections 1, 3, and 4. Containment and spill control for mineral-oil-filled transformers shall conform to the requirements of *IEEE 980-1994*, Sections 1, 2, 3, 4, 5.4, 6, 7, 8.2.2.2, 8.3, and 8.4.

5.4 Metering, Monitoring, and Relaying

5.4.1 Metering shall incorporate microprocessor-based multifunction devices unless specified otherwise on the **Data Sheet**.

5.4.2 When specified on the **Data Sheet**, metering and protective devices shall have digital communication capabilities.

5.4.3 Protective relaying shall incorporate microprocessor-based multifunction devices unless specified otherwise on the **Data Sheet**.

5.5 Switchgear

5.5.1 Low-voltage switchgear shall be metal-enclosed drawout type as specified in *PIP ELSSG01* unless specified otherwise on the **Data Sheet**.

5.5.2 Medium-voltage switchgear shall be metal-clad drawout type as specified in *PIP ELSSG02* unless specified otherwise on the **Data Sheet**.

5.5.3 Switchgear-tripping voltages shall be 125-volt battery-supported DC unless specified otherwise on the **Data Sheet**.

5.6 Switchgear and Substation Batteries

Switchgear and substation batteries shall be lead-acid flooded-cell type as specified in *PIP ELSAP11* unless otherwise specified on the **Data Sheet**.

5.7 Switchgear Buildings and Enclosures

Switchgear shall be housed in prefabricated buildings such as those specified in *PIP ELSSG11* or in outdoor enclosures such as those specified in *PIP ELSSG12* or in built-in-place buildings as specified on the **Data Sheet**.

6. Motors

6.1 AC motors shall be specified in accordance with the appropriate PIP specification and with the horsepower requirements and system supply voltages specified on the **Data Sheet** entry identified in Section 3.5 of this Practice. Refer to *PIP ELSMT01*, *PIP ELSMT02*, *PIP ELSMT03*, and *PIP ELSMT04*.

6.2 Motors shall be installed as specified in *PIP ELIMT000, PIP ELIMTN00, PIP ELIMS00,* and *PIP ELIMTT00* installation details unless specified otherwise on the **Data Sheet**.

7. Motor Control

7.1 Single-Phase Motor Control

Controllers for single-phase motors should be manual motor starters with overload protection, located near the motors. Manual starters shall be used only if the motor can restart automatically after a power failure without creating a safety problem. Short-circuit protection shall be in accordance with the *NEC*. Local magnetic starters may be provided if required for the application.

7.2 480-Volt Motor Control

7.2.1 MCCs shall be specified per *PIP ELSMC12*, *PIP ELSMC13*, or other, as indicated on the **Data Sheet**.

7.2.2 MCCs shall be centrally located where possible and practical. They shall not be located in classified areas, nor where they may be exposed to corrosive chemicals, dust, or water, nor where they would be subject to damage by moving equipment. The preferred location is within an environmentally controlled, separate electrical equipment room. MCCs located indoors shall be NEMA 1 gasketed unless specified otherwise on the **Data Sheet**.

7.2.3 If an MCC must be located in a building or room within a Class I, Division 2 area, the building or room shall be purged and/or pressurized per *NFPA 496* to allow the use of general purpose equipment.

7.2.4 Where MCCs must be located outdoors in non-classified areas, they shall be supplied with NEMA 3R enclosures unless specified otherwise on the **Data Sheet**.

7.2.5 MCCs shall be supplied in front-only or back-to-back configurations as specified on the **Data Sheet**.

7.2.6 Floor space shall be allocated for 20% potential MCC growth, unless otherwise indicated on the **Data Sheet**.

7.2.7 Where groups of individual motor starters are located outdoors, they shall be mounted on switchracks.

7.2.8 Individual motor starters located outdoors in non-classified areas shall be supplied with NEMA 4X enclosures unless specified otherwise on the **Data Sheet**.

7.2.9 Motor starters located in classified areas shall have explosion-proof enclosures. Enclosures shall be bolted type unless otherwise specified on the **Data Sheet**. Explosion-proof starters shall be applied within the short-circuit rating of the starter assembly as listed by an NRTL.

7.2.10 The methodology of interfacing between the MCC and the control system is outside the scope of this document and shall be specified separately.

7.2.11 The minimum starter size shall be NEMA Size 1 unless specified otherwise on the **Data Sheet**.

7.2.12 Motors shall be protected by ambient-compensated, bi-metallic NEMA Class 20 motor overloads unless specified otherwise on **Data Sheet**.

7.3 Low-Voltage Adjustable Speed Drives

Low-voltage adjustable speed drives shall be as specified in *PIP ELSMC20* unless specified otherwise on the **Data Sheet**. Adjustable speed drives, motors, and associated equipment shall be designed as a coordinated system and according to manufacturer recommendations.

7.4 Medium-Voltage Motor Control

7.4.1 For 2.3-kV and 4-kV motors, refer to the **Data Sheet** for the horsepower range where circuit breakers are to be used as motor starters.

7.4.2 Where contactors are used as motor starters, they shall be Class E2 fused contactors. Contactors shall be drawout (roll out), unless specified otherwise on the **Data Sheet**. A separate isolation switch shall be provided.

7.4.3 Medium-voltage motors greater than 7.2 kV shall be controlled using 15-kV class or higher switchgear.

7.4.4 Medium-voltage motor starters shall be specified according to *PIP ELSMC11* unless specified otherwise on the **Data Sheet**.

7.4.5 Where medium-voltage adjustable speed drives are required, they shall be specified as in *PIP ELSMC21* unless specified otherwise on the **Data Sheet**.

7.4.6 A microprocessor-based motor protective relay of the type specified on the **Data Sheet** shall be provided for motor and motor circuit protection.

7.4.7 Differential protection shall be provided for medium-voltage motors ≥1500 hp unless specified otherwise on the **Data Sheet**.

8. Grounding

8.1 Substation

A ground grid or loop shall be provided and shall be designed in accordance with *IEEE 80* and the *NEC*. Grid conductors shall be bare or covered stranded copper as specified on the **Data Sheet** and sized to accommodate the worst case fault condition. If a substation fence is provided, the grid shall include a perimeter loop located 3 feet outside the fence and bonded to the fence and gates.

8.2 System Grounding

8.2.1 Electrical systems shall be grounded and bonded in accordance with Article 250 of the *NEC*. System grounding shall be as specified on the **Data Sheet** (see Section 3.5 of this Practice).

8.2.2 480-volt systems shall be wye-connected, high-resistance grounded using equipment specified in *PIP ELSGS01* unless specified otherwise on the **Data Sheet**. Alarms from high-resistance grounding systems shall be connected to plant monitoring system.

8.2.3 Medium-voltage motor control buses shall be low-resistance grounded using transformer neutral grounding resistors as specified in *PIP ELSGS11* unless specified otherwise on the **Data Sheet**.

8.2.4 Medium-voltage distribution systems that are derived from owner-supplied transformers shall be low-resistance grounded using transformer neutral grounding resistors as specified in *PIP ELSGS11* unless specified otherwise on the **Data Sheet**.

8.3 Equipment Grounding

8.3.1 The path to ground from circuits, equipment, and enclosures shall be permanent and continuous; shall have ample capacity to conduct any ground fault current likely to be imposed on it; and shall be of low impedance. The equipment-grounding conductors shall be of the types permitted in Article 250 of the *NEC* and as specified on the **Data Sheet**. They shall be connected to the grounding electrode at the service-supplied or separately derived system. Ground fault current path continuity must be maintained in circuits passing through non-metallic enclosures or raceways.

8.3.2 When specified on the **Data Sheet** or for motors rated 2300 volts and higher, motors shall also be bonded to one of the following:

a. adjacent building or structure steel

b. reinforcing mesh or bars in the concrete foundation

c. adequately sized bare, tin-coated or green-colored, covered copper conductor around the equipment foundation and connected to at least two ground rods or the ground grid

8.3.3 If specified on the **Data Sheet** all 460-volt motors shall also be bonded by one of the methods mentioned in the section above.

8.3.4 When conditions require the use of cathodic protection, grounding systems may require different designs.

8.4 Plant Grounding System

8.4.1 The grounding system shall be as specified on the **Data Sheet**.

8.4.2 Where a ground loop system is specified on the **Data Sheet**, taps from the ground loop to all major equipment and structural steel shall be provided.

8.4.3 For facilities outside of plant ground grid, a grounding system shall be provided. Connection of the remote grounding system to the plant grounding system is recommended.

8.4.4 The plant grounding system impedance to earth shall not exceed 5 ohms. Results shall be obtained by methods identified in *PIP ELTFT01*.

8.4.5 Connections to the grounding system and the minimum depth of the buried grounding system shall be as shown on the **Data Sheet** or as detailed in *PIP ELIGD000*.

8.4.6 Instrument grounding shall be installed according to *PIP PCCEL001*.

8.4.7 Where bare underground cables are connected to cathodically protected systems, the cathodic protection current flow to the cable can be significantly reduced by use of tin-coated copper cable. If specified on the **Data Sheet**, tinned copper cable shall be installed.

8.5 Static Electricity Grounding

8.5.1 Static grounding is not required if the impedance between units of equipment is less than 1.0 megohm.

8.5.2 Tank trucks, tank cars, portable drums, marine craft, storage tanks, vessels, agitators, etc., shall be protected against static electricity, lightning, and stray currents. Refer to *API RP2003, NFPA 77,* and *NFPA 780* for details.

9. Lighting

9.1 Illumination Levels

Illumination levels shall be in accordance with Table 3 of *API RP540* unless specified otherwise on the **Data Sheet**.

9.2 Luminaires and Circuits

9.2.1 Luminaire type and voltage rating for each area of the facility shall be as specified on the **Data Sheet**.

9.2.2 Outdoor lighting shall be controlled automatically. Photocell control, provided with time delay and other protection to negate the effect of lightning, is preferred. The method of photocell control shall be as specified on the **Data Sheet**. In areas where plant flares, clouds of dust, and similar conditions exist, an astronomical clock should be used. The astronomical clock shall be specified on the **Data Sheet**, when required.

9.2.3 Standby lighting shall provide minimal egress lighting in operating areas in the event of a power failure. These luminaires shall be circuited and run separately from general lighting. The type of standby lighting shall be as specified on the **Data Sheet**.

9.2.4 Battery-powered stand-by lights shall be provided in the control room, substation buildings, and other locations as specified on the **Data Sheet**. Exit signs need to be illuminated during the loss of normal lighting.

9.2.5 The loss of a luminaire or lighting circuit shall not leave any area in darkness.

10. Power Receptacles and Convenience Outlets

10.1 120-Volt Receptacles

10.1.1 The 120-volt receptacles shall be located in process units so that equipment at grade can be reached with extension cords not longer than 50 feet unless specified otherwise on the **Data Sheet**.

10.1.2 All receptacles located in washdown areas or in other areas having wet atmospheric conditions shall be equipped with weatherproof covers and boxes.

10.1.3 All 120-volt receptacles located in non-classified areas shall be NEMA 5-20R unless specified otherwise on the **Data Sheet**.

10.1.4 Ground-fault circuit-interrupter (GFCI) protected receptacles shall be provided where required by the *NEC* and where specified on the **Data Sheet**.

10.2 480-Volt Receptacles

10.2.1 All 480-volt receptacles shall be three-wire, four-pole, and three-phase and shall be installed in convenient locations within 150 feet of areas in which 480-volt power to portable equipment is required. The 480-volt receptacles shall be 60A unless specified otherwise on the **Data Sheet**.

10.2.2 All four-pole receptacles shall be of the same size and rating.

10.2.3 A maximum of four (4) receptacles shall be connected to one feeder. Feeder cable sizes shall be based on a demand factor of 0.5.

10.2.4 480-volt receptacles shall match the plug type indicated on the **Data Sheet**.

10.3 Specialty Receptacles

Receptacles for use at voltages other than nominal 120 or 480 volts shall be selected according the application.

11. Wiring Methods

11.1 Cable Tray

11.1.1 Cable tray shall be heavy-duty-rated NEMA 20C and NRTL-listed and shall be labeled as an equipment-grounding conductor unless specified otherwise on the **Data Sheet**. The cable tray shall be secured with clips at every support. The tray shall be sized for a minimum of 20% spare after completion of project unless specified otherwise on the **Data Sheet**. Unless specified otherwise on the **Data Sheet**, the tray shall be of the ladder type with 9-inch rung spacing suitable for indoor or outdoor installations. The cable tray shall have a minimum load safety factor of 1.5 based on the load capacity as defined in *NEMA VE1*. The tray shall also be capable of a 200-pound static load located at mid-span. All bolts, nuts, and washers for metallic trays shall be stainless steel. All bolts, nuts, and washers for use with fiberglass tray systems shall be fiberglass.

11.1.2 Expansion joints shall be provided as required by *NEMA VE1*, Table 6-1, for long, straight tray runs.

11.1.3 Cable tray shall be installed to allow a minimum of 12 inches of access above the top of each tray.

11.1.4 Installation of cables in cable trays shall be in accordance with the *NEC*.

11.1.5 Cable tray systems shall be installed above or to the side of process lines where possible and at least 12 inches from steam lines.

11.1.6 Cable trays shall not have covers unless specified otherwise on the **Data Sheet**.

11.1.7 Separate trays shall be provided for each voltage class of cables unless specified otherwise on the **Data Sheet**.

11.2 Aboveground Conduit and Fittings

11.2.1 Acceptable sizes, material, and construction of conduit systems shall be as identified on the **Data Sheet**.

11.2.2 When specified on the **Data Sheet**, electrical metallic tubing (EMT) may be used in indoor unclassified locations where the EMT will not be subject to vibration, corrosion, or physical damage (e.g., office buildings, administration buildings, guardhouses, change houses, etc.).

11.2.3 Flexible conduit shall be liquid-tight and suitable for the area classification in which it is installed. Flexible conduit shall be used to connect vibrating equipment to the conduit system. Flexible conduit shall be no more than 3 feet in length.

11.2.4 All conduit connections to cabinets and junction boxes located outdoors or in washdown areas shall be made with factory hubs or weather-tight rigid conduit hubs.

11.2.5 Conduits shall not enter the top of cabinets or junction boxes located outdoors or in washdown areas. Bottom entry of cabinets or junction boxes is preferred.

11.2.6 Conduit drains shall be installed at the low point in all conduit systems entering electrical enclosures installed outdoors. Drainage provision shall be made in the bottom of all pull boxes, junction boxes, control panels, etc.

11.2.7 Where long conduit runs are installed, a method of support shall be used that allows for expansion and contraction. Expansion fittings, with bonding jumpers around the fittings, shall be installed as required.

11.2.8 On fireproofed structures, the design shall permit conduit supports to be installed before fireproofing and in such a manner that the conduit does not become imbedded in fireproofing materials.

11.2.9 Conduit used in corrosive areas shall be as specified on the **Data Sheet**. Any conduit coatings shall be applied both on the outside and the inside.

11.3 Underground Conduit and Duct Banks

11.3.1 Underground conduit materials shall be as specified on the **Data Sheet**.

11.3.2 Stub-ups shall be made using rigid galvanized steel conduit elbows and galvanized fittings as required and shall include an insulated bushing on any exposed end of the conduit.

11.3.3 Minimum size of underground conduit shall be 1 inch. Acceptable sizes shall be as identified on the **Data Sheet**.

11.3.4 All conduit runs installed below grade (except in floor slabs) shall be encased in a minimum of 3 inches of concrete on all sides. Concrete shall be 3000 psi with a slump of 5 inches and shall conform to *ASTM C94*. The concrete shall be either colored throughout or colored at the top of the encasement. The coloring shall be a shade of red. Reinforced concrete shall be used for all underground conduits.

11.3.5 The minimum spacing between conduits in underground duct banks shall be 1-1/2 inches.

11.3.6 The minimum depth of concrete encasement for all underground conduits shall be as specified on the **Data Sheet**. This depth shall be measured from grade to the top of the top conduit.

11.3.7 All horizontal bends in underground conduits shall be made using long radius sweeps.

11.3.8 When duct banks pass through manholes, the duct banks shall slope downward toward the manholes at a minimum slope of 3 inches per 100 feet.

11.3.9 Unless indicated otherwise on the **Data Sheet**, a minimum 20% (or not less than one) spare conduit(s) shall be installed in all underground duct banks.

This does not apply to single or double conduit duct banks for street lighting or to individual, remotely located equipment.

11.4 Direct Burial

Installation of direct burial cable shall be as specified on the **Data Sheet**.

11.5 Overhead Pole Lines

Installation of overhead pole lines shall be as specified on the **Data Sheet**.

11.6 Messenger Cable

Installation of messenger-supported cable shall be as specified on the **Data Sheet**.

12. Power and Control Wiring

12.1 Multiconductor cable shall be specified according to *PIP ELSWC01*, *PIP ELSWC02*, and *PIP ELSWC03*.

12.2 Grounding conductor(s), sized in accordance with Article 250 of the *NEC* shall be included in all multiconductor power cables.

12.3 All power/control wiring shall have copper conductors and construction as identified on the **Data Sheet**.

12.4 The minimum conductor size for power wiring shall be No. 12 AWG, with the exception of conductors for individual luminaire drops, which may be No. 14 AWG.

12.5 The minimum conductor size for control in multiconductor cables shall be No. 14 AWG unless specified otherwise on the **Data Sheet**.

12.6 Use of composite power and control cable shall be as permitted by the **Data Sheet**.

12.7 Cables shall not enter the tops of cabinets or junction boxes located outdoors or in washdown areas. Bottom entry of cabinets or junction boxes is preferred.

12.8 Power cable termination methods shall be as specified on the **Data Sheet**.

12.9 Full ring compression lugs shall be used for power wiring where available. Indent type lugs shall be used for power wiring where full ring compression lugs are not available.

13. Instrumentation

Instrument tray cable shall be specified in accordance with *PIP ELSWC05*. The 600-volt tray cable used for instrumentation shall be specified in accordance with *PIP ELSWC03*. All other instrumentation design requirements shall be specified in accordance with *PIP PCCEL001*.

14. Freeze Protection and Process Heat-Tracing Systems

14.1 Freeze protection and process heat-tracing systems shall be designed in accordance with *IEEE 515* and *NFPA 70-2002 (NEC)*, Article 427.

14.2 Heat-tracing system components shall be supplied as specified on the **Data Sheet**.

14.3 The heat-tracing systems include power transformers, electric heat trace control panels, electric heat cables, temperature sensors, temperature controllers, circuit breakers, enclosures, conduit, wire, insulation, and all necessary auxiliary equipment and controls.

14.4 Electric heat-tracing control panels, power transformers, and power distribution equipment shall be centrally located to minimize the lengths of heating power circuits in the area.

14.5 All tracing design shall utilize a minimum of 25% safety factor in calculated heat input. Heat loss calculation shall be submitted to verify compliance.

14.6 Installation of the heating cable, components, and controls shall begin after pressure testing of the pipeline and installation of all the instruments. Thermal insulation shall not be installed until the electrical installation and testing is complete.

14.7 Heat tracing for pipes shall include all inline components. All flanges, pumps, valves, devices, supports, and appurtenances shall be traced with appropriate additional lengths of heater cable as required to allow equipment removal without disconnecting and removing the heat tracing.

14.8 Heater cable design shall be suitable to deliver rated performance and service life when subjected to voltage variations from 90% to 110% of nominal distribution voltages.

14.9 Components of the electric heat-tracing systems shall be approved for the area classification in which they are installed.

14.10 Heating requirements and sectionalizing shall be coordinated with process requirements.

14.11 Each heat-tracing circuit shall be equipped with a suitable device for isolation and installation of a lockout device.

15. Cathodic Protection

Cathodic protection, when required, will be specified separately.

16. Uninterruptible/Standby Power Supply

16.1 Critical power supply systems shall be designed as shown on the **Data Sheet**.

16.2 When specified on the **Data Sheet**, an uninterruptible power supply (UPS) shall be provided and sized to accommodate the process control loads plus 20% spare capacity. The UPS shall have its own dedicated battery and distribution panel. A separate detailed specification shall be issued for the UPS system if required. When specifying a UPS system, refer to *PIP ELSAP03* and *PIP ELSAP04*. The UPS battery type shall be flooded cell as specified in *PIP ELSAP15* unless specified otherwise on the **Data Sheet**.

16.3 When specified on the **Data Sheet**, standby power shall be provided by an alternate utility/plant feeder or a turbine-driven or diesel generator. Transfer switches shall be provided for critical loads not requiring uninterruptible power.

17. Electrical Requirements for Skid-Mounted or Packaged Systems

Unless specified otherwise on the **Data Sheet**, electrical requirements for skid-mounted or packaged systems shall be as specified by *PIP ELSPS01*.

18. Lightning Protection

18.1 Tall or isolated structures and the high-voltage switchyard shall be protected against lightning in accordance with *NFPA 780*.

18.2 Down conductors from air terminals or lightning mast shall be connected to individual ground rod as well as to the plant grounding system.

COMPLETE REVISION
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Process Industry Practices
Electrical

PIP ELSSG01
Design and Fabrication of Low-Voltage Metal-Enclosed AC Power Circuit Breaker Switchgear

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time by the responsible Function Team and will be reviewed every 5 years. This Practice will be revised, reaffirmed, or withdrawn. Information on whether this Practice has been revised may be found at www.pip.org.

PIP will not consider requests for interpretations (inquiries) for this Practice.

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Process Industry Practices
Electrical

PIP ELSSG01
Design and Fabrication of Low-Voltage Metal-Enclosed AC Power Circuit Breaker Switchgear

Table of Contents

1. Introduction

1.1 Purpose

This Practice provides requirements for design, fabrication, and testing of metal-enclosed, low-voltage AC power circuit breaker switchgear assemblies.

1.2 Scope

This Practice describes the requirements for metal-enclosed power switchgear assemblies employed in three-phase AC electrical systems having a voltage not higher than 1000 volts and located in a nonclassified area.

2. References

Applicable parts of the following Practices and industry codes and standards shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles will be used herein where appropriate.

