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ELECTRICAL DESIGN CRITERIA

(PROJECT STANDARDS AND SPECIFICATIONS)

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SCOPE

The purpose of this Project Standards and Specifications is to summarize the codes and standards, and standard design criteria and practices that will be used during a project. The general electrical design criteria defined herein form the basis of the design for the electrical components and systems of the project. More specific design information will be developed during detailed design to support equipment and erection specifications. It is not the intent of this Project Standards and Specifications to present the detailed design information for each component and system, but rather to summarize the codes, standards, and general criteria that will be used.

REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

1. AFEMA (The Anti-friction Bearing Manufacturers Association)
2. ANSI (American National Standards Institute)
3. ASTM (American Society for Testing and Materials)
4. EEI (Edison Electric Institute)
5. CEA (Insulated Cable Engineers Association)
6. IEEE (Institute of Electrical and Electronics Engineers)
7. IES (Illuminating Engineering Society)
8. EC (National Electrical Code)
9. NEMA (National Electrical Manufacturers Association)
10. NESC (National Electrical Safety Code)
11. NFPA (National Fire Protection Association)
12. OSHA (Occupational Safety and Health Act)
13. UL (Underwriters' Laboratories)
14. NACE (National Association of Corrosion Engineers)

In addition to the general codes and standards listed above, the following specific standards will be utilized:

Batteries

- NEMA IB 4-Determination of Ampere-hour and Watt-hour Capacity of Lead-Acid Industrial Storage Batteries for Stationary Service
- IEEE 450-Recommended Practice for Maintenance, Testing and Replacement of Large Lead-Acid Storage Batteries
- IEEE 484-Recommended Practice for Installation Design and Installation of Large Lead-Acid Storage Batteries for Generating Stations and Substations

Battery Chargers

- NEMA AB 1-Molded Case Circuit Breakers
- NEMA PV 5-Constant-Potential Type Electric Utility (Semiconductor Static Converter) Battery Chargers

Cable, Low Voltage Power, Control and Instrument

- ASTM B8-Concentric-Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft
- ASTM B33-Tinned Soft or Annealed Copper Wire for Electrical Purposes
- ICEA S-19-81, NEMA WC-3-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
- ICEA S-68-516, NEMA WC-8-Ethylene-Propylene-Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
- NFPA 258-Standard Test Method for Measuring the Smoke Generated by Solid Materials
- NFPA 70-National Electric Code (NEC)
- ANSI/UL 44-Safety Standard for Rubber-Insulated Wires and Cable

Cable, Medium Voltage Power

- ICEA 6-Ethylene Propylene Rubber Insulated Shielded Power Cables, Rated 5 through 69 kilovolt (kV)
- ASTM B8-Concentric Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
- ASTM B33-Tinned Soft or Annealed Copper Wire for Electrical Purposes
- ICEA S-66-524-Cross Linked-Thermosetting, Polyethylene-Insulated Wire and Cable for Transmission and Distribution of Electrical Energy
- ICEA S-68-516-Ozone-Resistant Ethylene-Propylene Rubber Insulation for Power Cables Rated 0 to 35,000 Volts

- ICEA S-19-81, NEMA WC-3-Rubber Insulated Wire and-Cable for the Transmission and Distribution of Electrical Energy
- NFPA 70-National Electric Code (NEC)

Cable Tray

- NEMA VE-1 Cable Tray Systems

Cathodic Protection Equipment

- ANSI B1.1-Unified Inch Screw Threads
- ANSI B2.1-Pipe Threads
- ASTM A518-Corrosion-Resistant High Silicon Cast Iron
- ASTM B418-Cast and Wrought Galvanic Zinc Anodes for Use in Saline Electrolytes
- NEMA AB-1-Molded Case Circuit Breakers
- NEMA ICS-Industrial Controls and Systems
- NEMA WC-5, ICEA S-61-402-Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
- NEMA WC-7, SS-66-524-Cross-Linked-Thermosetting, Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

Circuit Breakers, High Voltage

- ANSI/IEEE C37.04-Rating Structure for alternating current (AC) High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- ANSI C37.06-Preferred Ratings and Related Required Capabilities for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- ANSI/IEEE C37.09-Test Procedure for AC High Voltage Circuit Breakers rated on a Symmetrical Current Basis
- ANSI/IEEE C37.010-Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- ANSI C37.11-Requirements for Electrical Control for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis and a Total Current Basis.