2.1 Process Industry Practices (PIP)

- PIP ELSBD01 - *Design and Fabrication of Metal-Enclosed Nonsegregated-Phase Bus Duct Assemblies*
- PIP ELSBD01D - *Data Sheet for Design and Fabrication of Metal-Enclosed Nonsegregated-Phase Bus Duct Assemblies*
- PIP ELSGS01 - *Design and Fabrication of High-Resistance Grounding System (600 Volts or below)*
- PIP ELSGS01D - *Data Sheet for Design and Fabrication of High-Resistance Grounding System (600 Volts or below)*
- PIP ELSSG01D - *Data Sheet for Design and Fabrication of Low-Voltage Metal-Enclosed AC Power Circuit Breaker Switchgear*

2.2 Industry Codes and Standards

- American National Standards Institute, Inc. (ANSI)
  - ANSI C37.50 - *Switchgear - Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures*
- Institute of Electrical and Electronic Engineers (IEEE)
  - IEEE C37.13 - *Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures*
  - IEEE C 37.20.1 - *Standard for Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear*

- National Electrical Manufacturers Association (NEMA)
  - NEMA C37.16 - *Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors–Preferred Ratings, Related Requirements, and Application Recommendations*
  - NEMA C37.17 - *Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers*
- Underwriters Laboratories (UL)
  - UL 1558 - *Standard for Safety Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear*

3. Definitions

purchaser: The party who awards the contract to the supplier. The purchaser may be the owner or the owner's authorized agent.

supplier: The party responsible for furnishing the low-voltage metal-enclosed AC power circuit breaker switchgear

4. Requirements

4.1 Switchgear Assembly

4.1.1 The switchgear assembly shall consist of metal-enclosed freestanding vertical steel structures containing power buses, a ground bus, low-voltage power circuit breakers, and auxiliary control devices in accordance with the attached purchaser's *PIP ELSSG01D* Data Sheet and one-line diagram(s).

4.1.2 The switchgear shall be designed such that the breakers can be tripped and closed and the breaker position can be viewed with the doors closed.

4.1.3 If specified on the purchaser's *PIP ELSSG01D* Data Sheet, red and green indicating lights shall be provided to indicate breaker closed and open positions, respectively.

4.1.4 All enclosures shall be fabricated from freestanding steel frames and steel panels, and doors shall be formed to provide a strong and rigid structure.

4.1.5 Enclosure panel and doors shall be 14-gage minimum thickness.

4.1.6 Enclosures shall be NEMA 1 unless specified otherwise on the purchaser's *PIP ELSSG01D* Data Sheet.

4.1.7 All bolted doors and removable panels shall be secured with captive slotted fasteners or machine screws or machine bolts engaging captive nuts or tapped holes in structural members. Self-tapping sheet metal screws shall not be permitted.

4.1.8 Any removable panels weighing more than 50 pounds (23 kg) shall have two lifting handles.

4.1.9 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, all rear access doors shall be full height, hinged, and bolted. All rear access doors shall have provisions for padlocking.

4.1.10 All doors shall have hinges. The hinges may be either continuous or separate. If separate hinges are used, a minimum of three hinges shall be provided on full-height doors.

4.1.11 Provisions shall be made for the addition of vertical sections with future breakers at open ends of the line-up. This shall include removable plates or side sheets furnished on the end of vertical sections.

4.1.12 All breaker compartment doors shall be provided with door handle latches.

4.1.13 Provisions shall be made for padlocking breakers in the test and disconnected positions.

4.1.14 In double-ended switchgear, each main and tie breaker shall be in separate vertical sections.

Comment: This does not preclude metering, auxiliary equipment, or a feeder breaker being in the same vertical section with the main breaker or tie breaker.

4.1.15 The purchaser shall be notified of any breaker-derating factors caused by ambient conditions and the cumulative circuit loads in the vertical sections with multiple breakers in accordance with *IEEE C37.20.1* - 2002, Section 8.4.2.3.

4.1.16 Spaces shall be provided for future use as indicated on the one-line diagram. Spaces shall be of three types: equipped, unequipped, and blank. Spaces shall be configured as follows:

a. Equipped and unequipped spaces shall be capable of being modified to add future circuit breakers of the same ampere rating without a shutdown of the switchgear.

b. Equipped spaces shall be furnished with all hardware, wiring, doors, and miscellaneous equipment including current transformers and monitoring devices required to permit completion of the unit by the addition of only a circuit breaker.

c. Unequipped spaces shall be provided with doors but with no other equipment for future use except the power stabs. Unequipped spaces shall not be used for mounting control switches and other auxiliary equipment.

d. Power stabs (both line and load side) shall be provided with covers to prevent accidental contact with live parts when door is opened.

e. Blank spaces shall be completely empty cubicles with doors but without power stabs or other equipment.

4.1.17 Automatic shutters shall be provided over the power stabs unless indicated otherwise on the purchaser's *PIP ELSSG01D* Data Sheet.

4.1.18 Removable vertical barriers shall be provided in the rear cable compartments to prevent accidental contact of personnel with all energized buses. The barriers shall not cover load connections.

4.1.19 Sheet steel barriers shall be provided between power and control compartments.

4.1.20 Unless otherwise specified on the purchaser's *PIP ELSSG01D* Data Sheet, full height and depth barriers shall be provided between adjacent vertical sections in the rear load terminal compartments.

4.1.21 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, sheet steel barriers shall be provided between breaker compartments in vertical sections.

4.1.22 Equipment shall be designed to be shipped completely assembled if practical.

4.1.23 If equipment must be disassembled for shipment, material and instructions shall be provided for assembling shipping sections, including making main power bus connections at shipping splits.

4.1.24 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, enclosure vent openings shall be provided with stainless steel screens having a maximum opening size of 1/16 inch (1.6 mm).

4.1.25 Breaker control power shall be as indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

4.1.26 Nonflashing indicator lights shall have replaceable, cluster-type LED lamps and colored lens.

4.1.27 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, thermography windows shall be provided. Location of windows shall be as indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

4.1.28 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, the switchgear assembly shall be UL labeled.

4.2 Power Circuit Breakers

4.2.1 Low-voltage power circuit breakers shall be air break type and shall be designed, rated, manufactured, and tested in accordance with *IEEE C37.13*, *NEMA C37.16, NEMA C37.17,* and *ANSI C37.50*.

4.2.2 Breakers shall be of the stored-energy type with standard draw-out construction for both power and control circuits. They shall be three-pole and complete with necessary operating mechanisms.

4.2.3 Breakers shall be operated electrically or manually as indicated on the purchaser's *PIP ELSSG01D* Data Sheet. Electrically operated breakers shall also be capable of manual operation.

4.2.4 Direct-acting overcurrent trip devices shall be solid state RMS sensing, unless indicated otherwise on the purchaser's *PIP ELSSG01D* Data Sheet,

and shall incorporate time delay characteristics, as indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

4.2.5 The trip device display shall be visible with the cubicle door closed.

4.2.6 If required, current-limiting fuses shall be provided to extend the breaker rating and shall cause the breaker to trip if any of the fuses operate. The purchaser shall be notified if these fuses are required.

4.2.7 Each low-voltage power circuit breaker or each breaker in combination with current-limiting fuses shall be capable of interrupting the available short-circuit current in accordance with the purchaser's *PIP ELSSG01D* Data Sheet.

4.2.8 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, mechanism operated contacts (MOCs) and truck operated contacts (TOCs) shall be supplied as two normally open (N.O.) and two normally closed (N.C.) each, wired out to terminals.

4.2.9 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, electrically operated breakers shall have provisions for remote operation by a hand-held control station.

4.2.9.1 The control station shall have 20 ft (6 m) of type SO cord with a polarized plug on the end.

4.2.9.2 The control station shall have two guarded pushbuttons, a green button for opening and a red button for closing.

4.2.10 If remote operation is indicated, a matching receptacle complete with a threaded cover shall be installed in the breaker compartment door.

4.2.11 If remote operation is indicated, a local electrically operated close button or switch shall not be provided on the front of the compartment.

4.3 Bus Work

4.3.1 The power buses shall be uninsulated unless indicated otherwise on the purchaser's *PIP ELSSG01D* Data Sheet.

4.3.2 Bus material shall be copper unless indicated otherwise on the purchaser's *PIP ELSSG01D* Data Sheet.

4.3.3 Bolted joints shall be tin-plated unless indicated otherwise on the purchaser's *PIP ELSSG01D* Data Sheet.

4.3.4 All horizontal and vertical bus and bus supports shall be designed and braced to withstand the short-circuit current in accordance with *IEEE C 37.20.1* - 2002, paragraph 5.4.4, unless a higher level is indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

4.3.5 A 1/4-inch by 2-inch minimum copper ground bus shall be provided at the rear and for the entire length of the assembly.

a. The bus shall be drilled at each end for a NEMA two-hole lug.

b. Ground bus joints shall be solidly bolted.

c. Self-tapping bolts and screws shall not be used.

d. Copper compression type lugs shall be provided if indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

4.3.6 The ground bus shall be firmly secured in each vertical section.

4.3.7 If a neutral bus is indicated on the purchaser's *PIP ELSSG01D* Data Sheet, it shall extend the full length of the switchgear and be insulated from ground.

4.3.8 Unless indicated otherwise on the purchaser's *PIP ELSSG01D* Data Sheet**,** the neutral bus shall have the same continuous current rating as the phase bus.

4.4 Voltage Transformers

4.4.1 Voltage transformers for metering or protective relaying purposes shall be protected by disconnecting-type current-limiting primary fuses.

4.4.2 Secondary voltage shall be 120 volts, with primary voltage as indicated on the one-line diagram.

4.4.3 Each transformer shall have a fused secondary winding.

4.4.3.1 Secondary fuses shall be located in the low-voltage control compartment.

4.4.3.2 Fuse holders shall be labeled to indicate size and type of fuse and to identify the transformer (e.g., Phase "A" PT).

4.5 Control Power Transformers

4.5.1 The primary fuses shall coordinate with the magnetizing inrush current and the secondary protection of the control power transformer.

4.5.2 The kVA rating of the control power transformer(s) shall be determined by the supplier, taking into account any additional loads external to the switchgear, as indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

4.5.3 A form C contact shall be provided for remote alarming of any loss of control power.

4.5.4 Secondary voltage shall be 240/120 volts, with primary voltage as indicated on the one-line diagram.

4.5.5 Primary and secondary windings shall be protected by disconnect-type current-limiting fuses.

4.5.6 Transformers shall be located in the low-voltage control compartment.

4.6 Current Transformers

Current transformers for metering or protective relaying purposes shall be rated in accordance with purchaser's *PIP ELSSG01D* Data Sheet or the one-line diagram.

4.7 Switches

4.7.1 Ammeter and voltmeter switches shall be provided if indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

4.7.2 Ammeter switches shall be the four-position rotary type.

4.7.3 Voltmeter switches shall be the four-position rotary type unless indicated otherwise on the purchaser's *PIP ELSSG01D* Data Sheet.

4.8 Metering

4.8.1 Switchgear metering shall be provided in accordance with the purchaser's *PIP ELSSG01D* Data Sheet.

4.8.2 Communication capabilities shall be provided if indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

4.8.3 All metering and control equipment shall be accessible from the front of the switchgear.

4.8.4 If analog-type metering is specified on the purchaser's *PIP ELSSG01D* Data Sheet, it shall be of the circular 250-degree-scale switchboard type, 1% accuracy, 4-1/2 inch square, and flush mounted.

4.8.5 Control power for microprocessor-type metering shall be as indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

4.9 Space Heaters

4.9.1 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, space heaters shall be provided in each vertical section.

4.9.2 An expanded metal cage shall be provided around the heaters to guard against accidental contact. Caution signs with black engraving on yellow background shall be provided on each vertical section stating the following:

CAUTION: SPACE HEATERS MAY BE ENERGIZED INSIDE.

4.9.3 The power supplies to the heaters shall be from the source indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

4.9.4 The heaters shall be rated at 240 volts and shall be sized to provide the required heat output when operated on a 120-volt system.

4.9.5 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, a panel-type indicating ammeter shall be provided in each main heater circuit, with "normal current" range indicated on the ammeter scale.

4.9.6 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, thermostats shall be provided.

4.9.7 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, a push-to-test pushbutton shall be installed parallel with the thermostat for testing the space heaters.

4.10 Breaker Interlocking and Transfer Schemes

4.10.1 If a breaker interlocking or transfer scheme is indicated on the purchaser's *PIP ELSSG01D* Data Sheet and one-line diagram, it shall be arranged to operate as indicated on the diagram and any supplemental descriptions provided.

4.10.2 The transfer scheme shall be disabled if any of the transfer breakers are in the test position.

4.11 Wiring and Terminations

4.11.1 Control wiring shall be flame retardant, 600-volt, type SIS switchboard copper wire (or an equivalent in accordance with *IEEE C37.20.1* - 2002, Section 7.1.3.1.4) and shall be continuous from terminal to terminal without splices and tagged at both ends with permanent plastic sleeve-type wire markers.

4.11.1.1 Adhesive-type markers shall not be permitted.

4.11.1.2 Locking fork-type lugs shall be provided.

4.11.1.3 Minimum conductor size shall be 14 AWG.

4.11.1.4 Wire markers shall match the supplier's interconnection drawing.

4.11.2 Wiring for current transformer secondary leads shall be crimped in self-insulated ring-type lugs and terminated on shorting screw-type terminal blocks at the first connection after the transformer. Minimum conductor size shall be 10 AWG unless otherwise indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

4.11.3 All wiring harnesses shall be securely bundled and shall be protected from rubbing against other parts within the enclosure.

4.11.3.1 Bushings, grommets, or other mechanical protections shall be provided if wiring is installed through barriers, around edges of metal sheets, or raceways.

4.11.3.2 Adhesive-type supports shall not be permitted.

4.11.4 Wiring shall be connected to only one side of all field wiring terminal blocks, and no more than two wires per terminal shall be permitted.

4.11.4.1 Terminal blocks for field wiring to the main and tie breakers and for any transfer scheme shall not be located in the rear load terminal compartments.

4.11.4.2 Terminal blocks for field wiring to feeder breakers shall be located in the rear load terminal compartments.

4.11.5 Terminal blocks shall be supplied and clearly marked for wiring that will be installed by the purchaser, including wiring between shipping sections.

4.11.6 Spare terminal blocks shall be provided in accordance with the purchaser's *PIP ELSSG01D* Data Sheet.

4.11.7 Power cable lugs will be provided by the purchaser.

4.11.7.1 The bus drilling shall be for NEMA two-hole lugs.

4.11.7.2 The size and quantity of cables shall be as indicated on the one-line diagram or purchaser's *PIP ELSSG01D* Data Sheet.

4.12 Bus Ducts

4.12.1 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, the bus ducts shall be furnished and coordinated with the respective switchgear assemblies, the supply transformers, and other associated equipment.

4.12.2 Dimensions and details of transformer throats or other equipment connections shall be supplied by the responsible party noted on the purchaser's *PIP ELSSG01D* Data Sheet.

4.12.3 Design of the bus duct shall be in accordance with *PIP ELSBD01* and *PIP ELSBD01D*.

4.13 Nameplates

4.13.1 Permanent nameplates shall be provided to identify each circuit breaker, source disconnect point, instrument, instrument switch, relay, and auxiliary component and to identify all equipment and terminal blocks within each assembly.

4.13.2 All nameplates shall be made of laminated plastic at least 3/32 inch thick and shall be affixed with stainless steel hardware.

4.13.3 Switchgear assembly-identifying nameplate may be supplier's standard showing manufacturer, shop order number, and date as a minimum.

4.13.4 Door-mounted devices shall be identified inside the compartment, in addition to the external identification. The inside nameplates may be adhesive type.

4.13.5 Nameplates for each circuit breaker compartment shall be white with 1/4-inch-high engraved black lettering.

4.13.6 Warning nameplates shall be provided on each compartment door in which an external voltage source is terminated. Lettering shall be black on yellow background and shall be a minimum of 1/4 inch high. The nameplate shall read as follows:

CAUTION: THIS UNIT IS SUPPLIED BY AN EXTERNAL VOLTAGE SOURCE.

4.13.7 A nameplate schedule will be provided by the purchaser.

4.14 Finish

4.14.1 Finish color shall be *ANSI 61* light gray unless otherwise specified on the purchaser's *PIP ELSSG01D* Data Sheet.

4.14.2 For outdoor and indoor service in noncorrosive environments, the manufacturer's standard surface preparation and coating system are acceptable.

4.14.3 The finish coat shall be free from craters, pinholes, holidays, embedded foreign matter, and other visual defects.

4.14.4 The topcoat shall provide complete hiding, consistent coverage and thickness, and uniform color.

4.14.5 For service in corrosive environments, the finish and protective coatings shall be in accordance with the specification shown on the purchaser's *PIP ELSSG01D* Data Sheet.

4.15 Secondary System Grounding

4.15.1 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, a high-resistance grounding system shall be provided and incorporated in the switchgear assembly in accordance with *PIP ELSGS01*.

4.15.2 If indicated on the purchaser's *PIP ELSSG01D* Data Sheet, a ground detection system on individual feeder breakers shall be provided in accordance with the one-line diagram.

4.16 Accessories

The following switchgear accessories shall be furnished:

a. A breaker-lifting device supplied at one per switchgear assembly. Lifting capacity shall be shown on the lifting device.

b. Hand crank or handle for moving the breaker into the "connected," "test," or "disconnected" position

c. Device for manually charging the stored energy operating mechanism of electrically operated breakers

d. Test plugs for draw-out relays

e. Portable test kit for solid-state trip units (quantity of kits as indicated on the purchaser's *PIP ELSSG01D* Data Sheet)

4.17 Shipping

4.17.1 Preparation for shipment shall be in accordance with supplier's standards unless otherwise noted on the request for quotation and/or purchase order. The supplier shall be solely responsible for the preparation for shipment.

4.17.2 Loose equipment, such as auxiliary test devices, charts, replacement parts, manual operating handles, packing devices, etc., shall be appropriately packaged, tagged for easy identification, and secured for shipment inside the switchgear.

4.17.3 All moving parts shall be securely blocked and braced in relays, contactors, and other components with moving parts that might be damaged in shipment.

5.17.4 Additional shipping and handling requirements that appear in the individual equipment specifications shall be strictly adhered to, if applicable.

5.17.5 If the switchgear is shipped in more than one section, each open shipping split shall be protected with plywood or other approved method.

4.18 Inspection and Testing

4.18.1 The following tests shall be performed:

a. A complete functional and operational test on the wiring, control devices, relays, and breaker trip and close circuits

b. A dielectric test on the control wiring at 1500 volts minimum and 60 hertz for 1 minute

c. Supplier's standard routine tests

d. Production tests defined in *IEEE C37.20.1* - 2002, Section 6.3. Tests shall be conducted with all draw-out elements racked in and breakers closed.

4.18.2 The purchaser shall be notified 2 weeks in advance of testing.

4.18.3 The purchaser or the purchaser's representative reserves the right to inspect and observe the tests at the factory.

4.19 Documentation

All drawings and other documents shall be furnished as indicated in Table 1 as a part of the purchase order.

TABLE 1 - SUPPLIER DRAWING AND DATA REQUIREMENTS FOR LOW-VOLTAGE METAL-ENCLOSED SWITCHGEAR

A	B	C	D	DESCRIPTION
	X	X	X	One-line diagram, three-line diagram, control elementary, and connection diagrams
X	X	X	X	General layout of equipment, showing all dimensions, weights, and required clearances.
X	X			Circuit breaker data, including detailed description of breakers, rated insulation level (BIL), and rated short-circuit current.
X	X	X		Bus data, including the insulation and bracing materials and methods
	X	X		Current transformer data, including type, class, accuracy, and saturation curves
	X	X		Potential transformer data, including the type, class, and accuracy
	X	X	X	Detailed plans and elevation drawings showing location of all components
X	X	X		Solid-state trip unit data, including the model number, technical information, and time-current curves
	X	X		Meter data, including the model number and technical information of all meters and transducers
		X		Certified type test reports
	X	X		Foundation loading diagrams and soleplate details
	X	X	X	Individual cell schematics
	X	X	X	Individual cell connection wiring diagrams
G	D		D	Detailed (D) or general (G) bill of material including name of the manufacturer and catalog number of all components
		X(1)		Installation, operation, and maintenance manual
		X		Recommended spares parts list

A. These documents shall be provided with proposal.

B. These documents shall be provided for purchaser's review and authorization to proceed before fabrication.

C. These documents shall be provided as part of the final certified document submittal.

(1) One additional set of installation, operation, and maintenance manuals shall be included with the equipment when shipped.

D. The final as-built shall be provided within 2 weeks following shipment.

Comment: One reproducible set of drawings shall be provided plus the specified number of copies of all documentation and operating manuals as indicated on the purchaser's *PIP ELSSG01D* Data Sheet. Format for final as-builts reproducibles shall be CAD convertible .DXF electronic format unless other wise indicated on the purchaser's *PIP ELSSG01D* Data Sheet.

4.20 Conflict Resolution

Any conflicts among the referenced documents shall be identified to the purchaser in writing for resolution. When resolving conflicts, the following order of precedence shall apply:

a. Purchase order

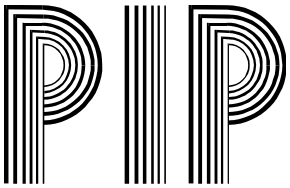
b. One-line diagram(s) and associated drawings

c. Data sheet, *PIP ELSSG01D*

d. This Practice, *PIP ELSSG01*

e. Referenced standards

COMPLETE REVISION
April 2005



Process Industry Practices
Electrical

PIP ELSWC03
600-Volt Power and Control Cable Specification

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time by the responsible Function Team and will be reviewed every 5 years. This Practice will be revised, reaffirmed, or withdrawn. Information on whether this Practice has been revised may be found at www.pip.org.

PIP will not consider requests for interpretations (inquiries) for this Practice.

PRINTING HISTORY

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Process Industry Practices
Electrical

PIP ELSWC03
600-Volt Power and Control Cable Specification

Table of Contents

1. Introduction

1.1 Purpose

This Practice provides requirements for purchase of 600-volt-rated power and control tray cable (Type TC) and metal-clad (Type MC) cable.

1.2 Scope

This Practice describes the minimum technical requirements for fabrication, inspection, testing, and shipping of insulated copper cable. This Practice covers 600-volt-rated multiple conductor power and control tray cable and metal-clad cable.

2. References

Applicable parts of the following Practices and industry codes and standards shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles will be used herein where appropriate.

2.1 Process Industry Practices (PIP)

- PIP ELSWC03D - *Data Sheet for 600-Volt Power and Control Cable*

2.2 Industry Codes and Standards

- American Society for Testing Materials (ASTM)
  - ASTM B8 - *Conductors, Copper, Concentric-Lay-Stranded, Hard, Medium-Hard, or Soft*
- Institute of Electrical and Electronics Engineers (IEEE)
  - IEEE 1202 - *Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies*
- Insulated Cable Engineers Association (ICEA)
  - ICEA S-73-532 (NEMA WC57) - *Control Cables*
- National Fire Protection Association (NFPA)
  - NFPA 70 - *National Electrical Code (NEC)*
- Underwriters Laboratories (UL)
  - *UL 1277 - Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members*
  - *UL 1569 - Metal-Clad Cables*
  - UL 2225 - *Metal-Clad Cables and Cable-Sealing Fittings for Use in Hazardous (Classified) Locations*

3. Definitions

purchaser: The party who awards the contract to the supplier. The purchaser may be the owner or the owner's authorized agent.

4. Requirements

4.1 Fabrication

4.1.1 General

4.1.1.1 Site conditions shall be in accordance with the purchaser's *PIP ELSWC03D* Data Sheet.

4.1.1.2 Type TC cable shall be in accordance with the requirements of *NEC-2005*, Article 336.

4.1.1.3 Type MC cable shall be in accordance with the requirements of *NEC-2005*, Article 330.

4.1.1.4 If used in cable tray, cables shall be in accordance with the requirements of *NEC-2005*, Article 392.

4.1.1.5 The ampacity shall be in accordance with the requirements of *NEC-2005*, Article 330.80, for Type MC and in accordance with *NEC-2005*, Article 336.80, for Type TC.

4.1.1.6 The type of cable used in adjustable speed drive applications shall be indicated on the purchaser's *PIP ELSWC03D* Data Sheet.

4.1.1.7 For adjustable speed drive applications, a shield or metallic sheath shall be provided.

4.1.1.8 If specified on the purchaser's *PIP ELSWC03D* Data Sheet, Type TC cable shall comply with the crush and impact requirements of Type MC cable and shall be identified for such use.

4.1.2 Conductor

The conductor(s) shall be Class B stranded copper in accordance with *ASTM B8*.

4.1.3 Insulation

4.1.3.1 Insulation type shall be in accordance with the purchaser's *PIP ELSWC03D* Data Sheet.

4.1.3.2 Unless otherwise specified on the purchaser's *PIP ELSWC03D* Data Sheet, individual wire insulation shall be 600 volt, 75°C (167°F) (minimum) rated. Cable shall be suitable for installation in wet and dry locations.

4.1.3.3 Individual wires shall be color coded using *ICEA S-73-532* Appendix E, Method 1, and colors in accordance with *ICEA S-73-532* Table E-2 (without white and green).

4.1.3.4 If specified on the purchaser's *PIP ELSWC03D* Data Sheet, for multiconductor power cable sizes 8 AWG and larger, wire identification shall be *ICEA S-73-532* Appendix E, Method 4 (numbered printing on single color insulation).

4.1.4 Ground Wire

4.1.4.1 Unless specified otherwise on the purchaser's *PIP ELSWC03D* Data Sheet, a bare grounding conductor or conductors, sized in accordance with *NEC-2005* Article 250.122 requirements, shall be provided in all cables.

4.1.4.2 For cable sizes 10 AWG and smaller, a green insulated conductor is acceptable as the grounding conductor.

4.1.4.3 For adjustable speed drive applications, three concentric grounding conductors shall be provided.

4.1.5 Metallic Sheath

4.1.5.1 For Type MC cable, a metallic sheath shall be provided that is in accordance with *UL 1569.*

4.1.5.2 The metallic sheath shall be either continuous-welded, impervious, corrugated aluminum, aluminum interlocked armor, or galvanized steel interlocked armor in accordance with the purchaser's *PIP ELSWC03D* Data Sheet.

4.1.5.3 If specified on the purchaser's *PIP ELSWC03D* Data Sheet, the cable shall be labeled in accordance with the requirements of *UL 2225* as "MC-HL" for use in Class I, Division 1 locations.

4.1.6 Outer Jacket

4.1.6.1 An outer, nonmetallic, flame-retardant jacket that is constructed of materials specified on the purchaser's *PIP ELSWC03D* Data Sheet shall be applied over the completed cable assembly.

4.1.6.2 Outer jacket color shall be manufacturer's standard unless otherwise specified on the purchaser's *PIP ELSWC03D* Data Sheet.

4.1.6.3 Outer jacket shall be oil-resistant and sunlight-resistant. Jacket shall be marked "Sunlight-Resistant" in accordance with *UL 1277.*

4.1.6.4 If specified on the purchaser's *PIP ELSWC03D* Data Sheet, the cable shall be rated for direct burial.

4.1.7 Cable Identification

The cable shall be marked and identified in accordance with *NEC-2005* Article 310-11.

4.1.8 Cable Length Tolerance

Unless specified otherwise on the purchaser's *PIP ELSWC03D* Data Sheet, the length tolerance of each segment of cable shall be minus 0% to plus 5%.

4.2 Inspection and Testing

4.2.1 Factory inspection and testing shall be performed on Type TC cables in accordance with *UL 1277*.

4.2.2 Factory inspection and testing shall be performed on Type MC cables in accordance with *UL 1569*.

4.2.3 Type TC and MC cables shall also pass *IEEE 1202* vertical tray flame tests.

4.2.4 If specified on the purchaser's *PIP ELSWC03D* Data Sheet, additional testing shall be performed as indicated.

4.3 Shipping

4.3.1 Cable reel type and lagging shall be in accordance with the purchaser's *PIP ELSWC03D* Data Sheet.

4.3.2 Minimum cable reel identification and marking for Type TC cables shall be in accordance with *UL 1277*.

4.3.3 Minimum cable reel identification and marking for Type MC cables shall be in accordance with *UL 1569*.

4.3.4 Additional cable reel identification shall be in accordance with the purchaser's *PIP ELSWC03D* Data Sheet.

4.4 Documentation

The following information shall be provided with the quotation:

a. Standard and maximum reel lengths

b. Overall diameter over armor and outer jacket

c. Diameter over cable assembly (not including armor and jacket)

d. Cable weight per 1,000 ft (305 m)

e. Maximum conductor continuous operating temperature

f. Minimum bending radius

g. Cable current-carrying capacity

h. Maximum pulling tension and sidewall loading for each cable assembly

i. Minimum cable-pulling temperature

j. Descriptive literature (catalogs, etc.)

4.5 Conflict Resolution

Any conflicts between the referenced documents shall be identified in writing to the purchaser for resolution. In general, when resolving conflicts, the following order of precedence shall apply:

a. Purchase order

b. *PIP ELSWC03D* Data Sheet

c. This Practice, *PIP ELSWC03*

d. Referenced standards

COMPLETE REVISION
April 2006

Process Industry Practices
Electrical

PIP ELSMC20
Low Voltage AC Adjustable Speed Drive Specification

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time by the responsible Function Team and will be reviewed every 5 years. This Practice will be revised, reaffirmed, or withdrawn. Information on whether this Practice has been revised may be found at www.pip.org.

PIP will not consider requests for interpretations (inquiries) for this Practice.

PRINTING HISTORY
November 1999 *Issued*
April 2006 *Complete Revision*

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Process Industry Practices
Electrical

PIP ELSMC20
Low Voltage AC Adjustable Speed Drive Specification

Table of Contents

1. Introduction

1.1 Purpose

This Practice provides the requirements for purchase of low voltage AC adjustable speed drives (ASDs).

1.2 Scope

This Practice describes the requirements for design, construction, performance, inspection, testing, shipment, and documentation of low voltage (up to 600 volt input) AC, 3-phase, adjustable speed drives for squirrel cage induction motors.

This Practice does not include the motor requirements. If a coordinated package is required, the purchaser shall also include the motor specifications.

2. References

Applicable parts of the following Practice, industry codes and standards, and references shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 Process Industry Practices (PIP)

- PIP ELSMC20D - Data Sheet for *PIP ELSMC20 - Low Voltage AC Adjustable Speed Drive Specification*

2.2 Industry Codes and Standards

- Institute of Electrical and Electronic Engineers (IEEE)
  - IEEE 519 - *Guide for Harmonic Control and Reactive Compensation of Static Power Converters*
  - IEEE 1100 - *Powering and Grounding Sensitive Electronic Equipment (Emerald Book)*
- National Electrical Manufacturers Association (NEMA)
  - NEMA ICS 6 - *Industrial Control and Systems Enclosures*
- National Fire Protection Association (NFPA)
  - NFPA 70 - *National Electrical Code (NEC)*

3. Definitions

owner: The party who owns the facility wherein the ASD will be used

pulse-width modulated inverter (PWM): An inverter whose switching will vary the time duration of voltage or current for control of the output

purchaser: The party who awards the contract to the supplier. The purchaser may be the owner or the owner's authorized agent.

supplier: The party responsible for providing the ASD

4. Requirements

4.1 General

4.1.1 The ASD inverter shall be pulse-width modulated (PWM) type and fully digital.

4.1.2 This Practice covers an ASD for driving a single motor. If parallel operation of motors is required, additional information shall be specified in a separate attachment.

4.1.3 The ASD shall limit harmonic distortion reflected onto the distribution system at the point of common coupling (as defined on the purchaser's *PIP ELSMC20D* Data Sheet) to the voltage and current distortion levels defined by *IEEE 519* for general system applications. If shown on the purchaser's *PIP ELSMC20D* Data Sheet, the supplier shall run a computer simulation of the system to generate an estimate of the harmonic levels produced by the ASD and provide it to the purchaser.

4.1.4 If specified on the purchaser's *PIP ELSMC20D* Data Sheet, the ASD will be mounted within a low voltage motor control center (MCC) or switchgear lineup. The MCC or switchgear requirements will be covered by a separate specification and the ASD will be listed as a component of the MCC or switchgear.

4.1.5 The equipment shall be completely factory-built, assembled, wired, and tested. If it is necessary to disassemble the units for ease of transportation, all materials and instructions shall be provided for easy field reassembly.

4.1.6 The ASD shall be NRTL listed/labeled if specified on the purchaser's *PIP ELSMC20D* Data Sheet.

4.1.7 The maximum noise level of the unit shall not exceed 85 dBA at a distance of 3 feet (0.9 m) from the unit.

4.1.8 The ASD shall be capable of constant and/or variable torque applications and operating conditions as specified on the purchaser's *PIP ELSMC20D* Data Sheet.

4.1.9 The Service Factor of the ASD shall be 1.0.

4.1.10 Motor data and feeder cable lengths are shown on the purchaser's *PIP ELSMC20D* Data Sheet. The supplier shall supply and advise purchaser of any special requirements on the ASD output, such as filtering, that may be required for the specific installation.

4.1.11 Power factor shall be greater than .95 lagging over the entire speed range.

4.1.12 Efficiency of the ASD shall be a minimum of 97% at full load and speed.

4.2 Input Power

4.2.1 The main input power shall be as shown on the purchaser's *PIP ELSMC20D* Data Sheet.

4.2.2 The ASD shall have a tolerance for voltage ± 10% and frequency ± 2 Hz.

4.3 Output Power

4.3.1 The ASD shall have an output frequency of 0.1 Hz to 400 Hz.

4.3.2 The ASD shall have speed regulation of 0.1% in open-loop mode and 0.01% in closed-loop mode.

4.3.3 The ASD shall have frequency resolution of 0.01 Hz digital and 0.1 Hz analog.

4.3.4 The ASD shall have frequency accuracy of ± 0.01% of maximum frequency for the digital input and ± 0.2% of maximum frequency for the analog input (at 25°C ± 10°C).

4.3.5 The ASD overload current shall be 100% continuous.

4.3.6 The ASD one-minute overload current rating shall be 110% of rated output current if variable torque application is specified on the purchaser's *PIP ELSMC20D* Data Sheet.

4.3.7 The ASD one-minute overload current rating shall be 150% of rated output current if constant torque application is specified on the purchaser's *PIP ELSMC20D* Data Sheet.

4.4 Control Features

4.4.1 As a minimum, the ASD shall have the capability to operate in the following modes:

a. Speed control as V/Hz or open-loop

b. Open-loop torque control

4.4.2 The ASD shall accept the control signals specified on the purchaser's *PIP ELSMC20D* Data Sheet.

4.4.3 The ASD shall be able to start and stop from a two-wire control (dry contact), three wire momentary contact closure, keypad, and/or serial interface.

4.4.4 The ASD source voltage for external "Start - Stop" circuit logic shall be as specified on the purchaser's *PIP ELSMC20D* Data Sheet.

4.4.5 The ASD shall be designed to operate within the "Voltage Tolerance Envelope" as defined by Figure 3-10 of *IEEE 1100-1999* and shall not permit any voltage interruption to the connected load.

4.4.6 The ASD shall have programmable digital inputs.

4.4.7 See the purchaser's *PIP ELSMC20D* Data Sheet for a listing of controls to be provided by the supplier if a stand-alone enclosure or MCC mounting is specified on the purchaser's *PIP ELSMC20D* Data Sheet.

4.5 Communications and Software

4.5.1 The ASD shall have communications options capabilities as specified on the purchaser's *PIP ELSMC20D* Data Sheet.

4.5.2 If specified on the purchaser's *PIP ELSMC20D* Data Sheet, software that is capable of remotely configuring and/or monitoring the ASD shall be provided.

4.6 Operational Functions

4.6.1 The ASD shall have programmable output frequency limits.

4.6.2 The ASD shall have an optional dynamic braking circuit available.

4.6.3 The ASD shall operate the motor in the forward or reverse direction.

4.6.4 The ASD shall contain two programmable jump frequencies with adjustable bandwidths.

4.6.5 The ASD shall be capable of jogging the motor.

4.6.6 The ASD shall have configurable preset speeds and profiles, i.e., acceleration, de-acceleration, etc.

4.6.7 The ASD shall be capable of determining the speed and direction of a spinning motor and adjust its output to 'pick up' the motor.

4.6.8 The ASD shall have a programmable function to select a restart mode after a loss of power.

4.6.9 The ASD shall have programmable electronic overload protection that complies with NEC 2005 Article 430 Part III.

4.6.10 The ASD shall have other operational features as specified on the purchaser's *PIP ELSMC20D* Data Sheet.

4.7 Protective Features

4.7.1 The ASD shall be capable of re-setting faults remotely and locally.

4.7.2 The ASD shall have as a minimum the following programmable alarms and/or trips:

a. Overspeed

b. Undertorque

c. Undervoltage

d. Overvoltage

e. Undercurrent

f. Overcurrent

g. Inverter overheat

h. Motor Overload

i. ASD Overload

j. Short Circuit

k. Ground Fault

l. Communications Loss

m. Inverter overheat trip

n. Emergency off trip

o. Communication interruption error

p. Main circuit undervoltage trip

q. Overtorque trip

4.7.3 If shown on the purchaser's *PIP ELSMC20D* Data Sheet, additional protective features shall be provided.

4.8 Monitor Features

4.8.1 The ASD shall have a backlighted LCD digital display that is visible with the door closed.

4.8.2 The digital display shall be capable of displaying the following conditions:

a. Frequency

b. % current and amps

c. % voltage and volts input & output

d. RPM

e. Output watts

f. Torque

4.8.3 The ASD's keypad shall be mounted on the exterior of the enclosure.

4.8.4 The ASD shall have programmable 4-20 mA analog outputs.

4.8.5 The ASD shall have programmable relay outputs.

4.8.6 The ASD shall include a common alarm contact which shall be closed during normal operation and shall open on ASD fault conditions.

4.8.7 The ASD shall provide one normally open and one normally closed contact to indicate motor run status. Contacts shall have a minimum rating of 2 A at 120 VAC and 125 VDC.

4.8.8 See the purchaser's *PIP ELSMC20D* Data Sheet for a listing of indications to be provided if a stand-alone enclosure or MCC mounting is specified on the purchaser's *PIP ELSMC20D* Data Sheet.

4.9 Stand-Alone Enclosures

4.9.1 If specified on the purchaser's *PIP ELSMC20D* Data Sheet, a stand-alone enclosure shall be provided for either wall mounting or floor mounting.

4.9.2 The ASD enclosure shall be supplier's standard in conformance with *NEMA ICS 6* unless specified otherwise on the purchaser's *PIP ELSMC20D* Data Sheet.

4.9.3 The enclosure shall be suitable for indoor or outdoor locations as shown on the purchaser's *PIP ELSMC20D* Data Sheet.

4.9.4 The enclosure shall be suitable for the area classification as shown on the purchaser's *PIP ELSMC20D* Data Sheet.

4.9.5 All enclosure openings exceeding 0.25 inch (6 mm) in width shall be provided with screens to prevent the entrance of snakes, rodents, etc. The maximum screen mesh opening width shall be 0.25 inch (6 mm).

4.9.6 Where forced cooling is required, a "loss of cooling" alarm dry-contact shall be provided.

4.9.7 Air filters shall be of a washable type or a disposable type that can be easily removed or replaced without shutting down the ASD.

4.9.8 The enclosure shall have a lockable handle with key.

4.9.9 Use supplier's standard finish unless specified otherwise on the purchaser's *PIP ELSMC20D* Data Sheet.

4.9.10 If specified on the purchaser's *PIP ELSMC20D* Data Sheet, space heaters shall be supplied.

4.9.11 Nameplates

4.9.11.1 All nameplates shall be made of laminated plastic at least 3/32-inch thick and shall be affixed with stainless steel hardware.

4.9.11.2 Door-mounted devices shall be identified inside the compartment, in addition to the external identification. The inside nameplates may be adhesive type.

4.9.11.3 Nameplates shall be white with minimum 1/4-inch-high engraved black lettering.

4.9.11.4 Meters, relays, switches, and other devices on and within the ASD shall be permanently identified.

4.10 Disconnects

4.10.1 If specified on the purchaser's *PIP ELSMC20D* Data Sheet, the ASD shall include an incoming disconnect device with an interlocked and padlockable handle mechanism.

4.10.1.1 The purchaser's *PIP ELSMC20D* Data Sheet shows the type of disconnect to be provided.

4.10.1.2 Disconnect device shall have a momentary withstand rating greater than the available fault current shown on the purchaser's *PIP ELSMC20D* Data Sheet.

4.10.2 If multiple doors are supplied, each door shall be interlocked with the disconnect device. The interlocks shall include provisions to manually override for test and repair.

4.10.3 If specified on the purchaser's *PIP ELSMC20D* Data Sheet, the ASD shall include an output disconnect or contactor.

4.10.4 If specified on the purchaser's *PIP ELSMC20D* Data Sheet, the ASD shall include a manual bypass feature. This feature shall provide a bypass contactor and an output isolation contactor to bypass the ASD and allow the motor to operate at fixed speed. The bypass contactor shall be electrically and mechanically interlocked with the output contactor. All bypass selector switches, controls, and indicating lights shall be packaged in the ASD enclosure.

4.11 Wiring and Terminations

4.11.1 Terminal blocks shall be provided for connection of external wiring and shall be conveniently located, clearly numbered, and permanently identified.

4.11.2 Terminal blocks for external power wiring terminations shall be designed to accommodate compression-type wire lugs for ASDs greater than 50 hp. Mechanical connections may be used for ASDs 50 hp or less.

4.11.3 Connection points for power and control shall be segregated from each other. If necessary, this may be accomplished through the use of terminal barriers and covers.

4.11.4 Where wiring is run through a metal sheet or barrier, bushings, grommets, or other mechanical protection shall be provided.

4.11.5 All internal wiring shall be terminated with no more than two (2) conductors per terminal block point.

4.11.6 The ASD shall have an internal mechanical ground connection suitably sized for terminating stranded copper ground conductors. Ground connections shall be near the incoming and outgoing power cable termination points.

4.11.7 Enclosures shall be designed to accommodate power cable entry as specified on the purchaser's *PIP ELSMC20D* Data Sheet.

4.11.8 Compression lugs shall be provided with the equipment for the termination of all power wiring, if specified on the purchaser's *PIP ELSMC20D* Data Sheet.

4.11.9 Minimum wire bending space shall meet or exceed the values shown in *NEC*-2005 Table 430.10(B) for termination of the power cable and shall be dimensioned on the supplier's drawing.

4.12 Inspection and Testing

Supplier's standard tests shall be performed and additional testing shall be required if specified on the purchaser's *PIP ELSMC20D* Data Sheet. Minimum testing shall include:

a. Mechanical operation tests performed for each ASD to verify satisfactory operation. These tests shall include checking operating mechanisms and interlock devices.

b. Electrical function tests performed to ensure proper operation of all devices and components.

4.13 Shipping

4.13.1 Unless specified otherwise, preparation for shipment shall be in accordance with the supplier's standards.

4.13.2 Loose equipment shall be appropriately packaged and secured for shipment inside the enclosure or shipping container. These items shall be properly tagged for easy identification.

4.14 Documentation

4.14.1 Quotation

Two (2) copies of the following documents shall be provided with the quotation:

a. Descriptive bulletins to include ratings, protection, controls, diagnostics and operation of the ASD

b. Information and recommendations for this application on harmonic filtering, cross-talk, isolation, input signal conditioning, special load terminators, and motor de-rating

c. Factory test procedures

d. Full heat loss data for each typical unit

e. A complete listing of accessories, including special tools normally used for operation, maintenance, and testing of the specified equipment

4.14.2 Supplier Drawings and Data

4.14.2.1 The supplier shall submit drawings and data of the type and quantity shown in Section 4.14.3 and the purchaser's *PIP ELSMC20D* Data Sheet.

4.14.2.2 A tabulation of factory settings for all adjustable devices in the ASD as shipped shall be included.

4.14.3 Supplier Drawing and Data Requirements

Table 1. Documentation Requirements

A with Bid	**B** for Review	**C** Final Certified	**D** As Built	Description
	X	X	X	Detailed bill of material
X	X	X	X	General layout of equipment, showing all dimensions, weights, location and outline drawings showing the final assembled configuration
	X	X	X	Connection wiring diagrams for all electrical equipment
	X	X	X	Single-line, 3-line, and control schematic diagrams
X				List of accessories
		X		Tabulation of factory settings
		X (1)		Installation, operation, programming, and maintenance manual
		X		Certified test reports (if specified on the purchaser's *PIP ELSMC20D* Data Sheet)
			X	Final as-built drawings
X		X		Recommended priced spare parts list

A. These documents shall be provided with the proposal.

B. These documents shall be provided for the purchaser's review and authorization to proceed before fabrication.

C. These documents shall be provided as part of the final certified document submittal.

(1) Equipment shall be shipped with one set of installation, operation, and maintenance manuals.

D. The final as-built documents shall be provided within 2 weeks following shipment.

Note: One (1) reproducible set of drawings plus the specified number of copies of all documentation and operating manuals as shown on the purchaser's *PIP ELSMC20D* Data Sheet will be provided. Reproducibles shall be CAD convertible .DXF electronic format.

4.15 Conflict Resolution

Any conflicts between the reference documents shall be identified in writing to the purchaser for resolution. If resolving conflicts, the following order of precedence shall apply:

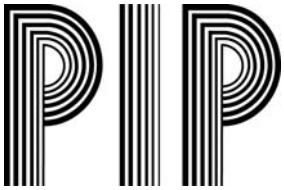
a. Purchase Order

b. *PIP ELSMC20D* Data Sheet

c. This Practice, *PIP ELSMC20*

d. Referenced Standards

COMPLETE REVISION
October 2006



Process Industry Practices
Electrical

PIP ELSMC13
Low-Voltage Motor Control Centers

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time.