Conduit

- UL 6, ANSI C80.1-Rigid Steel Conduit
- UL 797, ANSI C80.3-Electrical Metallic Tubing
- UL 514, ANSI C80.4-All Fittings
- UL 886-Hazardous Area Fittings
- UL 360-Flexible Liquid-tight Conduit

- NEMA TC6-PVC and ABS Plastic Utilities Duct for Underground Installation
- NEMA TC9-Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation
- UL 651-Electrical Rigid Nonmetallic Conduit
- NEMA TC2, UL 514-Fittings for Electrical Rigid Nonmetallic Conduit

Distribution Panels

- ANSI C971-Low Voltage Cartridge Fuses, 600 volts or less
- NEMA AB1-Molded Case Circuit Breakers
- NEMA PB1-Panelboards
- UL 50-Electrical Cabinets and Boxes
- UL 67-Panelboards
- NEMA ICS-Industrial Controls and Systems
- NEMA KSI-Enclosed Switches

Grounding

- ASTM B8-Specifications for Concentric-Lay Stranded Copper Conductors
- NEC-National Electric Code
- NEMA CC-1-Electrical Power Connectors for Substations
- IEEE 80-IEEE Guide for Safety in AC Substation Grounding

Lighting Fixtures

- NEMA FA1-Outdoor Floodlighting Equipment
- NEMA LE1-Fluorescent Luminaries
- UL 57-Standard for Safety, Electric Lighting Fixtures
- UL 844-Standard for Safety, Electric Lighting Fixtures for Use in Hazardous Locations
- UL 924-Standard for Safety, Emergency Lighting Equipment

Lightning Arresters

- ANSI/IEEE C62.1-Surge Arresters for AC Power Circuits

Secondary Unit Substations

- ANSI C37.13-Low-Voltage AC Power Circuit Breakers Used in Enclosures
- ANSI C37.16-Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors
- ANSI/IEEE C37.20-Switchgear Assemblies

- ANSI C37.50-Test Procedures for Low-Voltage AC Power Circuit Breakers Used in Enclosures
- ANSI C37.51-Conformance Testing of Metal-Enclosed Low-Voltage AC Power Circuit Breaker Switchgear Assemblies
- ANSI C57.12.00-General Requirements for Distribution, Power and Regulation Transformers
- ANSI/IEEE C57.12.01-General Requirements for Dry-Type Distribution and Power Transformers
- ANSI/IEEE C57.12.90-Test Code for Liquid Immersed Distribution, Power and Regulating Transformers
- ANSI/IEEE C57.12.91-Test Code for Dry-Type Distribution and Power Transformers
- ANSI C57.13-Requirements for Instrument Transformers
- NEMA CC1-Electrical Power Connectors for Substations
- NEMA TR-1-Transformers, Regulators, and Reactors
- NEMA ICSI-General Standards for Industrial Controls and Systems
- NFPA 70-National Electric Code

Metal-Clad Switchgear and Nonsegregated Phase Bus

- ANSI C37.04-Rating Structure for AC High-Voltage Circuit Breakers on a Symmetrical Current Basis
- ANSI C37.04 Preferred Ratings and Related Required Capabilities for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- ANSI C37.20-Switchgear Assemblies Including Metal-Enclosed Bus
- ANSI C57.13-Requirement for Instrument Transformers

Motor Control Centers

- NEMA ST-20-Dry-Type Transformers for NEMA General Purpose Applications
- NEMA AB-1-Molded Case Circuit Breakers
- NEMA ICS-1-General Standards for Industrial Controls and Syste
- NEMA ICS-2-Industrial Control Devices, Controllers, and Assemblies
- UL 67-Electric Panelboards
- UL 489-Molded Case Circuit Breakers and Circuit Breaker Enclosures
- UL 508-Industrial Control Equipment
- UL 845-Motor Control Centers
- NFPA 70-National Electric Code

Motors, Low Voltage

- NEMA MG1-Motors and Generators
- AFBMA 9/ANSI B3.15-Antifriction Bearing Manufacturers Association
- NEMA MG2 AFBMA 11/ANSI B3.16-Safety Standard for Construction and Guide for Selection, Installation and Use of Electrical Motors and Generators
- NEMA MG13-Frame Assignment for Alternating Current Integral Horsepower Induction Motors

Motors, Medium Voltage

- ANSI/IEEE C50.41-Polyphase Induction Motors for Electric Power Generating Stations
- IEEE 112-Test Procedure for Polyphase Induction Motors and Generators
- NEMA MG1-Motors and Generators
- NEMA MG2-Safety Standard for Construction and Guide for Selection, Installation and Use of Electrical Motors and Generators

Neutral Grounding Resistors

- ANSI C76.1-Requirements and Test Codes for Outdoor Apparatus Bushings
- IEEE 32-Requirements, Terminology, and Test Procedures for Neutral Grounding Devices
- NEMA CC1-Electric Power Connectors

Relay Panels

- ANSI C37.20-Switchgear Assemblies Including Metal-Enclosed Bus
- ANSI 37.90-Relays and Relay Systems associated with Electric Power Apparatus
- NEMA WC-3, ICEA S-19-81-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

Transformers, Dry-Type

- ANSI U1-General Requirements for Dry-Type Distribution and Power Transformers
- NEMA ST20-Dry-Type Transformers for General Application
- UL 506-Standard for Safety, Specialty Transformers