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Process Industry Practices
Electrical

PIP ELSMC13
Low-Voltage Motor Control Centers

Table of Contents

1. Introduction

1.1 Purpose

This Practice provides the requirements for low-voltage motor control centers.

1.2 Scope

1.2.1 This Practice describes the requirements for the design, fabrication, inspection, testing, and shipping of factory-assembled 600 V motor control centers. It includes requirements for buses, enclosures, motor starters, fused switches, and circuit breakers. All equipment described in this Practice is suitable for use in dry, non-classified areas or in outdoor enclosures.

1.2.2 Panelboards and adjustable speed drives are outside the scope of this Practice.

2. References

Applicable parts of the following Practices, industry codes and standards, and references shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 Process Industry Practices (PIP)

- PIP ELSMC13D - *Low-Voltage Motor Control Centers Data Sheet*
- PIP ELSSG12 - *Design and Fabrication of Outdoor Enclosures for Motor Controllers and Switchgear*

2.2 Industry Codes and Standards

- Underwriters Laboratories (UL)
  - UL 845 - *Motor Control Centers*
- National Electrical Manufacturers Association (NEMA)
  - NEMA ICS 18 - *Industrial Control and Systems: Motor Control Centers*
- National Fire Protection Association (NFPA)
  - NFPA 70 - *National Electrical Code* (NEC)

3. Definitions

blank unit space: A space not equipped to accept a future unit

future unit space: A space specified and equipped to accept a future unit

motor control center (MCC): An assembly of one or more enclosed sections having common power buses and principally containing motor control units

owner: The party that owns the facility where the equipment will be used or installed

purchaser: The party who awards the contract to the supplier. The purchaser may be the owner or the owner's authorized agent.

supplier: The party responsible for providing the equipment

unit: A single combination motor-controller, feeder-tap assembly, or similar removable plug-in assembly (bucket)

unusable unit space: A space not suitable to accept a future unit

4. Requirements

4.1 General

4.1.1 MCCs shall be in accordance with *NEMA ICS 18.*

4.1.2 MCC site conditions shall be as specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.1.3 The unit wiring shall be Class I, Type B, in accordance with NEMA ICS 18, unless specified otherwise on the purchaser's *PIP ELSMC13D* Data Sheet. Wiring shall be stranded copper with 600 V, flame retardant insulation rated 90°C. Control wiring shall be #14 AWG minimum. Power wiring shall be #12 AWG minimum.

4.1.4 The temperature rise of bus joints and splices shall not exceed a 65°C rise above a 40°C ambient temperature.

4.1.5 The complete assembly and its components shall be suitable for continuous rated load current and available fault current as specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.1.6 Each compartment shall be a minimum of 6 inches high, unless otherwise specified on purchaser's *PIP ELSMC13D* Data Sheet. Load wiring to each device shall be directly from the wireways, not from an adjacent compartment.

4.1.7 Purchaser shall indicate the quantity and type of MCC units along with number of future and blank unit spaces on purchaser's one line or load summary. Supplier shall indicate any unusable unit spaces on general layout drawings submitted with proposal.

4.1.8 Purchaser shall furnish supplier with requirements for auxiliary control and metering devices such as incoming metering, pilot lights, controls, push buttons, etc., if required.

4.1.9 All unpainted parts and hardware shall be plated for corrosion resistance or shall be stainless steel.

4.1.10 The MCC shall be NRTL listed and labeled if specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.1.11 Units that contain multiple starters, switches, or breakers with a single access door are not allowed.

4.2 Enclosures

4.2.1 Main Enclosure

4.2.1.1 The enclosure shall be NEMA 1A gasketed, unless otherwise specified on the purchaser's *PIP ELSMC13D* Data Sheet. If outdoor weatherproof enclosures are specified on the purchaser's *PIP ELSMC13D* Data Sheet, outdoor enclosures shall be in accordance with *PIP ELSSG12*.

4.2.1.2 The enclosure shall be constructed of minimum 14 gauge metal thickness reinforced with formed structural members to resist warping.

4.2.1.3 The assembly shall be furnished with a removable lifting support.

4.2.1.4 Provisions shall be made for adding future sections as specified on the purchaser's *PIP ELSMC13D* Data Sheet. Removable cover plates shall be provided for future bus extension without interfering with cables or conduits entering wireway.

4.2.1.5 Integral base support angles (sills) shall be provided on the front and rear of the vertical section(s) and shall have holes to allow bolting to the floor.

4.2.1.6 Unless specified otherwise on the purchaser's *PIP ELSMC13D* Data Sheet, the MCC shall contain only front-mounted units with rear-bolted cover.

4.2.1.7 If back-to-back configuration is specified on the purchaser's *PIP ELSMC13D* Data Sheet, double vertical buses will be required, with the same phase configuration for the front and back sections.

4.2.1.8 All components and wiring connections shall be accessible in the front of the unit.

4.2.1.9 When specified on the purchaser's *PIP ELSMC13D* Data Sheet, enclosure and/or equipment doors shall include approved "viewer ports" to allow infrared scanning of the equipment without opening the equipment. When required, purchaser shall provide a detailed description of viewer port locations and quantities.

4.2.2 Doors and Covers

4.2.2.1 All doors and covers shall be flanged or otherwise constructed to form a sturdy, rigid construction for operation of circuit breaker or motor protection device handle and latch fastening.

4.2.2.2 Safety interlock and operating handle requirements are covered in Section 4.7.

4.3 Wireways

4.3.1 General

4.3.1.1 All metal edges in wireways shall be constructed to prevent damage to wire insulation.

4.3.1.2 Wireways shall be suitable for wiring from top or bottom entry.

4.3.1.3 Vertical and horizontal wireways shall have separate access.

4.3.1.4 Construction of the horizontal and vertical wireways and bus barriers shall be such that a fish tape, pushed into wireways at the bottom or top of the MCC, cannot contact any energized parts.

4.3.1.5 No accessories such as terminal strips shall be installed in wireways.

4.3.2 Vertical Wireways

4.3.2.1 Vertical wireways shall be a minimum of 4 inches (150 mm) wide and full depth of the units.

4.3.2.2 Where main circuit breaker, main fused switch, large starters, or special large units are installed without vertical wireways, all smaller load units in the same vertical section shall be provided with vertical wireways to interconnect with the horizontal wireways.

4.3.2.3 Means for supporting cables every 12 inches (300 mm) shall be provided.

4.3.2.4 Vertical wireway door shall run the complete height of the units and shall consist of no more than two individual doors for each vertical section.

4.3.2.5 All vertical wireways shall have a fixed metal barrier with openings for wire passage between the wireway and the unit. The wire passageway shall protect the wiring from damage by grommeting or other equivalent means.

4.3.3 Horizontal Wireways

4.3.3.1 Unless specified otherwise on the purchaser's *PIP ELSMC13D* Data Sheet, continuous, 6-inch minimum height horizontal top and bottom wireways shall be provided.

4.3.3.2 Top wireway top cover shall be removable for drilling for conduit and other access.

4.3.4 Wire and Cable Bending Space

4.3.4.1 All wire-bending space for manufacturer-installed wiring shall comply with the requirements of *UL 845*.

4.3.4.2 Space available for installation of field wiring sized up to the larger of the maximum current rating of the unit or the cable size shown on the One Line Diagram(s) shall comply with minimum cable bending radius requirements of the *NEC*.

4.4 Power Buses

4.4.1 General

4.4.1.1 Power bus bracing shall be as specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.4.1.2 Holes for all bolted electrical connections shall be no larger than necessary for proper insertion of bolts.

4.4.1.3 Bus shall have just enough exposure to allow the insertion of a plug-in unit.

4.4.1.4 Barriers shall be provided to separate the bus compartment from wiring space at top, bottom, and sides of each section.

4.4.1.5 Barriers shall be adequate to prevent accidental contact and to restrict propagation of unit-originated arc into the bus compartment.

4.4.1.6 Vertical and horizontal bus material shall be copper, unless specified otherwise on the purchaser's *PIP ELSMC13D* Data Sheet. Bus plating, whether joints only or entire bus, shall be as specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.4.1.7 All splice connections shall be made with at least two bolts using washers and shall be easily accessible for installation and inspections.

4.4.1.8 Labels indicating bolt torque requirements shall be attached to the inside of bus covers.

4.4.2 Horizontal Power Bus

4.4.2.1 Horizontal power bus and splice bars ampacity shall be as specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.4.2.2 Bus shall be pre-drilled for extension on each end, without the need for additional bus supports or bracing.

4.4.3 Vertical Power Bus

4.4.3.1 Vertical power bus and splice bars ampacity shall be as specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.4.3.2 The plug-in unit stabs and the vertical power bus at the stab location shall be lubricated with an anti-seizing compound. Lubricant shall be kept off of insulating surfaces.

4.4.3.3 Vertical power bus shall be isolated.

4.4.3.4 Vertical power bus shall be continuously covered with insulating material.

4.5 Grounding

4.5.1 General

4.5.1.1 Units shall be individually grounded.

4.5.1.2 Resistance between the unit enclosure and the equipment grounding bus shall not exceed 0.005 ohm.

4.5.2 Horizontal Ground Bus

4.5.2.1 Horizontal ground bus shall be copper and shall have provisions for future extension.

4.5.2.2 Ground bus shall be uniform and continuous across the entire length of the MCC.

4.5.2.3 Ground bus shall be sized and located in top or bottom of the MCC as specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.5.3 Vertical Ground Bus

4.5.3.1 A bare copper vertical ground bus shall be provided, unless specified otherwise on the purchaser's *PIP ELSMC13D* Data Sheet.

4.5.3.2 Vertical ground bus shall be bolted to the horizontal ground bus in each section.

4.5.3.3 If the MCC has a vertical ground bus, each withdrawable unit shall make a wiping-action slide connection to the vertical bus. The ground connection shall "make" before the line stabs are engaged and shall "break" after the line stabs are disengaged.

4.6 Incoming Line Section

4.6.1 Provision shall be made for connecting incoming lines from above or below to the main bus or main disconnect device as specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.6.2 Rigid bus shall be used to connect the incoming lugs or main disconnect device to the main horizontal bus.

4.6.3 Supplier shall provide NEMA drilling and hole spacing (9/16-inch hole by 1-3/4-inch spacing) for purchaser-supplied lugs or provide full ring compression lugs if specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.6.4 If supplier is required to provide termination lugs, supplier shall provide purchaser with the lug type and installation specifications.

4.6.5 No horizontal wireway shall be permitted to pass through an incoming line compartment.

4.6.6 Attachment points for lugs shall be braced to withstand, without distortion, any torque imposed by the incoming line cables.

4.6.7 If a main circuit breaker disconnect device is specified on the purchaser's *PIP ELSMC13D* Data Sheet, it shall conform to the requirements of Section 4.9.

4.6.8 If an incoming line fused disconnect switch is specified on the purchaser's *PIP ELSMC13D* Data Sheet, it shall be rated equal to or greater than the ampacity of the main bus.

4.6.9 If specified on the purchaser's *PIP ELSMC13D* Data Sheet, provisions shall be made for metering as specified.

4.7 Units

4.7.1 General

4.7.1.1 External control power and wiring shall enter the units from the side.

4.7.1.2 Fixed-connection units shall be connected to the bus with cable and shall have two-hole compression connectors and lock-washers. Connection shall be suitable for bus thermal properties.

4.7.1.3 The conductor between the incoming line stab and the unit disconnect device shall be fully rated based on the disconnect or starter maximum current rating, without exceeding the allowable temperature rise of the conductor or components.

4.7.1.4 Line side conducting parts that remain energized if the unit disconnect is "Off" shall be covered with a barrier or otherwise protected from accidental contact with fingers or tools.

4.7.1.5 Internal assembly fastening methods shall be as specified by the device manufacturer (torque on screws, bolts, etc.).

4.7.1.6 All wiring shall be marked on each end with permanently embossed wire markers of the heat-shrinkable or slip-on type. Wrap-around, adhesive, and rigid snap-on markers are not acceptable.

4.7.2 Arrangement

4.7.2.1 Terminal strips and fuse holders shall be located for safe and unobstructed access.

4.7.2.2 Load and control wiring from unit to raceway shall be removable without de-energizing units above or below.

4.7.3 Plug-In

4.7.3.1 Self-aligning plug-in unit stab construction shall be provided to ensure positive electrical and mechanical contact to the bus under all load and rated fault conditions. All stabs shall be silver or tin plated.

4.7.3.2 If specified on the purchaser's *PIP ELSMC13D* Data Sheet, automatic shutters shall be included to cover all openings to the vertical bus if a unit is removed.

4.7.3.3 Automatic shutters shall be provided if the unit door is removed as an integral part of the draw-out unit.

4.7.3.4 Installation or removal of plug-in units shall not expose personnel to energized components.

4.7.4 Termination

4.7.4.1 Terminals shall not encroach on the vertical wireway.

4.7.4.2 Terminals accessible to the wireways shall be protected or isolated to prevent accidental contact while altering wiring to other compartments.

4.7.4.3 Manufacturer's manuals shall include torque requirements for connections.

4.7.4.4 If specified on the purchaser's *PIP ELSMC13D* Data Sheet, units rated over 100 amperes shall be supplied with load terminations that consist of flat drilled tabs or bus ends suitable for connection of standard two hole compression lugs. If supplier is required to provide termination lugs, supplier shall provide purchaser with the lug type and installation specifications.

4.7.4.5 NEMA standard drilling and hole spacing shall be provided for terminations.

4.7.5 Safety Interlocks

4.7.5.1 The safety interlock provided shall allow the compartment door to be opened with the unit disconnect handle in the "On" position. The safety interlock shall be designed to allow access with a tool without interrupting power.

4.7.5.2 Each plug-in unit shall be equipped with a mechanical safety interlock that will prevent connecting or disconnecting to the vertical bus with the unit's disconnect handle in the "On" position.

4.7.6 Unit Disconnect Operating Handles

4.7.6.1 The operating handle shall clearly indicate whether the disconnect is in the "On" or "Off" position.

4.7.6.2 Operating handles for breakers used as a disconnect shall be:

a. Self-indicating in the "Tripped" position

b. Predominantly up for "On"

c. Predominantly down for "Off"

d. In accordance with the height requirements of *NEC-2005*, Article 404.8

4.7.6.3 Operating handles shall accept a minimum of three standard padlocks, any one of which can lock the handle in the "Off" position only.

4.7.6.4 Unit operation to close disconnect device shall be possible only by defeating the interlock if the compartment door is open.

4.8 Combination Starters and Contactors

4.8.1 General

4.8.1.1 The motor starters shall be NEMA-rated, full voltage, combination type using a thermal magnetic circuit breaker, magnetic-only circuit breaker, or current-limiting fused switch combined with a magnetic air or vacuum contactor as specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.8.1.2 If specified on the purchaser's *PIP ELSMC13D* Data Sheet, starters NEMA Size 4 and above shall be vacuum-break contactors.

4.8.1.3 Starter units shall be the plug-in type if available, unless otherwise stated on the purchaser's *PIP ELSMC13D* Data Sheet.

4.8.1.4 Line side wiring shall be protected from mechanical or electrical damage.

4.8.1.5 Thermal-magnetic circuit breakers, magnetic-only breakers, and fused switch assemblies shall be capable of interrupting fault current equivalent to the bus bracing specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.8.1.6 The minimum size starter shall be NEMA Size 1.

4.8.1.7 The continuous current rating of each starter or contactor assembly shall be based on the maximum NEMA horsepower or breaker rating or switch rating.

4.8.1.8 Fused switch assemblies shall comply with the requirements of Section 4.9.2.

4.8.1.9 If specified on the purchaser's *PIP ELSMC13D* Data Sheet, an integrated digital communication and control system shall be provided.

4.8.2 Control Power Transformer or Control Power Supply

4.8.2.1 Each combination starter shall include a 480 V to 120 V control power transformer, unless specified otherwise on the purchaser's *PIP ELSMC13D* Data Sheet.

4.8.2.2 Control power transformer continuous rating shall be supplier's standard, unless specified otherwise on the purchaser's *PIP ELSMC13D* Data Sheet.

4.8.2.3 All ungrounded primary and secondary leads shall be fused in accordance with *NEC-2005*, Table 450.3(B).

4.8.2.4 Primary fuses shall be current-limiting type with a current interrupting rating not less than 100,000 amperes.

4.8.2.5 The control power transformer shall have one secondary terminal grounded to the unit frame.

4.8.2.6 If specified on the purchaser's *PIP ELSMC13D* Data Sheet, 24 volt DC control power shall be used. Dual power supplies shall be

provided for each MCC unless otherwise on the purchaser's *PIP ELSMC13D* Data Sheet.

4.8.3 Control Circuit

4.8.3.1 Starters requiring control power at line voltage shall be provided with a fuse block and a 600 V, Class "CC" current-limiting fuse in each control circuit conductor connected to an ungrounded phase conductor.

4.8.3.2 Control power terminal blocks shall be "pull-apart" type located within the starter unit.

4.8.3.3 If specified on the purchaser's *PIP ELSMC13D* Data Sheet, each contactor coil shall be equipped with a surge suppression device for interface with sensitive electronic equipment.

4.8.3.4 If specified on the purchaser's *PIP ELSMC13D* Data Sheet, undervoltage ride-through device shall be provided. Caution has to be used to make sure motor does not close in out of phase between motor back emf and power system.

4.8.4 Contactor Unit

4.8.4.1 Contactor unit parts shall be corrosion resistant.

4.8.4.2 Contactor shall be provided with self-cleaning contacts.

4.8.4.3 Contactor disassembly and assembly of moving and fixed contacts and operating coil shall not require special tools.

4.8.4.4 Voltage and frequency of operating coils shall be easily identifiable from the front of the unit.

4.8.4.5 Contacts and coil shall be removable without removing unit from the MCC.

4.8.4.6 Contactors with coils operating at line voltage shall be provided with interposing 120 V control relay located in the same starter unit.

4.8.4.7 Contactors shall be equipped with spare auxiliary contacts as shown on the purchaser's *PIP ELSMC13D* Data Sheet.

4.8.5 Overload Relays

4.8.5.1 Unless specified otherwise on the purchaser's *PIP ELSMC13D* Data Sheet, overload relays shall be standard electro-mechanical three-pole Class 20 without ambient compensation.

4.8.5.2 If electronic solid state overload relays are specified on the purchaser's *PIP ELSMC13D* Data Sheet, they shall be three-pole, current-sensing, solid state Class 20. If specified on the purchaser's *PIP ELSMC13D* Data Sheet, include single-phasing protection and/or ground fault detection. The overload trip range shall allow setting at 125% of the motor full load current according to the *NEC-2005* Table 430.250. Visible indication of overload trip shall

be provided without opening the door. Overload trip setting shall be marked on the overload relay in amperes.

4.8.5.3 Overload relay shall be equipped with externally operable, nonmetallic manual reset.

4.8.5.4 Automatic reset overloads shall be provided if specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.8.5.5 If an overload heater conversion table is required, it shall be permanently attached to the inside of each compartment enclosure door.

4.8.5.6 Unless specified otherwise on the purchaser's *PIP ELSMC13D* Data Sheet, heaters shall be supplied according to the purchaser's attached documentation.

4.8.6 Single Phase Protection

4.8.6.1 If specified on the purchaser's *PIP ELSMC13D* Data Sheet, phase loss protection shall be provided.

4.8.7 Motor Protection Devices

4.8.7.1 Motor protection device assemblies shall be rated to withstand the available fault current and shall be capable of operating continuously at rated current.

4.8.7.2 The adjustment range for the motor protection devices shall be suitable for the *NEC-2005*, Table 430.251(B), motor-locked rotor current, unless otherwise specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.9 Feeder Units

4.9.1 Circuit Breaker Units

4.9.1.1 Circuit breakers shall be of the molded case, thermal magnetic type, and shall provide inverse-time overcurrent protection and instantaneous short circuit protection. The breaker shall be rated to interrupt the available fault current as specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.9.1.2 Circuit breakers 250 amperes and smaller shall be plug in unless otherwise specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.9.1.3 Minimum breaker frame size shall be 100 amperes.

4.9.2 Fused Switch Units

4.9.2.1 Fused switches shall be heavy-duty continuous service type (with full locked rotor interrupting capacity) and shall have a current rating no less than that of the fuse clips.

4.9.2.2 Fused switches shall be capable of carrying the fault energy required to operate the fuses as specified on the purchaser's *PIP ELSMC13D* Data Sheet or the purchaser's attached documentation.

4.9.2.3 Internal assembly fastening methods shall be as specified by the fused switch manufacturer (torque on screws, bolts, etc.).

4.9.2.4 Fused switch contacts shall be visible with the switch and compartment door open.

4.9.2.5 Disconnects 250 amperes and smaller shall be plug in unless otherwise specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.9.2.6 Units shall be rated to withstand maximum available rated fault current.

4.9.2.7 If specified on the purchaser's *PIP ELSMC13D* Data Sheet, the supplier has the option to provide high set magnetic trip type molded-case switches in lieu of visible blade switches greater than the ampacity specified.

4.9.2.8 Fuse clips shall have momentary current capacity in excess of possible short-circuit current let through of the fuses specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.9.2.9 Fuse clips shall be tin plated or silver plated to prevent corrosion.

4.9.2.10 Fuse holder shall be compatible with fuse class, specified on the purchaser's *PIP ELSMC13D* Data Sheet or on the purchaser's attached documentation.

4.9.2.11 Fuses shall be UL, 600 V class specified on the purchaser's *PIP ELSMC13D* Data Sheet or on the purchaser's attached documentation, with a minimum interrupting rating of 200,000 amperes.

4.10 Space Heaters

4.10.1 Space heaters shall be provided if specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.10.2 Space heaters shall be provided to eliminate condensation within the section.

4.10.3 Heaters shall be located uniformly at the bottom rear of the vertical sections.

4.10.4 Space heaters shall be 120 VAC low sheath temperature operating at 160°C or less.

4.10.5 A metal cage or barrier shall be provided around the heaters to guard against accidental contact. Caution signs with black engraving on yellow background shall be provided on each vertical section stating: "Caution: Space Heaters May Be Energized Inside."

4.10.6 All heaters shall be wired to terminal blocks in a single junction box accessible from the front of the MCC. Wiring with a temperature rating suitable for connection to the heater element shall be used.

4.10.7 Feeder for space heater shall be provided by purchaser.

4.10.8 A molded case circuit breaker shall be installed on each heater circuit if specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.10.9 An adjustable thermostat control, or humidistat, shall be provided, as specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.10.10 A normally closed, momentary test push button and analog ammeter shall be provided if specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.11 Painting

Finish shall be supplier's standard unless otherwise specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.12 Nameplates

4.12.1 MCC and compartments shall be provided with nameplates as required by the *NEC* and as specified on the purchaser's nameplate schedule.

4.12.2 If specified on the purchaser's *PIP ELSMC13D* Data Sheet, nameplates shall be provided inside each starter to identify the door-mounted devices.

4.12.3 An MCC nameplate with 2-inch (50 mm) letters shall be located near the top of the MCC, above the main disconnect device. Nameplate shall be engraved per purchaser's nameplate schedule.

4.13 Inspection and Testing

4.13.1 Suppliers providing controllers to this Practice shall have subjected identical units to the interruption, current withstand, and dielectric withstand tests specified by NEMA *ICS 18* and its internal references.

4.13.2 After completion of the assembly and wiring of each controller, all the electrical and mechanical interlocks, control devices, protective relays, indicator lights, meters, and optional equipment provided shall be thoroughly tested to the extent required to guarantee a completely workable controller assembly before shipping.

4.13.3 Witness of function testing and production tests or other inspections shall be required if specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.14 Shipping

4.14.1 Supplier shall identify the following on each shipping group:

a. Purchase order number

b. Requisition number

c. MCC and section number(s)

d. Equipment number

e. Project number

4.14.2 Shipping assemblies shall be mounted on rigid skids for handling with a crane or forklift truck.

4.14.3 Protection by waterproof wrapper shall be provided.

4.14.4 Provided that the shipping split does not expose the MCC to the elements, the weatherproof wrapper will not be required for weatherproof enclosures.

4.14.5 Shipping bolts, supports, braces, etc., to be removed upon installation shall be painted red or yellow.

4.14.6 If the MCC is split for shipment, supplier shall provide detailed directions for re-assembly.

4.15 Documentation

4.15.1 Documentation Content

4.15.1.1 Documentation shall be furnished in approved electronic format unless otherwise specified on the purchaser's *PIP ELSMC13D* Data Sheet.

4.15.1.2 Drawings shall have a space on the right-hand bottom corner for the purchaser's title block.

4.15.1.3 Schematic drawings shall be provided for each starter size, type, and unique control wiring configuration.

4.15.2 Supplier Drawing and Data Requirements

Supplier shall provide one (1) reproducible set of drawings plus the specified number of copies of all documentation and operating manuals as specified on the purchaser's *PIP ELSMC13D* Data Sheet. Reproducible drawings shall be in CAD convertible .dxf electronic format.

Table 1. Documentation Requirements

A With Bid	B For Review	C Final Certified	D As Built	Description
	X	X	X	Detailed bill of Material
X	X	X	X	General layout of equipment, showing all dimensions, weights, location; outline drawings showing the final assembled configuration
	X	X	X	Schematic and connection wiring diagrams for all electrical equipment
X				List of accessories
		X(1)		Installation, operation, and maintenance manual
		X		Copies of certified test reports
			X	Final as-built drawings
X		X		Recommended spare parts list with pricing

Notes:

A. These documents shall be provided with the proposal.

B. These documents shall be provided for the purchaser's review and authorization to proceed before fabrication.

C. These documents shall be provided as part of the final certified document submittal.

(1) Equipment shall be shipped with one set of installation, operation, and maintenance manuals.

D. The final as-built documents shall be provided within 2 weeks following shipment.

4.16 Conflict Resolution

Any conflicts between the reference documents shall be identified in writing to the purchaser for resolution. If resolving conflicts, the following order of precedence shall apply:

a. Purchase Order

b. Purchaser's one line or load summary

c. *PIP ELSMC13D* Data Sheet

d. This Practice, *PIP ELSMC13*

e. Referenced Standards

COMPLETE REVISION
June 2004

Process Industry Practices
Electrical

PIP ELSMT01
AC Squirrel Cage Induction Motors (600 Volts and Below) Specification

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time by the responsible Function Team and will be reviewed every 5 years. This Practice will be revised, reaffirmed, or withdrawn. Information on whether this Practice has been revised may be found at www.pip.org.

PIP will not consider requests for interpretations (inquiries) for this Practice.

PRINTING HISTORY

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Process Industry Practices
Electrical

PIP ELSMT01
AC Squirrel Cage Induction Motors (600 Volts and Below) Specification

Table of Contents

1. Introduction

1.1 Purpose

This Practice provides requirements for manufacturing and testing AC squirrel cage induction motors.

1.2 Scope

This Practice describes the requirements for design, construction, and testing requirements for high-efficiency, totally enclosed, fan-cooled (TEFC) or nonventilated (TENV), single-speed, polyphase squirrel cage induction motors that are 600 volts and below.

This document is a complete revision of *PIP ELSMT01*, and therefore, revision markings are not provided.

2. References

2.1 Process Industry Practices (PIP)

- PIP ELSMT01D - *Data Sheet for ELSMT01 AC Squirrel Cage Induction Motors (600 Volts and Below)*

2.2 Industry Codes and Standards

- Institute of Electrical and Electronics Engineers (IEEE)
  - IEEE 841 - *Standard for Petroleum and Chemical Industry - Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - up to and including 370 kW (500 hp)*
- National Electrical Manufacturers Association (NEMA)
  - NEMA MG 1 - *Motors and Generators*
- National Fire Protection Association (NFPA)
  - NFPA 70 - *National Electrical Code (NEC)*

3. Definitions

purchaser: The party who awards the contract to the supplier. The purchaser may be the owner or the owner's authorized agent.

4. Requirements

4.1 Service Conditions

Equipment shall be designed to perform satisfactorily at the site conditions in accordance with the purchaser's *PIP ELSMT01D* Data Sheet.

4.2 General

4.2.1 The motor and its accessories shall be in accordance with the requirements contained in the latest edition of *IEEE 841* and *NEMA MG 1* unless specifically amended in this Practice or indicated otherwise on the purchaser's *PIP ELSMT01D* Data Sheet.

4.2.2 Motor enclosures shall be totally enclosed fan cooled (TEFC) or totally enclosed nonventilated (TENV).

4.2.3 The motor and its accessories shall be rated for continuous operation at 1.15 service factor with a 60-hertz sine wave supply voltage, unless indicated otherwise on the purchaser's *PIP ELSMT01D* Data Sheet.

4.2.4 The temperature rise of motor shall be limited to 80°C (176°F) at 1.0 service factor and 90°C (194°F) at 1.15 service factor.

4.2.5 Specific application and other requirements for each motor are given on the purchaser's *PIP ELSMT01D* Data Sheet.

4.2.6 All arc-producing devices such as sliding contacts, switching mechanisms, and resistance devices shall be suitable for the area classification as indicated on the purchaser's *PIP ELSMT01D*.

4.3. Mechanical Features

4.3.1 Mounting

4.3.1.1 The motor shall be horizontally mounted unless specified otherwise on the purchaser's *PIP ELSMT01D* Data Sheet.

4.3.1.2 If specified on the purchaser's *PIP ELSMT01D* Data Sheet, motors installed vertically with shaft end down shall have a noncorrosive drip cover over fan cover. Shield shall be designed to provide protection against wind-driven rain during operating and idle conditions.

4.3.1.3 If specified on the purchaser's *PIP ELSMT01D* Data Sheet, motors installed with shaft end up shall have a brass or aluminum slinger ring that has interference fit to shaft and is located within 1/2 inch (12.7 mm) of bearing housing. Slinger shall have a diameter large enough to provide protection during idle periods.

4.3.2 Terminal Box

4.3.2.1 Motor terminal boxes shall comply with requirements contained in Section 6.5 of *IEEE 841*-2001.

4.3.2.2 The location of terminal housing shall be assembly symbol F-1 as shown in *NEMA MG 1*-2003, Figure 4-6 (on the right-hand side, as seen from the nondrive end), unless specified otherwise on the purchaser's *PIP ELSMT01D* Data Sheet.

4.3.2.3 If specified on the purchaser's *PIP ELSMT01D* Data Sheet, an oversized terminal box shall be supplied.

4.4 Bearings

4.4.1 Bearings shall be regreasable without disassembly of fans or fan covers in accordance with *IEEE 841*-2001, Section 6.1(b).

4.4.2 Bearings shall be suitable for and supplied with rust-inhibiting grease compatible with polyurea-thickened grease.

4.4.3 Grease fittings shall only be supplied on motors with regreasable bearings.

4.4.4 Other types of bearing lubrication methods such as oil mist or nonregreasable factory-lubricated sealed bearings shall be provided if indicated on the purchaser's *PIP ELSMT01D* Data Sheet.

4.5 Fans

4.5.1 All fans shall be bidirectional unless otherwise indicated on the purchaser's *PIP ELSMT01D* Data Sheet.

4.5.2 If unidirectional fans are specified, the direction of rotation shall be indicated by permanent, legible markings.

4.5.3 Fans shall be made of nonsparking bronze alloy or conductive high-strength plastic.

4.6 Space Heaters

4.6.1 Space heaters shall be provided if specified on the purchaser's *PIP ELSMT01D* Data Sheet.

4.6.2 Space heaters and design shall be in accordance with *IEEE 841*-2001, Section 11.

4.6.3 Space heater leads shall be terminated in a housing separate from the motor terminal leads.

4.6.4 Space heaters shall be 120 volts unless otherwise specified on the purchaser's *PIP ELSMT01D* Data Sheet.

4.6.5 An engraved nameplate that contains the following statement shall be provided on the front of the motor terminal box:

CAUTION: SPACE HEATERS MAY BE ENERGIZED.

4.6.6 The exposed surface of space heaters shall not exceed 80% of the ignition temperature indicated on the purchaser's *PIP ELSMT01D* Data Sheet. The maximum surface temperature (based upon a 40°C [104°F] ambient temperature) shall be permanently marked on a visible nameplate mounted on the motor.

4.7 Terminal Leads

4.7.1 Terminal leads from the motor and space heaters shall be stranded copper conductors.

4.7.2 One terminal lead per phase shall be provided except for larger motors where two leads per phase may be furnished for large conductor sizes to allow for flexibility.

5. Inspection and Testing

5.1 The motor shall be tested in accordance with the applicable requirements in *IEEE 841*-2001, Section 9, unless specified otherwise on the purchaser's *PIP ELSMT01D* Data Sheet.

5.2 Additional special testing shall be performed if specified on the purchaser's *PIP ELSMT01D* Data Sheet.

6. Documentation

6.1 Certified copies of all test results shall be provided.

6.2 Supplier drawings and data requirements are given in Table 1.

TABLE 1 - DOCUMENTATION REQUIREMENTS

A	B	C	DESCRIPTION
X		X	Completed purchaser's *PIP ELSMT01D* Data Sheet and location of motor manufacture
X	X	X	Dimensional outline drawing showing weight, location of terminal boxes, and all accessories
		X	Certified test reports
		X	Installation, operation, and maintenance manual
		X	Recommended priced spare parts list
NOTES::			
A. These documents shall be provided with proposal.			
B. These documents shall be provided for purchaser's review and authorization to proceed before fabrication.			
C. These documents shall be provided as part of the final certified document submittal.			

6.3 Project Documents Precedence

Any conflicts between the following documents shall be identified to the purchaser in writing for resolution. If resolving conflicts, the following order of precedence shall apply:

a. Purchase order

b. *PIP ELSMT01D* Data Sheet(s)

c. This Practice, *PIP ELSMT01*

1. All components to be assembled into a single module.
2. Module will utilize an electronically controlled 24VDC fuel control valve.
3. Module will interface with new package controls.
4. Module will include fast action primary fuel shutoff valves and feedback control circuits.
5. Module will incorporate the following components:
    a. Electronic Fuel Valve – PECC (VL)
    b. Primary shutoff valve and control solenoid
    c. Liquid fuel purge drain solenoid
    d. Liquid Fuel pressure transmitter
    e. Liquid Fuel Boost pressure transmitter
    f. PCD Pressure Transmitter
    g. Flame out switch
    h. Air Inlet Temperature RTD
    i. Fuel valve check switch
    j. Torch Solenoids
    k. Torch drain back orifice
    l. Torch Check Valve
    m. Safety Relief valve
    n. Air Assist Solenoid
    o. Back Pressure Switch
    p. By Pass valve

EDITORIAL REVISION
February 2006

Process Industry Practices
Electrical

PIP ELSWC07
Shielded Power Cable Specification
(5 to 46 kV)

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time by the responsible Function Team and will be reviewed every 5 years. This Practice will be revised, reaffirmed, or withdrawn. Information on whether this Practice has been revised may be found at www.pip.org.

PIP will not consider requests for interpretations (inquiries) for this Practice.

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Process Industry Practices
Electrical

PIP ELSWC07
Shielded Power Cable Specification
(5 to 46 kV)

Table of Contents

1. Introduction

1.1 Purpose

This Practice provides requirements for the purchase of 5 kV- to 46 kV-rated shielded power cable.

1.2 Scope

This Practice describes the minimum technical requirements for design, material, construction, inspection, testing, and shipping of solid dielectric, insulated shielded copper cable. The scope is from 5 kV to 46 kV single and multiple conductor shielded power cables.

2. References

Applicable parts of the following Practices and industry codes and standards shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles will be used herein where appropriate.

2.1 Process Industry Practices (PIP)

- PIP ELSWC07D - *Data Sheet for* PIP ELSWC07, *Shielded Power Cables Rated 5 to 46 kV* (completed for application)

2.2 Industry Codes and Standards

- American Society for Testing Materials (ASTM)
  - ASTM B3 - *Soft or Annealed Copper Wire*
  - ASTM B8 - *Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft*
  - ASTM B496 - *Compact Round Concentric-Lay-Stranded Copper Conductors*
- Insulated Cable Engineers Association (ICEA)
  - ICEA S-93-639 (NEMA WC74) - *5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy*
- Institute of Electrical and Electronics Engineers (IEEE)
  - IEEE 1202 - *Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies*
- National Electrical Manufacturers Association (NEMA)
  - NEMA WC 26 - *Binational Wire and Cable Packaging Standard*
- National Fire Protection Association (NFPA)
  - NFPA 70 - *National Electrical Code (NEC)*

- Underwriters Laboratories
  - UL 1072 - *Medium-Voltage Power Cables*
  - UL 1569 - *Metal-Clad Cables*

3. Definitions

purchaser: The party who awards the contract to the supplier. The purchaser may be the owner or the owner's authorized agent.

supplier: The party responsible for furnishing the shielded power cables

4. Requirements

4.1 Design and Fabrication

4.1.1 Conductors

4.1.1.1 Conductor material shall be Class B, stranded, soft or annealed copper in accordance with *ASTM B3*, *ASTM B8*, or *ASTM B496* and configured as specified on the purchaser's *PIP ELSWC07D* Data Sheet.

4.1.1.2 Conductor diameter shall be in accordance with *ICEA S-93-639*.

4.1.2 Conductor Shield (Stress Control Layer)

The conductor shield shall be in accordance with *ICEA S-93-639*-2000, Section 3.

4.1.3 Insulation

4.1.3.1 Insulation shall be in accordance with *ICEA S-93-639*-2000, Section 4.

4.1.3.2 The insulation material, the voltage rating, and the insulation level shall be in accordance with the purchaser's *PIP ELSWC07D* Data Sheet.

4.1.3.3 Unless specified otherwise on the purchaser's *PIP ELSWC07D* Data Sheet, cable shall be rated at 90°C for normal operation, 130°C for emergency overload conditions, and 250°C for short-circuit conditions.

4.1.3.4 Unless specified otherwise on the purchaser's *PIP ELSWC07D* Data Sheet, individual conductor phase identification shall be manufacturer's standard.

4.1.3.5 Insulation thickness for shielded cables shall be in accordance with *NEC* Table 310.64 for wet and dry locations.

4.1.4 Insulation Shielding

4.1.4.1 Insulation shielding shall be in accordance with *ICEA S-93-639*-2000, Section 5.

4.1.4.2 Nonmetallic semiconducting covering shall be extruded and in accordance with *ICEA S-93-639*-2000, Table 5-2.

4.1.4.3 Unless otherwise indicated on the purchaser's *PIP ELSWC07D* Data Sheet, a nonmagnetic metal tape shield shall be applied directly over the semiconducting covering.

4.1.4.4 Unless otherwise specified on the purchaser's *PIP ELSWC07D* Data Sheet, the metal tape shall be minimum 5.0 mil bare copper, continuous length, and applied helically with a 12.5% minimum lap and in accordance with other requirements of *ICEA S-93-639* -2000, Section 6.

4.1.4.5 Shield drain wire(s) shall be supplied if specified on the purchaser's *PIP ELSWC07D* Data Sheet.

4.1.4.6 Shield drain wire(s) shall be bare and shall be in contact with the insulation shield to increase the short-circuit capacity.

4.1.5 Inner Conductor Jacket

4.1.5.1 If specified on the purchaser's *PIP ELSWC07D* Data Sheet, an inner jacket shall be provided over the conductor assembly. Wall thicknesses and tolerances shall be in accordance with *ICEA S-93-639*, Section 7.1.

4.1.5.2 Unless specified otherwise on the purchaser's *PIP ELSWC07D* Data Sheet, inner jacket material shall be PVC.

4.1.6 Ground Conductor(s)

Unless specified otherwise on the purchaser's *PIP ELSWC07D* Data Sheet, ground conductor(s) for multiple conductor cables shall be supplied and shall be Class B compressed, concentric stranded bare copper in accordance with *ASTM B3* and *ASTM B8*, sized in accordance with the following table:

Copper Power Conductor* Sizes	Minimum Grounding Conductor Size
8 AWG	8 AWG
6 - 2 AWG	6 AWG
1 - 2/0 AWG	4 AWG
3/0 AWG - 250 kcmil	3 AWG
300 - 400 kcmil	2 AWG
450 - 600 kcmil	1 AWG
750 - 1000 kcmil	1/0 AWG

*Note: Consult manufacturer for grounding conductors for larger cables.

4.1.7 Fillers and Binder Tape

For multiple conductor cables, the insulated single conductors shall be cabled together with nonhygroscopic filler material and an overall binder tape.

4.1.8 Armor Assembly

If specified on the purchaser's *PIP ELSWC07D* Data Sheet, *ICEA S-93-639*-2000, Section 7.3, Division I-type protective armor shall be provided for multiple conductor cables. The armor shall be in accordance with *UL 1569* for Type MC cables.

4.1.9 Outer Jacket

4.1.9.1 Unless otherwise specified on the purchaser's *PIP ELSWC07D* Data Sheet, an outer protective PVC jacket shall be applied over the completed cable assembly.

4.1.9.2 Jacket shall be in accordance with *ICEA S-93-639*-2000, Section 7.1.

4.1.9.3 Unless otherwise specified on the purchaser's *PIP ELSWC07D* Data Sheet, jacket color shall be manufacturer's standard.

4.1.9.4 Jacket shall be oil-resistant and sunlight-resistant in accordance with *UL 1072*.

4.1.10 Cable Flame Rating

Unless otherwise specified on the purchaser's *PIP ELSWC07D* Data Sheet, cable shall be flame-retardant and shall meet or exceed the testing requirements of *IEEE 1202*.

4.1.11 Cable Identification

The cable shall be marked and identified in accordance with *NEC*, Article 310.11. Cables shall be NEC Type MV, marked "Sunlight Resistant," "For Use in Cable Tray," and for "Direct Burial" in accordance with *UL 1072*.

4.1.12 Cable Length Tolerance

Unless otherwise specified on the purchaser's *PIP ELSWC07D* Data Sheet, the tolerance for the length of each segment of cable shall be minus 0% to plus 2%.

4.2 Inspection and Testing

4.2.1 Factory inspection and testing shall be performed on all cables in accordance with the following standards:

a. *ICEA S-93-639*-2000, Section 9

b. *IEEE 1202*

c. *UL 1072*

4.2.2 If specified on the purchaser's *PIP ELSWC07D* Data Sheet, optional testing as defined by the purchaser shall be performed.

4.3 Shipping

4.3.1 Cable Reel Identification

4.3.1.1 Minimum reel identification and marking shall be in accordance with *NEMA WC 26*.

4.3.1.2 Additional reel identification shall be provided as indicated on the purchaser's *PIP ELSWC07D* Data Sheet.

4.3.2 Test Lead

A minimum of 3 ft (0.91 m) of the inner end of the cable shall be left out of the test hole to facilitate field testing on the reel.

Comment: Cable may be field-tested on the reel for acceptance.

4.3.3 Pulling Eyes

If specified on the purchaser's *PIP ELSWC07D* Data Sheet, a factory-installed pulling eye shall be provided.

4.3.4 Preparation for Shipment

4.3.4.1 Cable shall be placed on the reel type specified on the purchaser's *PIP ELSWC07D* Data Sheet to protect it from damage during shipment. Each end shall be firmly secured to the reel.

4.3.4.2 Unless otherwise specified on the purchaser's *PIP ELSWC07D* Data Sheet, each length of cable shall be shipped on a separate reel.

4.3.4.3 All cable ends shall be sealed with heat-shrinkable-type protective caps.

4.3.4.4 Reel packaging and protective coverings shall be in accordance with *NEMA WC 26*. If specified on the purchaser's *PIP ELSWC07D* Data Sheet, wood lagging shall be used.

4.4 Documentation

4.4.1 Documentation for Quotation

The following information shall be provided by the supplier with quotations:

a. Standard and maximum reel lengths

b. Overall diameter of complete cable assembly

c. Cable weight

d. Individual conductor diameter

e. Minimum bending radius

f. Maximum conductor continuous operating temperature

g. Cable short-circuit withstand capacity presented in graphical form or by formula

h. Maximum pulling tension and sidewall loading for each conductor or cable assembly

June 2007

Process Industry Practices
Electrical

PIP ELSAP20
Low-Voltage Automatic Transfer Switch

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time.

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Process Industry Practices
Electrical

PIP ELSAP20
Low-Voltage Automatic Transfer Switch

Table of Contents

1. Introduction

1.1 Purpose

This Practice provides the requirements for low-voltage automatic transfer switches.

1.2 Scope

This Practice describes the requirements for the design, fabrication, inspection, testing, and shipping of factory-assembled low-voltage automatic transfer switches. This Practice does not cover fast transfer systems.

2. References

Applicable parts of the following Practices, industry codes and standards, and references shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 Process Industry Practices (PIP)

- PIP ELSAP20D - Data Sheet for *Low-Voltage Automatic Transfer Switch*

2.2 Industry Codes and Standards

- Underwriters Laboratories (UL)
  - UL 508 - Industrial Control Equipment
  - UL 1008 - Standard for Transfer Switch Equipment
- National Electrical Manufacturers Association (NEMA)
  - NEMA ICS 10 - AC Automatic Transfer Switches
- National Fire Protection Association (NFPA)
  - NFPA 70 - *National Electrical Code* (NEC)

3. Definitions

closed transition: Transfer switch equipment providing momentary paralleling of both power sources during transfer in either direction. This permits the transfer of electrical loads without a power interruption. The closed transition is possible only if the sources are properly interfaced and synchronized.

delayed transition: Provides a timed disconnection of the load from the power sources during transfer, primarily to allow decay of motor residual voltage.

open transition: Transfer of power between a normal and alternate power supply if the normal power supply is interrupted or falls outside set parameters. Transfer takes enough time so that motors previously operating on the normal supply lose residual voltage and can be restarted on the alternate supply.

owner: The party that owns the facility wherein the low-voltage automatic transfer switch will be used.

purchaser: The party who awards the contract to the supplier. The purchaser may be the owner or the owner's authorized agent.

supplier: The party responsible for providing the low-voltage automatic transfer switch.

4. Requirements

4.1 General

4.1.1 Unless otherwise specified on the purchaser's *PIP ELSAP20D* Data Sheet, the automatic transfer switch shall be mounted indoors.

4.1.2 If specified on the purchaser's *PIP ELSAP20D* Data Sheet, the automatic transfer switch shall include a bypass-isolation switch.

4.1.3 Unless otherwise specified on the purchaser's *PIP ELSAP20D* Data Sheet, the automatic transfer and bypass-isolation functions shall not use molded case circuit breakers, or contactors.

4.1.4 The automatic transfer switch and bypass-isolation switch shall be completely factory interconnected and tested so that only the line and load connections to the bypass-isolation switch are required for field installation.

4.1.5 Unless otherwise specified on the purchaser's *PIP ELSAP20D* Data Sheet, all interconnections between the transfer switch and bypass-isolation switch shall be silver plated copper bus bar.

4.1.6 Switch shall be dead front construction.

4.1.7 Microprocessor based controller(s) shall provide sensing, controlling, and logic programming for the automatic transfer switch.

4.1.8 Automatic transfer switch and bypass-isolation switch shall be in accordance with *NEMA ICS-10*.

4.1.9 Automatic transfer switch, complete with bypass-isolation switch and all accessories, shall be UL listed and labeled in accordance with *UL 1008.*

4.1.10 Automatic transfer switch shall have internal mechanical ground connections suitably sized for terminating stranded copper ground conductors.

4.1.11 Ground connections shall be located near incoming and outgoing power cable termination points.

4.2 Transfer Switch

4.2.1 Transfer switch shall be rated as specified on the purchaser's *PIP ELSAP20D* Data Sheet.

4.2.2 Automatic transfer switch shall be rated to close on, and withstand, the RMS symmetrical short circuit current specified on the purchaser's *PIP ELSAP20D* Data Sheet.

4.2.3 Unless otherwise specified on the purchaser's *PIP ELSAP20D* Data Sheet, the automatic transfer switch shall be "open transition" type.

4.2.4 If closed transition transfer is specified on the purchaser's *PIP ELSAP20D* Data Sheet, the automatic transfer switch shall have the following characteristics:

a. Interconnection time 100 milliseconds maximum

b. Operate as open transition switch if the primary power source fails

4.2.5 If delayed transition transfer is specified on the purchaser's *PIP ELSAP20D* Data Sheet, the automatic transfer switch shall have the following characteristics:

a. Adjustable delayed transfer time

b. Delayed transfer in both directions

4.2.6 Transfer switch shall be double throw (i.e., opens one set of contacts while closing the other set), electrically operated, and mechanically held.

4.2.7 Electrical operator shall be a momentarily energized, single-solenoid mechanism.

4.2.8 Transfer switch shall be mechanically interlocked to ensure only one of two switch positions (i.e., normal and alternate).

4.2.9 Switch contacts shall always be closed on a minimum of one of the sources. In-between positions shall not be permitted.

4.2.10 Switch shall be positively locked and unaffected by momentary power outages.

4.2.11 Main contacts shall be silver plated.

4.2.12 Inspection of all contacts shall be possible from the front of the switch without disassembling operating linkages and/or disconnecting power conductors.

4.2.13 Stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.

4.2.14 If switched neutral conductor is specified on the purchaser's *PIP ELSAP20D* Data Sheet, the automatic transfer switch shall be provided with fully rated overlapping neutral transfer contacts with the following characteristics:

a. Neutrals connected together only during the transfer and retransfer operations

b. Contacts overlap 100 milliseconds maximum

4.2.15 If solidly connected neutral conductor is specified on the purchaser's *PIP ELSAP20D* Data Sheet, a neutral conductor plate with fully rated AL-CU (aluminum-copper) pressure connectors shall be provided.

4.3 Bypass-Isolation Switch

4.3.1 A two-way bypass-isolation switch shall provide manual bypass of the load to either source and permit isolation of the automatic transfer switch from all source and load power conductors.

4.3.2 Bypass to load carrying source shall be accomplished with make before break contacts so that power is not interrupted to the load.

4.3.3 Main contacts shall be manually driven.

4.3.4 Electrical ratings of the bypass-isolation switch shall be equal to or greater than the associated automatic transfer switch.

4.3.5 Separate bypass and isolation handles shall be used to provide clear distinction between the functions. Handles shall be permanently affixed and operable without opening enclosure doors.

4.3.6 The bypass switch handle shall have the following operating modes:

a. Bypass to Normal

b. Automatic

c. Bypass to Alternate

4.3.7 Operating speed of the bypass contacts shall be the same as the automatic transfer switch and independent of the speed at which manual handle operates.

4.3.8 The isolation switch handle shall have the following operating positions:

a. Automatic / Closed

b. Test

c. Isolated / Open

4.3.9 "Test" position shall permit testing the automatic transfer switch without disturbing power to the load.

4.3.10 "Isolated / Open" position shall completely isolate the automatic transfer switch from both lines and load without removing line and load conductors.

4.3.11 When in the "Isolated / Open" position, it shall be possible to completely withdraw the automatic transfer switch for inspection and maintenance.

4.3.12 When the isolation switch is in the "Test" or "Isolated / Open" position, the associated bypass switch shall function as a manual transfer switch to permit load transfer to either source of power regardless of the position or condition of the transfer switch.

4.4 Microprocessor Controllers

4.4.1 Microprocessor based controller(s) shall be capable of operating at the ambient conditions specified on the purchaser's *PIP ELSAP20D* Data Sheet.

4.4.2 Control module(s) shall be provided with protective covers, mounted separately from transfer switch mechanism, and shall be easily disconnected for routine maintenance.

4.4.3 Unless otherwise specified on the purchaser's *PIP ELSAP20D* Data Sheet, RS 485 interface for serial communication shall be provided.

4.4.4 Purchaser connections shall be wired to a common terminal block to simplify field-wiring connections.

4.4.5 LCD displays and keypads for viewing data and setting operational parameters shall be provided as integral parts of controllers for viewing data and setting operational parameters.

4.4.6 LCD displays shall be provided with "System Status" screens that display clear descriptions of the active operating sequences and switch positions.

4.4.7 Operational parameters shall be settable either locally or remotely by way of serial communications.

4.4.8 Voltages and frequencies on both the normal and alternate sources shall be continuously monitored.

4.4.9 Pickup, dropout, and trip setting capabilities shall be provided in accordance with Table 1.

Table 1 – Pickup, Dropout, and Trip Settings

Parameter	Dropout / Trip	Pickup / Reset
Undervoltage	75 to 98%	85 to 100%
Overvoltage	105 to 110%	103 to 105%
Underfrequency	88 to 98%	90 to 100%
Overfrequency	103 to 105%	102 to 104%
Voltage unbalance	5 to 20%	1% below dropout

4.4.10 Unless otherwise specified on the purchaser's *PIP ELSAP20D* Data Sheet, transfer to an alternate power source shall be initiated upon reduction of the source voltage to 85% of nominal voltage and retransfer to normal shall be permitted when the source voltage restores to 90% of nominal voltage.

4.4.11 Unless otherwise specified on the purchaser's *PIP ELSAP20D* Data Sheet, the transfer to an alternate power source shall be initiated upon reduction of the source frequency to 90% and the retransfer to normal shall be permitted when the source frequency restores to 95%.

4.4.12 An adjustable time delay of 0 to 6 seconds minimum shall be provided to override momentary normal source outages and delay all transfer and engine starting signals. The default time delay setting shall be 1 second.

4.4.13 An adjustable time delay of 0 to 5 minutes minimum on transfer to the alternate power source shall be provided. The time delay shall be initially set at 0.

4.4.14 Unless otherwise specified on the purchaser's *PIP ELSAP20D* Data Sheet, retransfer to normal source shall be manually performed.

4.4.15 Controllers shall be capable of sensing the phase rotation of both the normal and emergency sources. A source shall be considered unacceptable if the phase rotation is not the preferred rotation selected.

4.4.16 Controllers shall be provided with diagnostic screens. The screens shall provide information on the status of input signals to the controllers that may prevent load transfer commands from being completed.

4.5 Optional Features

4.5.1 If specified on the purchaser's *PIP ELSAP20D* Data Sheet, the following signal lights shall be provided:

a. Green light to indicate that an automatic transfer switch is connected to the normal source

b. Red light to indicate that an automatic transfer switch is connected to the alternate power source

4.5.2 If specified on the purchaser's *PIP ELSAP20D* Data Sheet, auxiliary contacts, rated 10 amps at 250 VAC, shall be provided to indicate the following conditions:

a. Automatic transfer switch is connected to the normal source

b. Automatic transfer switch is connected to the alternate source

4.5.3 If specified on the purchaser's *PIP ELSAP20D* Data Sheet, a contact, rated 5 amps at 30 VDC, shall be provided for a low-voltage engine start signal.

4.5.4 If specified on the purchaser's *PIP ELSAP20D* Data Sheet, a test switch shall be provided to simulate normal source failure.

4.5.5 If specified on the purchaser's *PIP ELSAP20D* Data Sheet, one of the following capabilities shall be provided to test all indicator lights:

a. Push-to-test indicator lights

b. A push button

4.5.6 If specified on the purchaser's *PIP ELSAP20D* Data Sheet, microprocessor controller(s) shall provide an internal engine exerciser. The controller shall be capable of programming engine exercise routines. The following minimum programming functions shall be provided:

a. Enable and disable routine

b. Enable and disable transfer of load during routine

c. Set start time (i.e., time, day, week, and month)

d. Set duration of run period

e. At end of specified duration of engine exercise routine, switch shall transfer load back to normal and run engine for specified cool down period (applies only when the engine was exercised under operating load)

4.6 Enclosures

4.6.1 Main Enclosures

4.6.1.1 The main enclosure shall be constructed in accordance with *UL 508*.

4.6.1.2 Unless otherwise specified on the purchaser's *PIP ELSAP20D* Data Sheet, enclosures shall be NEMA 1.

4.6.1.3 All components and wiring connections shall be accessible from the front of enclosure.

4.6.1.4 Enclosures shall have lockable handles with a minimum of two keys provided.

4.6.1.5 Enclosure openings greater than 0.25 inch (6 mm) in width shall be provided with screens to prevent the entrance of snakes, rodents, etc. Screen mesh opening width shall be 0.25 inch (6 mm) maximum.

4.6.1.6 Unless otherwise specified on the purchaser's *PIP ELSAP20D* Data Sheet, finish shall be supplier's standard.

4.6.2 Space Heaters

4.6.2.1 If specified on the purchaser's *PIP ELSAP20D* Data Sheet, space heaters shall be provided.

4.6.2.2 Heaters shall be rated at 240 volts and sized to provide the required heat output when operated on a 120-volt system.

4.6.2.3 Space heaters shall be mounted on a stand-off insulator and provided with an expanded metal cage for personnel protection.

4.6.2.4 A caution plate, as shown in Figure 1, shall be provided on the door of a transfer switch if a space heater has been specified.

OBSERVE CAUTION
EXTERNAL POWER SOURCE
CONNECTED TO SPACE HEATER

Figure 1. Caution Plate

4.6.2.5 Unless specified otherwise on the purchaser's *PIP ELSAP20D* Data Sheet, circuits for space heaters shall be furnished by purchaser.

4.6.2.6 As specified on the purchaser's *PIP ELSAP20D* Data Sheet, either adjustable thermostat controls or high-temperature cutouts shall be provided.

4.6.2.7 If specified on the purchaser's *PIP ELSAP20D* Data Sheet, normally closed, momentary test push buttons, and analog ammeters shall be provided.

4.6.3 Nameplates

4.6.3.1 Prominent and detailed instruction plates shall be provided for convenient operation.

4.6.3.2 Nameplates shall be made of laminated plastic 3/32-inch thick minimum and shall be provided with stainless steel hardware.

4.6.3.3 In addition to external identification, door-mounted devices shall be identified inside the compartments. Inside nameplates may be adhesive type.

4.6.3.4 Nameplates shall be white with 1/4-inch-high minimum engraved black lettering.

4.6.3.5 Meters, relays, switches, and other devices on and within the transfer switch shall be permanently identified.

4.7 Inspection and Testing

4.7.1 Unless otherwise specified on the purchaser's *PIP ELSAP20D* Data Sheet, supplier's standard tests shall be performed.

4.7.2 If specified on the purchaser's *PIP ELSAP20D* Data Sheet, purchaser will witness supplier's standard tests.

4.7.3 If specified on the purchaser's *PIP ELSAP20D* Data Sheet, additional testing shall be performed.

4.7.4 Minimum testing shall include the following:

a. Mechanical operation tests to verify satisfactory operation

b. Electrical function tests to ensure proper operation of all devices and components

4.8 Shipping

4.8.1 Unless otherwise specified on the purchaser's *PIP ELSAP20D* Data Sheet, preparation for shipment shall be in accordance with supplier's standards.

4.8.2 Loose equipment shall be appropriately packaged and secured for shipment inside enclosures or shipping containers.

4.8.3 Loose equipment shall be properly tagged for easy identification.

4.9 Documentation

4.9.1 Documentation Content

4.9.1.1 Drawings and data of the type and quantity shown in Table 2 and the purchaser's *PIP ELSAP20D* Data Sheet shall be submitted.

4.9.1.2 Unless otherwise specified on the purchaser's *PIP ELSAP20D* Data Sheet, drawings shall be provided in approved electronic format.

4.9.1.3 Drawings shall have a space on the right-hand bottom corner for the purchaser's title block.

4.9.1.4 A tabulation of factory settings for all adjustable devices in the automatic transfer switch as shipped shall be provided.

4.9.2 Conflict Resolution

Any conflicts between the reference documents shall be identified in writing to the purchaser for resolution. If resolving conflicts, the following order of precedence shall apply:

a. Purchase Order

b. *PIP ELSAP20D* Data Sheet

c. This Practice, *PIP ELSAP20*

d. Referenced Standards

Table 2 – Documentation Requirements

A With Bid	**B For Review**	**C Final Certified**	**D As Built**	**Description**
	X	X	X	Detailed bill of materials
X	X	X	X	General layout of equipment, showing all dimensions, weights, location; outline drawings showing the final assembled configuration
	X	X	X	Schematic and connection wiring diagrams for all electrical equipment
	X	X	X	Single-line, 3-line, and control schematic diagrams
X				List of accessories
		X		Tabulation of factory settings
		X(1)		Installation, operation, programming, and maintenance manual
		X		Copies of certified test reports
			X	Final as-built drawings
X		X		Recommended spare parts list with pricing

Notes:

A. These documents shall be provided with the proposal.

B. These documents shall be provided for the purchaser's review and authorization to proceed before fabrication.

C. These documents shall be provided as part of the final certified document submittal.

(1) Equipment shall be shipped with one set of installation, operation, and maintenance manuals.

D. The final as-built documents shall be provided within 2 weeks following shipment.

COMPLETE REVISION
July 2004

Process Industry Practices
Electrical

PIP ELSGS01
Design and Fabrication of High-Resistance Grounding System (600 Volts or Below)

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time by the responsible Function Team and will be reviewed every 5 years. This Practice will be revised, reaffirmed, or withdrawn. Information on whether this Practice has been revised may be found at www.pip.org.

PIP will not consider requests for interpretations (inquiries) for this Practice.

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Process Industry Practices
Electrical

PIP ELSGS01
Design and Fabrication of High-Resistance Grounding System (600 Volts or Below)

Table of Contents

1. Introduction

1.1 Purpose

This Practice provides requirements for fabricators of high-resistance grounding systems.

1.2 Scope

This Practice and the purchaser's data sheet, *PIP ELSGS01D*, define minimum requirements for design, fabrication, testing, and documentation of 600-volts class, three-phase, high-resistance grounding systems installed in non-classified areas.

This document is a complete revision of *PIP ELSGS01*, and, therefore, revision markings are not provided.

2. References

Applicable parts of the following Practices and industry codes and standards shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles will be used herein where appropriate.

2.1 Process Industry Practices (PIP)

– PIP ELSGS01D - *Data Sheet for Design and Fabrication of High-Resistance Grounding System (600 Volts or Below)*

2.2 Industry Codes and Standards

- Institute of Electrical and Electronic Engineers (IEEE/ANSI)
  - IEEE 32 - *IEEE Standard Requirements, Terminology, and Test Procedure for Neutral Grounding Devices*
  - IEEE/ANSI C37.20.1. - *IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear*
  - NFPA 70 - *National Electrical Code*

3. Definitions

owner: The party who owns the facility wherein the high-resistance grounding system will be used

purchaser: The party who awards the contract to the supplier. The purchaser may be the owner or the owner's authorized agent.

supplier: The party responsible for furnishing and/or installing the high-resistance grounding system

4. Requirements

4.1 General

4.1.1 Unless otherwise specified on the purchaser's data sheet, *PIP ELSGS01D*, the grounding system shall ground the power system using high-resistance grounding principles so that the ground fault current is limited to an adjustable value of approximately 1 to 5 amperes during a phase-to-ground fault condition.

4.1.2 The grounding system shall be capable of producing a pulsing current into the ground fault that can be traced to the fault with a multi-range portable clamp-on ammeter. Pulsing current shall be at least 3 amperes more than the setting of the ground fault current.

4.1.3 An adjustable time delay for ground fault alarm activation of approximately 0.2 to 2.0 seconds shall be provided to allow override of a momentary ground fault alarm condition.

4.1.4 The grounding system shall continuously monitor the ground current in the electrical system neutral and indicate ground fault by means of an overcurrent relay.

4.1.5 A resistor shall be provided to initiate a controlled fault on one phase if the system test push button is pressed. This test resistor circuit shall be inhibited if a system ground fault is indicated by the ground fault relay.

4.1.6 The grounding system shall have normally closed (open to alarm) contacts to provide remote indication of ground fault and loss of control voltage conditions.

4.1.7 Unless otherwise specified on the purchaser's data sheet, *PIP ELSGS01D*, a control power source from within the equipment shall be provided.

4.1.8 Unless otherwise specified on the purchaser's data sheet, *PIP ELSGS01D*, the grounding system shall be designed for operation on a 480-volt line-to-line (L-L) system.

4.1.9 The grounding system shall be suitable for use on a wye or delta configuration as specified on the purchaser's data sheet, *PIP ELSGS01D*.

4.1.10 If a delta system configuration is specified, three (3) single-phase neutral-deriving, dry-type 220°C insulation, 80°C rise, 120-volt secondary transformers shall be provided.

4.1.11 Equipment shall be labeled by a nationally recognized testing laboratory (NRTL).

4.2 Site Conditions

4.2.1 The grounding system shall operate at the altitude indicated on the purchaser's data sheet, *PIP ELSGS01D*, without de-rating.

4.2.2 The grounding system shall be designed for the building code and seismic zone indicated on the purchaser's data sheet, *PIP ELSGS01D*.

4.2.3 Unless otherwise specified on the purchaser's data sheet, *PIP ELSGS01D*, the grounding system shall be capable of operating continuously at rated output in an ambient temperature range of 32°F (0°C) to 104°F (40°C).

4.2.4 The grounding system shall operate over the entire temperature range at a relative humidity of 5% to 95% non-condensing.

4.3 Enclosure

4.3.1 Unless otherwise specified on the purchaser's data sheet, *PIP ELSGS01D*, the grounding system shall be integrated into the switchgear or motor control center enclosure.

4.3.2 Unless otherwise specified on the purchaser's data sheet, *PIP ELSGS01D*, the grounding system enclosure material shall be consistent with the switchgear or motor control center enclosure.

4.3.3 Unless otherwise specified on the on the purchaser's data sheet, *PIP ELSGS01D*, enclosure type shall be NEMA 1.

4.3.4 Energized parts operated at or above 50 volts shall be guarded.

4.3.5 Each enclosure compartment shall have hinged access doors.

4.3.6 All grounding system components and connection points shall be visible and shall be safely and easily accessible from the front of the enclosure.

4.3.7 Outdoor enclosures shall have hinged front panels with inner dead-front construction. Metering and controls shall be accessible without the use of tools.

4.3.8 Grounding system components shall be mounted on suitable back plates on the inside of the enclosure.

4.3.9 Enclosure ventilation openings shall have 1/8-inch mesh vermin-proof screens made of 304 stainless steel. Screens shall be located on the inside of the openings.

4.3.10 Bolts and nuts on removable panels shall be captive type.

4.3.11 Bolting and hardware shall be corrosion resistant.

4.3.12 All disconnect devices shall have a means for padlocking in the OFF position.

4.3.13 Unless otherwise specified on the purchaser's data sheet, *PIP ELSGS01D*, grounding systems not installed inside switchgear or motor control centers shall have cable entry from the bottom.

4.4 Control System

4.4.1 Control system shall include the following components, unless included as part of a digital control unit:

a. One (1) ammeter (0 to 5 A movement) to indicate ground current if a ground occurs on the system. Ammeter shall have suitable range to indicate maximum pulsing current.

b. Neutral current transformer

c. Test push-button to simulate a ground-fault condition

d. Reset push-button to reset the system

e. A red indicating light to indicate ground fault

f. A green indicating light to indicate normal condition

g. A ground current test loop and a test current test loop in resistor wiring that allow the use of a clamp on ammeter to measure ground current

h. A provision for selection of normal or pulse operation

i. A holding relay with two additional normally open and two normally closed contacts for use by the purchaser. Holding relay contacts shall be connected to terminal blocks for purchaser connections.

j. Unless otherwise specified on the purchaser's data sheet, *PIP ELSGS01D,* a switchgear class overcurrent relay in a drawout case with a minimum pickup current of 0.5 amperes or less

k. A filter to eliminate nuisance alarms if the overcurrent detection and alarm system is not inherently insensitive to adjustable speed drive carrier frequency and other harmonics

l. An undervoltage relay with two normally open and two normally closed contacts for remote indication of loss of control power. The contacts shall be connected to terminal blocks for purchaser's connections.

m. A pulsing contactor set to produce approximately 40 current pulsations per minute

n. A timer for the pulsing contactor

o. A control power transformer with secondary fuses

4.4.2 All indicating lights shall be replaceable high-brightness, single-element light-emitting diode (LED) lamps. A push to test function shall be provided for each light.

4.5 Disconnect Switch

4.5.1 The grounding system shall have a disconnect device for isolation of control power.

4.5.2 If specified on the purchaser's data sheet, *PIP ELSGS01D*, for a wye system, a disconnect switch shall be provided for the neutral connection.

4.5.3 If specified on the purchaser's data sheet, *PIP ELSGS01D*, for a delta system, a disconnect switch shall be provided for the neutral deriving transformer.

4.5.4 The disconnect device shall be prominently marked to warn that, if the device is opened, the power system will be ungrounded.

4.6 Resistors

4.6.1 The grounding system shall have continuous rated, wire or edge wound resistors of corrosion resistant material.

4.6.2 Resistors shall be rated to operate at 277-volts AC minimum.

4.6.3 For systems operating at 550 and 600 volts, resistors shall be rated at 350 volts AC minimum.

4.6.4 Resistor assembly shall have a minimum of four adjustable taps or shall be continuously adjustable.

4.6.5 Resistors shall be mounted on standoffs designed so that the surface temperature of the surrounding enclosure does not increase more than 20°C above ambient temperature during fault conditions.

4.7 Portable Ground Current Detector

4.7.1 The grounding system shall be designed to function in conjunction with a portable, clamp-on ground current detector.

4.7.2 Unless otherwise specified on the purchaser's data sheet, *PIP ELSGS01D*, the system shall be furnished with a portable ground current detector.

4.7.3 Portable ground current detector shall be provided with:

a. A multi-range switch for accurate measurement of pulsing current

b. A large window that is suitable for conduits with a nominal diameter of up to 5 inches

c. A removable arm to facilitate use of the detector in limited spaces in which conduits/cables are close together

d. A shorting switch to provide transient protection while detector is being positioned around conductors

e. A closed magnetic field to minimize effects of stray fields

f. An insulated handle for use on systems rated up to 4,160 volts nominal

g. A carrying case

4.8 Wiring

4.8.1 General

4.8.1.1 All wiring shall be stranded copper conductors.

4.8.1.2 Power and control wiring shall be #14 AWG minimum.

4.8.1.3 Wiring from transformer neutral to switchgear shall be #8 AWG, minimum.

4.8.1.4 Current transformer (CT) wiring shall be #10 AWG conductor minimum, unless device terminals do not allow the use of #10 conductor.

4.8.1.5 Wiring insulation shall be rated for 600 volts and a conductor temperature of 90°C minimum.

4.8.1.6 A separate, properly labeled terminal strip shall be provided for connection to remote devices.

4.8.1.7 Spare relay contacts shall be wired to terminal blocks.

4.8.1.8 Exposed wiring shall be neatly bundled, protected against contact with sharp edges, and secured with wire ties. Adhesive-back wire supports shall not be used to support wiring.

4.8.1.9 All wiring, except CT wiring, shall be terminated with seamless, insulated, locking-fork type lugs, unless device terminals do not allow their use.

4.8.1.10 CT circuit wiring shall be terminated with insulated, ring-type lugs, unless device terminals do not allow their use.

4.8.1.11 Wiring to the resistor shall be rated for the operating temperature of the resistor.

4.8.2 Terminal Blocks

4.8.2.1 Terminal blocks shall be front-accessible, rated for 600 volts, and suitable for holding spade and ring-type lugs.

4.8.2.2 A maximum of two wires shall be connected at each side of each terminal.

4.8.2.3 All purchaser-connected wiring shall be connected on one side of the terminal block provided for external connections.

4.8.2.4 Separate terminal blocks shall be provided for terminating the incoming neutral connection, the outgoing connection to ground, and the connection to an external source of 120-volt AC control power if required.

4.8.2.5 Each CT circuit shall be terminated in a properly identified shorting-type terminal block.

4.8.2.6 A separate, suitably marked terminal strip shall be provided for all resistor taps and to allow changing of taps from the front. An engraved nameplate indicating various tap connections shall be provided near this terminal strip.

4.8.3 Labeling

4.8.3.1 Each wire shall have permanent wire labels at both ends. Labels shall be consistent with wiring diagrams. Adhesive-type wire labels are not acceptable.

4.8.3.2 Relays, fuse blocks, terminal blocks, and other auxiliary devices shall be labeled with nameplates.

4.9 Space Heaters

4.9.1 All enclosures shall have space heaters.

4.9.2 Space heaters shall be rated for 240 volts and operated at 120-volts AC.

4.9.3 Unless specified otherwise on the purchaser's data sheet, *PIP ELSGS01D*, space heaters shall be controlled by a thermostat that shall be adjustable between 15°C (59°F) and 30°C (86°F).

4.9.4 Space heaters shall be completely wired for connection to an external power source.

4.9.5 Space heater load shall be as specified on the purchaser's data sheet, *PIP ELSGS01D.*

4.9.6 Space heaters shall be provided with expanded metal cages to protect personnel from contact with the hot surface.

4.9.7 Wiring to the space heater terminals shall be rated for the temperature of the heater.

4.9.8 Maximum sheath temperature of space heaters shall be 200°C.

4.10 Painting

4.10.1 External and internal steel surfaces of grounding system enclosure shall be painted.

4.10.2 Unless otherwise specified on the purchaser's data sheet, *PIP ELSGS01D*, paint color shall be *ANSI 61* light gray.

4.10.3 Unless otherwise specified on the purchaser's data sheet, *PIP ELSGS01D*, interior color shall be manufacturer's standard.

4.10.4 The finish coat shall be free from craters, pinholes, holidays, embedded foreign matter, and other visual defects.

4.10.5 The topcoat shall provide complete hiding, consistent coverage and thickness, and uniform color.

4.10.6 For outdoor and indoor service in non-corrosive environments, the supplier's standard surface preparation and coating system are acceptable if applied in accordance with the coating manufacturer's written instructions and if the finish coat is for outdoor use.

4.10.7 For service in corrosive environments, the painting and protective coatings shall be in accordance with the purchaser's data sheet, *PIP ELSGS01D.*

4.10.8 A 1-pint (0.5-L) container of paint shall be provided for field touch-up.

4.11 Nameplates

4.11.1 Unless otherwise specified on the purchaser's data sheet, *PIP ELSGS01D*, nameplates shall be made of laminated plastic with black engraved lettering on white background. Lettering shall be 1/4 inch high, minimum.

4.11.2 Nameplates shall be attached with stainless steel screws.

4.11.3 An instruction nameplate shall be on the front of the enclosure of the grounding system with complete step-by-step instructions for normal operation, ground fault detection, and test procedures. Instruction nameplate shall have engraved black lettering on white background.

4.11.4 Each main component on the front of the enclosure shall have a nameplate that indicates the name or function of the component.

4.11.5 Auxiliary equipment on the back or on the inside of the enclosure shall have nameplates indicating the name of the device as indicated on the control schematic drawing. The inside nameplates can be a permanent adhesive type.

4.11.6 If the grounding system has more than one source of external power, warning nameplates indicating multiple sources of power shall be provided.

4.12 Identification (ID) Tag

4.12.1 An ID tag made of laminated plastic with black figures on a white background shall be provided.

4.12.2 The tag shall list the *Equipment No.*, *Purchase Order No*., and *Project No.* as specified on the purchaser's data sheet, *PIP ELSGS01D*.

4.12.3 The ID tag shall also contain supplier's name, date, and location of manufacture, and information for complete identification of the equipment.

4.13. Testing

4.13.1 If specified on purchaser's data sheet, *PIP ELSGS01D*, manufacturer's standard tests, including a complete functional, operational, and point-to-point check of the wiring, shall be performed.

4.13.2 If specified on purchaser's data sheet, *PIP ELSGS01D*, purchaser shall witness tests.

4.13.3 A certified test report shall be provided before shipment of the grounding system.

4.13.4 Dielectric tests shall be performed in accordance with *ANSI/IEEE C37.20.1* and *IEEE 32*-1972, 10.3.

4.14 Documentation

4.14.1 Drawings shall provide a space on the right-bottom corner for purchaser's title block.

4.14.2 Schematic drawings shall include the following information as a minimum:

a. Complete schematic diagram with item numbers corresponding to bill of materials

b. Operation and contact arrangement of overcurrent and control relays

c. All resistor taps for various ground fault currents and pulsating current arrangement

d. Cross-reference to bill of materials and other drawings

4.14.3 Instructions for testing the power system to determine its normal capacitive charging current shall be provided.

4.14.4 Drawings submitted for approval shall include factory default setting of taps.

4.14.5 Documentation of the type and quantity shown in Table 1 and the purchaser's data sheet, *PIP ELSGS01D*, shall be provided.

4.14.6 One reproducible set of drawings and the specified number of copies of all documentation and operating manuals as indicated on the purchaser's data sheet, *PIP ELSGS01D*, shall be provided.

4.14.7 Unless otherwise specified on the purchaser's data sheet, *PIP ELSGS01D*, format for reproducible drawings shall be CAD convertible .dxf electronic format.

TABLE 1 - DOCUMENTATION REQUIREMENTS

A	B	C	D	DESCRIPTION
	X	X	X	Detailed bill of material
X	X	X	X	General layout of equipment, showing all dimensions, weights, location, and outline drawings, showing the final assembled configuration
		X	X	Connection wiring diagrams for all electrical equipment
	X	X	X	Single-line, 3-line, and control schematic diagrams
		X		Certified test reports
		X(1)		Installation, operation, and maintenance manual
			X	Final as-built drawings
X		X		Recommended priced spare parts list
NOTES:				
A. These documents shall be furnished with proposal.				
B. These documents shall be furnished for purchaser's review and authorization to proceed before fabrication.				
C. These documents shall be furnished as part of the final certified document submittal.				
(1) Equipment shall be shipped with one set of installation, operation, and maintenance manuals.				
D. The final as-built documents shall be furnished within 2 weeks following shipment.				

4.15 Conflict Resolution

Any conflicts between the referenced documents shall be identified to the purchaser in writing for resolution. In general, when resolving conflicts, the following order of precedence shall apply:

a. One-line diagram

b. *PIP ELSGS01D* Data Sheet

c. This Practice, *PIP ELSGS01*

d. Referenced standards

i. Descriptive literature (catalogs, etc.)

4.4.2 Documentation at Time of Shipping

The following information shall be provided to the purchaser:

a. Certified test reports at time of shipment

b. X-Y plot of the partial discharge test, supplied within 2 weeks after shipment

4.5 Conflict Resolution

Any conflicts between the referenced documents shall be identified in writing to the purchaser for resolution. In general, if resolving conflicts, the following order of precedence shall apply:

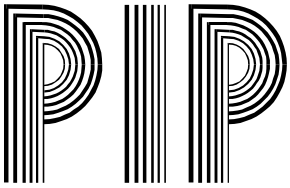
a. Purchase order

b. *PIP ELSWC07D* Data Sheet

c. This Practice, *PIP ELSWC07*

d. Other referenced standards

March 2001



Process Industry Practices
Electrical

PIP ELTFT01
Field Inspection and Testing of New Electrical Equipment

PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time by the responsible Function Team and will be reviewed every 5 years. This Practice will be revised, reaffirmed, or withdrawn. Information on whether this Practice has been revised may be found at http://www.pip.org.

Process Industry Practices
Electrical

PIP ELTFT01
Field Inspection and Testing of New Electrical Equipment

Table of Contents

1. Introduction

1.1. Purpose

This Practice provides the minimum requirements for field inspection and testing of new electrical equipment and facilities installed in a process industry application.

1.2. Scope

This Practice covers inspection and testing procedures for new low- and medium-voltage electrical facilities in a process industry. Minimum acceptable values for the testing results are included in this specification. Forms for recording inspection and test values are also included.

Certain specialty equipment and packaged equipment are application specific and are not covered by this Practice.

Some inspections and tests may require an independent testing organization or an equipment manufacturer's representative. It is outside the scope of this Practice to define which tests require a third party or to designate responsibility for obtaining and coordinating these third parties. When necessary, these tests will be defined in the project scope.

This Practice does not cover full compliance inspections required by various codes and regulations but does provide assurance of equipment integrity and compliance with project-specific documents.

2. References

2.1. Process Industry Practices (PIP)

- PIP ELTFT01D - *Field Inspection and Testing of New Electrical Equipment Data Sheet*

2.2. Industry Codes and Standards

- American National Standards Institute (ANSI)
- Institute of Electrical and Electronics Engineers (IEEE)
  - ANSI/IEEE Std. 141-1993 (R1999) - *Recommended Practice for Electric Power Distribution for Industrial Plants*
  - ANSI/IEEE Std. 81-1983 - *Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System*
  - ANSI/IEEE Std. 95-1977 (R1991) - *Recommended Practice for Insulation Testing of Large AC Rotating Machinery with High Direct Voltage*
  - ANSI/IEEE C57.13.1-1981 (R1999) - *Guide for Field Testing of Relaying Current Transformers*

  - IEEE 576-2000 - *Recommended Practice Installation, Termination, and Testing of Insulated Power Cable as Used in the Petroleum and Chemical Industry*

- International Electrical Testing Association (NETA)
  - NETA ATS-1999 - *Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (NETA ATS)*

3. Definitions

Check: Inspection to verify conformance with drawings and specifications; does not require witnessing by Owner's authorized representative.

CPT: Control power transformer

CT: Current transformer

Function test: A complete operational check of the entire system; requires witnessing by authorized representative unless waived in writing.

Inspect: A detailed physical inspection of equipment to verify conformance to drawings and specifications; requires witnessing by Owner's authorized representative unless waived in writing

MCC: Motor control center

PT: Potential transformer

Test: Application of external power source or test equipment to prove the integrity of the unit or system; requires witnessing by Owner's authorized representative unless waived in writing.

Tester: The party responsible for conducting the check items, inspection items, testing requirements, and function test items as covered herein for installed electrical equipment and electrical facilities as defined in the project scope

4. General

4.1 The Tester shall comply with all federal, state, and local regulations and codes as well as with site-specific safety procedures and requirements.

4.2 Before beginning any inspection and testing, the Owner and the Tester must agree on the electrical inspection and testing procedures.

4.3 Tester shall confirm that all check items, inspection items, and testing are performed before placing any equipment in operation.

4.4 The Tester shall be responsible for arranging and conducting the testing per the approved project schedule.

4.5 The Tester shall be responsible for maintaining the individual test sheets and the project master checkout sheet as defined in the project scope. These sheets shall be maintained in an up-to-date condition and are subject to review at any time. These sheets shall be submitted to the Owner's project electrical representative in final format at the completion of the project.

4.6 All components with test results that fall outside the acceptable range and individual measurements that fall outside the average of like measurements by 25 percent difference shall be immediately brought to the Owner's attention.

4.7 Inspection items, testing, and function test items shall be witnessed by an Owner's authorized representative unless specifically waived in writing. Tester shall give sufficient notice before any witnessed test.

4.8 Copies of the test results shall be submitted in preliminary form to the Owner's authorized representative within five (5) working days after each test. These preliminary results shall be submitted and approved by Owner before placing any equipment in operation.

4.9 Tester shall transmit all final testing forms to the Owner.

5. Acceptable Measurements

5.1 Insulation resistance tests shall be made at the following voltages with respect to the circuit voltage rating:

Volts DC	Circuit Rating (V)
500	0 - 300 volts
1000	301 - 600 volts
2500	601 - 2500 volts
5000	2501 volts and above

All circuit conductors shall be tested phase to phase and phase to ground. A phase-to-ground test on shielded cable shall mean "conductor to shield." Insulation resistance for wire and cable shall be corrected to 60°F (15.6°C). Insulation resistance for all other equipment items shall be corrected to 104°F (40°C). The measured insulation resistance values shall not be less than the following values.

5.1.1 Motors:

460 volt, cold machine	15 megohms
2300 volt, cold machine	25 megohms
Above 2300 volt, cold machine	75 megohms

5.1.2 Transformer windings in which all windings are grounded except the one under test:

Transformer (V)	Liquid (Oil)	Dry
0 - 600	100 megohms	500 megohms
601 - 5000	1000 megohms	5000 megohms
5001 - 15,000	5000 megohms	25,000 megohms

5.1.3 Switchgear buses, circuit breakers, motor control centers, and panelboards:

250 volt and below	25 megohms
600-volt equipment	100 megohms
2400-volt equipment	500 megohms
Equipment rated above 2400 volts	2000 megohms

5.1.4 For 600-volt-rated cables, insulation resistance shall not be less than 50 megohms.

5.1.5 For instrument and control conductors rated 300 volts and below, the insulation resistance shall not be less than 1 megohm.

5.1.6 For cables rated above 600 volts, minimum insulation resistance per 1000 feet of cable shall not be less than that calculated with the formula below:

R = k log10 D/d, where:

R = insulation resistance in megohms/1000 ft

k = insulation constant

D = diameter over insulation

d = conductor diameter

The calculated values of insulation resistance shall be rounded to the next lower 100-megohm value. For armored cables, the calculated insulation resistance shall be reduced to 80 percent and then rounded off to the nearest 100-megohm value. For lengths other than 1000 feet, the insulation resistance is inversely proportional to the cable length.

Insulation constant (k) values for different insulations are as follows:

Insulation Type	k
Ethylene propylene rubber (EPR)	20,000
Cross-linked polyethylene (XLP)	20,000
Butyl rubber	10,000
Thermoplastic	2000

5.2 The values from transformer turns ratio (TTR) tests shall not deviate more than 1/2 percent from either the adjacent coils or the calculated ratio given in *NETA ATS-1999*, paragraph 7.2.2.3.6.

5.3 The oil in all oil-filled equipment rated 69 kV and below shall be tested and shall meet the values shown in the following table (based on *NETA ATS-1999*, Table 10.4).

Test	Value
Dielectric breakdown, kV minimum	30
Dielectric breakdown, kV minimum @ 0.04" gap	20
Dielectric breakdown, kV minimum @ 0.08 gap	40
Interfacial tension mM/m minimum	35
Neutralization number, mg KOH/g maximum	0.03
Water content, ppm maximum	25
Power factor at 25ºC, %	0.15
Power factor at 100ºC, %	1.50
Color	1.0
Visual condition	Bright & clear

5.4 All ground resistance measurements shall be made by equipment utilizing the "fall of potential" method per *ANSI/IEEE Std. 81*. Maximum ground resistance for all electrical equipment is 5 ohms unless specified otherwise.

5.5 The test voltage for the DC step voltage test on medium-voltage switchgear and other non-inductive equipment shall be as shown in the following table (based on *NETA ATS-1999*, Table 10.11), unless specified otherwise by the Owner.

Insulation Class	Maximum Field-Applied DC Test (kV)
1.2	8.5
2.5	12.7
5.0	16.1
8.7	22.1
15.0	28.8
18.0	33.9
25.0	42.4
35.0	59.4
46.0	80.6
69.0	118.8

5.6 The maximum acceptable value of combustible gases for the transformer gas chromatograph (GC) test is 500 ppm.

5.7 Minimum acceptable polarization index for the dielectric absorption test on medium-voltage motor circuits is 2.0. For transformers, the minimum acceptable polarization index shall be according to the manufacturer's recommendations. If manufacturer's data are not available, the acceptance test results will serve as baseline data for future tests.

5.8 Maximum contact resistance for medium-voltage breakers and contactors shall meet manufacturer's recommendations. If manufacturer's data are not available, the resistance shall not vary between phases by more than 25 percent.

6. Grounding Systems

6.1. Below Ground

The following checks and inspections shall be performed before backfilling or concrete pouring:

6.1.1 Check that grounding system is in compliance with drawings and specifications.

6.1.2 Check ground well installations for accessibility to ground rods.

6.1.3 Inspect all underground splices.

6.1.4 Inspect all internal foundation ground connections.

6.1.5 Check ground grid and ground loop wire sizes and color identification.

6.2. Above Ground

6.2.1 Check that grounding system is in compliance with drawings and specifications.

6.2.2 Check all connections for tightness.

6.2.3 Check installations for mechanical protection of ground wire.

6.2.4 Test each ground loop segment for continuity between ground wells or ground terminal bars.

6.2.5 Test each main ground grid for resistance to earth using the fall of potential method. All connections to other ground grids shall be disconnected while performing this test.

6.2.6 Individual tests of resistance to earth shall be performed using the fall of potential method for the following equipment after their connection to the ground grid:

1. Electrical system neutral grounding locations
2. Switchgear ground bus (all voltage levels)
3. Grouped motor control centers ground bus (all applicable voltage levels)

4. Switchrack, transformer, and medium-voltage switch ground connections

7. Medium-Voltage Switchgear

7.1 Equipment and Installation Check Items

7.1.1 Check switchgear assembly for alignment, levelness, and tightness of all bolting.

7.1.2 Check all equipment for the removal of blocking, supports, temporary ties, and temporary jumper wires.

7.1.3 Check control power transformer and PT fuses for size, type, and circuit location.

7.1.4 Check CT and PT ratios.

7.1.5 Check CPT size.

7.1.6 Check all components for proper identification per the drawings and specifications.

7.2 Equipment and Installation Inspection Items

7.2.1 Inspect switchgear bus bar connections for tightness by verifying that the torque meets manufacturer’s specifications. Verify that connection hardware is consistent with the Owner’s project specifications.

7.2.2 Inspect switchgear bus supports for cleanliness and tightness.

7.2.3 Inspect ground connections to switchgear ground bus.

7.2.4 Inspect operation of the drawout mechanism including mechanical interlocks, position indicators, and safety features.

7.2.5 Inspect operation of shutter devices.

7.2.6 Inspect operation of PT disconnecting and grounding mechanisms.

7.2.7 Inspect circuit breaker insulating parts for cleanliness and dryness.

7.2.8 Inspect electrical contact surfaces of air circuit breaker for cleanliness and smoothness. Lubricate stationary contact surfaces per manufacturer's recommendations.

7.2.9 Inspect contact wipe and alignment of air circuit breaker and verify that it is in accordance with manufacturer's recommendations.

7.2.10 Inspect vacuum breaker mechanical adjustments and critical dimensions in accordance with manufacturer's recommendations.

7.2.11 Inspect circuit breaker manual operation (maintenance closing procedure) to verify that all parts are free and that they work smoothly.

7.2.12 Inspect operation of breaker mechanical trip function.

7.2.13 Inspect lubrication of breaker-operating mechanism and all other breaker moving parts.

7.3. Testing Requirements

7.3.1 Test insulation resistance of switchgear bus with a 1-minute test (phase to phase and phase to ground).

7.3.2 Test insulation resistance of all instrument transformers with a 1-minute test at applicable voltage.

7.3.3 Test insulation resistance of each circuit breaker (closed position) with a 1-minute test (phase to phase and phase to ground).

7.3.4 Test circuit breaker contact resistance with micro-ohmmeter.

7.3.5 Test dielectric strength of each medium-voltage circuit breaker (closed position) with DC high-potential unit using the step voltage method and with final voltage value according to the table in paragraph 5.5, unless specified otherwise by the Owner. (Isolate and test each phase to ground with the other two-phase terminals connected together and to ground.)

7.3.6 Test integrity of each vacuum interrupter on a vacuum circuit breaker in accordance with manufacturer's instructions.

7.3.7 Calibrate and test each protective relay. Settings on devices shall be in accordance with the approved relay settings summary or coordination study.

7.3.8 Test each CT secondary circuit by applying current to CT secondary circuit with CTs disconnected and by verifying operation of all applicable relays and metering devices. Perform a ratio-verification test using the voltage or current method in accordance with *ANSI C57.13.1*.

7.3.9 Test each window-type ground CT and their circuits by applying current to conductor passed through the window.

7.3.10 Test each PT secondary circuit by applying voltage to PT secondary circuit, with the PTs disconnected, and then by verifying the operation of all applicable relays and meters.

7.3.11 Test voltmeter, ammeter, and related selector switches.

7.3.12 Test operation of all space heaters, including switching and indicating devices.

7.3.13 Perform circuit breaker minimum voltage trip test. Trip unit should be operable at 40 percent of nominal voltage.

7.3.14 Verify that each circuit breaker opening time meets the manufacturer’s specifications.

7.3.15 For double-ended switchgear, test phasing after energizing but before closing the tie breaker.

7.4 Function Test Items

7.4.1 Function-test circuit breaker in test position:

1. Close and trip circuit breaker from its local and remote control devices. Verify operation of all auxiliary devices by functional testing.
2. Trip circuit breaker individually from each local protective device.
3. Test any special circuits such as main-tie-main controls.

7.4.2 Function-test circuit breaker in normal operating position before energization of bus.

7.4.3 When resistance-grounding systems are installed, function test the equipment using the available protection/alarm test features.

8. Power Transformers

8.1 Equipment and Installation Check Items

8.1.1 Check all components for proper identification per the drawings and specifications.

8.1.2 Check transformer nameplate rating, impedance, and available tap positions.

8.1.3 Check transformer case including cooling fins, primary terminal enclosure, or switch enclosure for any external mechanical damage.

8.1.4 Check transformer tank, cooling fins, and all other welded or bolted joints under oil for evidence of oil leakage.

8.1.5 Check all valves, fittings, and gasket surfaces for tightness and for any evidence of oil leakage.

8.1.6 Check transformer unit for inclusion of all standard auxiliary items according to the purchase specification.

8.1.7 Check transformer secondary terminal box for adequate weatherproofing.

8.1.8 Check primary terminal enclosure for adequate weatherproofing and bolting.

8.2. Equipment and Installation Inspection Items

8.2.1 Inspect operation of tap changer unit.

8.2.2 Inspect transformer level indicator for proper oil level.

8.2.3 Inspect transformer liquid temperature indicator and transformer pressure-vacuum indicator for appropriate readings.

8.2.4 Inspect ground connection to transformer ground pad and to transformer secondary neutral if applicable.

8.2.5 If supplied, inspect ground resistor and ground CT mounting and their connections.

8.3. Testing Requirements

8.3.1 All power transformer tests shall be per *NETA ATS.*

8.3.2 Oil samples from the transformer shall be obtained and tested for the following:

1. Dielectric breakdown voltage
2. Neutralization number
3. Specific gravity
4. Interfacial tension
5. Color
6. Power factor
7. Water content

8.3.3 Perform a gas chromatograph test on each transformer to establish initial base points.

8.3.4 Test insulation resistance of transformer windings by disconnecting surge arresters and using a 10-minute dielectric absorption test. Windings shall be tested primary to ground, secondary to ground, and primary to secondary.

8.3.5 Test each transformer using AC power factor test in accordance with test equipment manufacturer's instructions.

8.3.6 Test ground resistance of transformer grounding point using the fall of potential method.

8.3.7 When specified on the **Data Sheet**, test each transformer using transformer turns ratio (TTR) test at each no-load tap setting.

8.4 Function Test Items

8.4.1 Function-test operation of all safety interlock systems.

8.4.2 Function-test operation of auxiliary devices or systems:

1. Liquid temperature, level, pressure alarms, etc.
2. Fault pressure relay alarm or shutdown
3. Cooling fans
4. If provided, terminal compartment space heaters

8.4.3 Set transformer taps to give desired secondary voltage according to the design primary voltage for normal operating condition.

9. Shielded Power Cables

9.1 Equipment and Installation Check Items

9.1.1 Check cable size, type, and rating.

9.1.2 Check cable support systems (tray, conduit, or messenger) including conduit bushings, straps, clamps, messenger hardware, and thermal expansion provisions.

9.1.3 Check installation for adequate bending radius for all cables and individual conductors.

9.1.4 Check cables for any exterior mechanical damage.

9.1.5 Check grounding of cable support system including cable tray grounding jumpers.

9.1.6 Check wiring for proper identification according to the drawings and specifications.

9.1.7 Check conduits and cables for proper tagging.

9.1.8 Check equipment installations for location of seals, breathers, and drains.

9.2. Equipment and Installation Inspection Items

9.2.1 Inspect installation of cable termination fittings (including pouring of fittings if applicable).

9.2.2 Inspect all terminations and splices for conformance to manufacturer's recommendations.

1. Verify proper type and size of connector or lug.
2. Verify that proper hydraulic crimp tool and die is used.
3. Verify proper termination and splicing, including use of recommended tapes (semi-conducting, insulating), shielding, jacket, and tracking resistant cover or proper size preformed stress cone unit or system.
4. Verify that cable terminators are properly installed.

9.2.3 Inspect the proper routing of cable shield and bonding conductors through zero sequence CTs.

9.3. Testing Requirements

9.3.1 Upon receipt of cable, test insulation resistance of each conductor on the reel using a 1-minute test.

9.3.2 Test cable in final position after all splices are completed. Connections shall be completed to all components that can withstand the recommended DC high-potential test voltage. For components that cannot withstand the test voltage, the terminations shall be fully prepared including penciling of the insulation and making of the stress cones, but the terminations shall not be connected to the component. If potheads are used, all internal work shall be completed including pouring of the pothead, and the cable test voltage shall be set not to exceed the maximum withstand voltage guaranteed by the pothead manufacturer.

1. Test metallic shield of each cable for continuity.

2. Test each conductor including ground wire for continuity.
3. Test insulation resistance of each cable. (Test each conductor to ground with the other two conductors grounded.)
4. Test dielectric of each cable with DC high-potential step-voltage-type test using final test voltage given in *ANSI/IEEE Std. 141-1993* (*R1999*), Table 12-9, for the applicable cable type or for the voltage limitation of connected equipment.
5. Verify that all grounds are removed before energization.

9.4 Radiograph Requirements

When specified on the **Data Sheet**, radiographs shall be taken of all splices and terminations. Sufficient shots shall be taken to give a clear view of each conductor. All films shall be clearly identified and submitted to the Owner for permanent retention.

10. Non-Shielded Cable and Wiring

10.1 Equipment and Installation Check Items

10.1.1 Check cable size, type, and rating.

10.1.2 Check cable support systems (tray, conduit, or messenger) including straps, conduit bushings, clamps, messenger hardware, and thermal expansion provisions.

10.1.3 Check installation for adequate bending radius for all cables and individual conductors.

10.1.4 Check cables for any exterior mechanical damage.

10.1.5 Check grounding of cable support system including cable tray grounding jumpers.

10.1.6 Check wiring for proper identification according to the drawings and specifications. For cables rated 600 volts and below, check for conformance to color code.

10.1.7 Check conduits and cables for proper tagging.

10.1.8 Check equipment installations for location of seals, breathers, and drains.

10.2 Equipment and Installation Inspection Items

10.2.1 Inspect installation of cable termination fittings (including the pouring of the fittings if applicable).

10.2.2 Inspect all terminations and splices for conformance to manufacturer's recommendations.

1. Verify proper type and size of connector or lug.
2. Verify that proper hydraulic crimp tool and die are being used.

3. Verify that proper tapes are being used.
4. Verify that cable terminators are properly installed.

10.3 Testing Requirements

10.3.1. Upon receipt of each multi-conductor power cable, test insulation resistance with cable on the reel using a 1-minute test. Test each conductor to ground with the other conductors grounded.

10.3.2. Test each conductor, including ground, for continuity with cables in their final position with all splices completed.

10.3.3. For cables rated 600 volts and less, test insulation resistance of all cables with the cables in final position and with all splices and terminations completed. Test each conductor to ground with the other conductors grounded.

10.3.4. For the following cables above 600 volts, three-conductor metallic sheathed cables, or three single-conductor cables in metallic conduit, testing shall be as follows:

Testing shall be with cables in final position after all splices are completed. Connections shall be completed to all components that can withstand the recommended DC high-potential test voltage. For components that cannot withstand the test voltage, the terminations shall be fully prepared but shall not be connected to the component.

1. Test insulation resistance of each cable with a 1-minute test.
2. Test dielectric of each cable with a DC high-potential unit-step voltage-type test; the final test voltage shall be according to *ANSI/IEEE Std. 141-1993 (R1999)*, Table 12-9, for the applicable cable type.
3. Verify that all grounds are removed before energization.

11. Medium-Voltage MCCs

11.1 Equipment and Installation Check Items

11.1.1 Check MCC equipment for alignment, levelness, and tightness of all bolting.

11.1.2 Check all equipment for removal of blocking, supports, temporary ties, and temporary wire jumpers.

11.1.3 Check that all protective barriers are properly installed.

11.1.4 Check door alignment of individual starter units and door interlock operation.

11.1.5 Check operation of external overload protective device reset.

11.1.6 Check that drawout contacts are completely disconnected when drawout handle is operated.

11.1.7 Check CPT and PT fuses for size, type, and circuit location.

11.1.8 Check PT and CT ratios.

11.1.9 Check CPT size and rating.

11.1.10 Check voltage rating of contactor coil.

11.1.11 Verify that metering or relaying devices using resistance temperature detectors (RTDs) have the correct rating.

11.1.12 Check fuses and wiring to power factor correction capacitors for size and rating.

11.1.13 Check all components for proper identification according to the drawings and specifications.

11.2 Equipment and Installation Inspection Items

11.2.1 Inspect MCC bus bar connections for tightness by verifying that the torque meets manufacturer’s specifications. Verify that connection hardware is consistent with the Owner’s project specifications.

11.2.2 Inspect MCC bus bar supports for cleanliness and tightness.

11.2.3 Inspect ground connections to ground bus.

11.2.4 Inspect operation of mechanical interlocks, position indicators, drawout or rollout mechanism, and all safety interlock features.

11.2.5 Inspect contactor rating.

11.2.6 Inspect contactor-insulating parts for cleanliness and dryness.

11.2.7 Inspect contactor electrical contact surfaces for cleanliness and smoothness. Lubricate per manufacturer's instructions.

11.2.8 Inspect contactor-seating surfaces of unplated and laminated magnet faces of contactor and relays. Remove any rust or rust preventative if present.

11.2.9 Inspect contactor power stabs and adjust per manufacturer's instructions.

11.2.10 Inspect manual operation of contactor and mechanical relay devices to verify that all parts are free and that they work smoothly. For air contactors, verify adjustment for contact wipe and alignment per manufacturer's instructions.

11.2.11 Inspect lubrication of contactor moving parts.

11.2.12 Inspect contactor vacuum bottles for damage.

11.2.13 Inspect size, type, and rating of current-limiting power fuses.

11.2.14 Inspect overload protective device rating and setting.

11.3 Testing Requirements

11.3.1 Test insulation resistance of MCC bus with a 1-minute test (phase to phase and phase to ground).

11.3.2 Test insulation resistance of control power and instrument transformers with a 1-minute test at applicable voltage.

11.3.3 Test insulation resistance of contactor (closed position) with a 1-minute test (phase to phase and phase to ground).

11.3.4 Test contactor contact resistance with micro-ohmmeter.

11.3.5 Test integrity of each vacuum interrupter on a vacuum contactor in accordance with manufacturer's instructions.

11.3.6 Calibrate and test each protective relay with settings on devices being in accordance with approved relay settings summary or coordination study.

11.3.7 Test contactor drop-out time if power disturbance ride-through is specified.

11.3.8 Test operation of all space heaters including switching and indicating devices.

11.3.9 Test CT circuit by applying current to the CT primary circuit and verifying operation of all applicable relays and metering devices. When primary current injection is not practicable because of size of current requirements, test CT secondary circuit by applying current to CT secondary circuit with CT disconnected, and verify operation of all applicable relays and metering devices. Test window-type ground CTs and their circuits by applying current to a conductor passed through the window.

11.3.10 When specified on the **Data Sheet**, perform a CT ratio-verification test using the voltage or current method in accordance with *ANSI C57.13.1*.

11.3.11 Test voltmeter, ammeter, and related selector switches when installed.

11.3.12 Test proper operation of overload protective device. Operate mechanical trip option if present.

11.4 Function Test Items

11.4.1 Function-test each contactor in the test position:

1. Close and trip contactor with all local and remote control devices. Verify operation of all auxiliary devices by functional testing.
2. Trip contactor from each protective device individually. Verify operation of all auxiliary devices.

11.4.2 Verify operation of capacitor discharge resistor system on power factor capacitors using a properly sized voltmeter.

12. Motors

12.1 Equipment and Installation Check Items

12.1.1 Check motor nameplate hp, voltage, full load amps, and service factor.

12.1.2 Check motor rotation arrow to verify that it conforms to driven equipment requirements.

12.1.3 Check motor ground connections.

12.1.4 Check motor shaft for free rotation.

12.1.5 Check motor bearings for proper lubrication.

12.1.6 Check motor bearing isolation.

12.1.7 Check all components for proper identification according to the drawings and specifications.

12.1.8 Check all equipment items for conformance to area classification.

12.1.9 Check that resistance temperature detectors (RTDs) conform to drawings.

12.1.10 Check motor residual CTs for proper rating and connections.

12.1.11 Check motor surge capacitors and arresters for ratings and connections.

12.2 Equipment and Installation Inspection Items

12.2.1 Inspect motor bearing lubrication system.

12.3 Testing Requirements

12.3.1 The following tests shall be performed before connecting any wiring:

1. For motors rated 600 volts and below, test insulation resistance of each motor with a 1-minute test using a 1000-volt insulation tester.
2. For motors rated over 600 volts, test insulation resistance of each motor with a 10-minute dielectric absorption test. (For a three-lead motor, test motor windings to ground. For a six-lead motor, tie leads together and test windings to ground.)
3. For motors rated 4000 volts and above and 1000 hp and above, test dielectric with DC high-potential test according to *ANSI/IEEE Std. 95*.

12.3.2 For motors rated 600 volts or less, test insulation resistance of motor power cables plus motor following makeup of leads at motor with a 1-minute test.

12.3.3 For motors rated over 600 volts, test insulation resistance of motor power cable plus motor following makeup of leads at the motor with a 10-minute dielectric absorption test. Surge capacitors and arresters, if installed, must be disconnected.

12.4 Function Test Items

12.4.1 With motor uncoupled, verify proper rotation of motor.

Note: When canned pumps are applied, comply with the manufacturer's requirements for this equipment.

12.4.2 For motors rated 600 volts or less, with motor uncoupled, perform 30-minute run-in test on each motor.

1. Record no-load current.
2. Record bearing temperatures and vibration levels.

12.4.3 For motors rated over 600 volts, with motor uncoupled, perform a 1-hour run-in test on each motor.

1. Record no-load current.
2. Record bearing temperatures and vibration levels.
3. Verify motor operation at magnetic center.

13. Low-Voltage Switchgear

13.1 Equipment and Installation Check Items

13.1.1 Check switchgear assembly for alignment, levelness, and tightness of all bolting.

13.1.2 Check all equipment for removal of blocking, supports, temporary ties, and temporary jumper wires.

13.1.3 Check control power transformer and PT fuses for size, type, and circuit location.

13.1.4 Check PT and CT ratios.

13.1.5 Check control power transformer size.

13.1.6 Check all components for proper identification per the drawings and specifications.

13.1.7 When installed, check high-resistance grounding equipment, connections, and settings for conformance to drawings and specifications.

13.2 Equipment and Installation Inspection Items

13.2.1 Inspect switchgear bus bar connections for tightness by verifying that the torque meets manufacturer’s specifications. Verify that connection hardware is consistent with the Owner’s project specifications.

13.2.2 Inspect switchgear bus supports for cleanliness and tightness.

13.2.3 Inspect ground connection to switchgear ground bus.

13.2.4 Inspect proper operation of drawout mechanism including mechanical interlocks, position indicators, and safety features.

13.2.5 Inspect circuit breaker insulating parts for cleanliness and dryness.

13.2.6 Inspect circuit breaker electrical contact surfaces for cleanliness and smoothness. Lubricate per manufacturer's instructions.

13.2.7 Inspect circuit breaker contact wipe and alignment and verify that it is in accordance with manufacturer’s recommendations.

13.2.8 Inspect proper operation of breaker mechanical trip function.

13.2.9 Inspect lubrication of all breaker moving parts.

13.2.10 Inspect stab adjustment and lubricate per manufacturer's instructions.

13.3 Testing Requirements

13.3.1 Test insulation resistance of switchgear bus with a 1-minute test (phase to phase and phase to ground).

13.3.2 Test insulation resistance of each circuit breaker (closed position) with a 1-minute test (phase to phase and phase to ground).

13.3.3 Test circuit breaker contact resistance with a micro-ohmmeter.

13.3.4 Test insulation resistance of all instrument transformers with a 1-minute test.

13.3.5 Calibrate and test each circuit breaker protective device with settings according to drawings and specifications.

13.3.6 With CT disconnected, test CT secondary circuit for continuity and operation of applicable relays and meters by applying current to the CT secondary winding.

13.3.7 Test PT secondary circuit by applying voltage to the PT secondary, with PT disconnected, verifying operation of all applicable relays and meters.

13.3.8 Test window-type ground CTs and their circuits by applying current to a conductor passed through the window.

13.3.9 Test operation of all space heaters including switching and indicating devices.

13.4 Function Test Items

13.4.1 Function-test circuit breaker in test position:

1. Close and trip circuit breaker from its local and remote control devices. Verify operation of all auxiliary devices through functional test.
2. Trip circuit breaker individually from each local protective device.
3. Test any special circuits such as main-tie-main controls.

13.4.2 Function-test each circuit breaker in the operating position before connecting load side leads. Close and trip circuit breaker from all local and remote control devices. Verify proper operation of all auxiliary devices.

14. Low-Voltage MCCs and Switchracks

14.1 Equipment and Installation Check Items

14.1.1 Check MCC or switchrack installation for alignment, levelness, and tightness of all bolting.

14.1.2 Check all equipment for removal of blocking, supports, temporary ties, and temporary jumper wires.

14.1.3 Check door alignment of individual MCC units and door interlock operation.

14.1.4 Check all components for proper identification according to the drawings and specifications.

14.1.5 Check starter main and auxiliary contact condition and alignment.

14.1.6 Check starter and circuit breaker components for cleanliness, including all seating surfaces of unplated and laminated magnet faces. Remove any rust or rust preventative.

14.1.7 Check size, type, and rating of control power fuses.

14.1.8 Check size and rating of control power transformer.

14.1.9 Check voltage rating of starter coil.

14.1.10 Check mechanical function of all starter and circuit breaker movable parts.

14.1.11 Check all equipment items for conformance to area classification.

14.1.12 Check equipment installations for location of seals, breathers, and drains.

14.1.13 Check for proper equipment labeling.

14.2 Equipment and Installation Inspection Items

14.2.1 Inspect bus bar splice connections for tightness by verifying that the torque meets manufacturer's specifications. Verify that connection hardware is consistent with the project specifications.

14.2.2 Inspect bus bar supports for cleanliness and tightness.

14.2.3 Inspect line connections to bus bar for tightness.

14.2.4 Inspect ground connections to ground bus and/or structure.

14.2.5 For circuit breakers, inspect size, rating, and instantaneous setting. For power fuses, inspect size, type, and rating.

14.2.6 Inspect starter size, overload heater size, and overload relay setting.

14.2.7 Inspect operation of external overload reset device.

14.3 Testing Requirements

14.3.1 Test insulation resistance of MCC or switchrack bus with a 1-minute test (phase to phase and phase to ground) with all disconnects in open position.

14.3.2 Test insulation resistance of MCC or switchrack bus with a 1-minute test (phase to phase and phase to ground) with all circuit breakers in closed position. If resistance value is less than 100 megohms, remove the CPT fuses and re-test.

14.3.3 Test operation of all space heaters including switching devices.

14.4 Function Test Items

14.4.1 Function-test control circuit with motor leads disconnected. Close and trip starter from all control devices, and verify operation of auxiliary devices.

14.4.2 Verify operation of capacitor discharge resistor system on power factor capacitors using a properly sized voltmeter.

15. Panelboards and Lighting Systems

15.1 Equipment and Installation Check Items

15.1.1 Check panelboard nameplate voltage and current ratings.

15.1.2 Check each panelboard for a complete and accurate circuit directory.

15.1.3 Check panelboard circuit breaker ratings sizes.

15.1.4 Check size, type, and rating of all power and control power fuses.

15.1.5 Check size and rating of control power transformer.

15.1.6 Check voltage rating of contactor coil.

15.1.7 Check contactor main and auxiliary contact condition and alignment.

15.1.8 Check contactor and circuit breaker components for cleanliness, including all seating surfaces of unplated and laminated magnet faces. Remove any rust or rust preventative.

15.1.9 Check mechanical function of all contactor, disconnect switch, and circuit breaker movable parts.

15.1.10 Check lighting fixture nameplate voltage, wattage, temperature rating, and type.

15.1.11 Check lamp for proper size and type.

15.1.12 Check all components for proper identification according to the drawings and specifications.

15.1.13 Check all equipment items for conformance to area classification and environment.

15.1.14 Check for proper equipment labeling.

15.2 Equipment and Installation Inspection Items

15.2.1 Inspect grounding connection to transformer secondary neutral, panelboard neutral bus, and equipment cases.

15.3 Testing Requirements

15.3.1 Test insulation resistance of panelboards (each phase shall be tested to ground with all circuit breakers closed) before connecting any wiring.

15.3.2 After making connections, test insulation resistance of the transformer secondary plus panelboard to ground with all circuit breakers closed.

15.4 Functional Test Items

15.4.1 Verify voltage for desired level according to normal operating load condition.

15.4.2 Verify load balance of panelboard.