ELECTRICAL DESIGN CRITERIA

Electric Motors

General Motor Design Criteria

These paragraphs outline basic motor design guide parameters for selection and purchase of electric motors.
The following design parameters shall be considered:

- Motor manufacturer;
- Environment, including special enclosure requirements;
- Voltage, frequency, and phases;
- Running and starting requirements and, limitations and duty cycle;
- Motor type (synchronous, induction, direct current [DC], etc.) and construction;
- Power factor;
- Service factor;
- Speed and direction of rotation;
- Insulation;
- Bearing construction, rating life of rolling elements, and external lube oil system for sleeve or plate bearings;
- Ambient noise level and noise level for motor and driven equipment;
- Termination provisions for power, grounding, and accessories;
- Installation, testing, and maintenance requirements;
- Special features (shaft grounding, temperature and vibration monitoring, etc.); and
- Motor space heater requirements.

1. Safety Considerations for Motors

   The OSHA standard will be adhered to for personnel protection. Belt guards shall be specified for personnel safety and, when required, to prevent foreign objects from contacting belt surfaces. Guard screens will be provided over motor enclosure openings that would otherwise allow direct access to rotating parts. All electrical motors will be adequately grounded.
   Motors that are located in hazardous areas will be UL labeled and conform to all applicable regulatory requirements. Motor electrical connections are to be terminated within conduit boxes, mounted to the motor frame.

2. Codes And Standards

   All motors will be designed, manufactured, and tested in accordance with the latest applicable standards, codes, and technical definitions of ANSI, IEEE,

NEMA, and AFBMA, and where supplemented, by requirements of the project specifications.

3. Testing Requirements

Each type of alternating current and direct current machine will be tested at the supplier's factory to determine that it is free from electrical or mechanical defects and to provide assurance that it meets specified requirements. The following criteria and tests will be used in testing each type of machine:

- Fractional horsepower (HP), single-phase induction motors (less than 1 HP). Test procedures will be in accordance with IEEE 114. Test Procedure for Single-Phase Induction Motors.
- Integral horsepower, three-phase, 460 volt induction motors (from 1 HP to 200 HP).
- Routine tests listed in NEMA MG1-1251, Routine Tests for Polyphase Integral Horsepower Induction Motors.
- Test procedures will be in accordance with IEEE 112, Test Procedure for Polyphase Induction Motors and Generators.
- Induction motors rated above 600 volts (250 HP and above).
- Routine tests listed in NEMA MG1-20.46, Polyphase Induction Motors for Power Generating Stations, will be performed on each motor.
- The following additional tests and inspections will be performed on each motor larger than 500 horsepower.
  - Locked-rotor current at fractional voltage.
  - Current balance.
  - Final value of motor noise levels including statement that there is no objectionable single frequency noise.
- Direct current motors.

The standard routine tests and inspections will be performed on each motor. These shall include the following:

- High potential dielectric test.
- Measurement of resistance of all windings.
- Inspection of bearings and bearing lubrication system:
  - No-load running armature current, shunt field current and speed in revolutions per minute, at rated voltage.
  - Full load armature current, shunt field current, and speed in revolutions per minute, at rated voltage.
- Test procedures will be in accordance with IEEE 113, Test Code for Direct Current Machines.

4. Electrical Design Criteria

   Special requirements for individual motors and specifications for special application motors will be included in the individual specification's technical sections.

   a. Rating

      Motors shall be selected to permit the connected load to develop its specified output continuously without encroaching on the service factor under normal operating conditions. The service factor shall be 1.15 for motors 200 horsepower and less. Motors larger than 200 horsepower shall have a service factor of 1.0.

      Motors will be designed for full voltage starting and frequent starting, where required. Motors will be suitable for continuous duty in the specified ambient conditions. Intermittent duty motors will be selected where recognized and defined as standard by the equipment standards and codes.

      The torque of all induction motors will be required to accelerate inertia loads of both motor and driven equipment to full speed without damage to the motor or other equipment. This will be accomplished at any voltage from 90 percent to 110 percent of motor nameplate voltage, except those to be individually considered. A 20 percent voltage drop from the specified motor nameplate rating will be allowed for motor starting.

   b. Temperature Considerations

      Integral horsepower motors will be designed for an ambient temperature of 40 degrees Celsius (°C). Motors located in areas where the ambient temperature exceeds 40°C will be designed for that ambient condition.

   c. Windings and Insulation

      All insulated windings will have a minimum of Class F nonhygroscopic insulation systems rated for temperature rise and ambient temperature in accordance with NEMA MG1 standards. When ambient temperatures greater than 40°C are specified, the allowable temperature rise will be reduced in accordance with NEMA MG1 standards.

      All insulated stator winding conductors and wound-rotor motor secondary windings will be copper. Where required, the windings will be treated with a resilient, abrasion resistant material.

   d. Overspeeds

      Squirrel-cage and wound-rotor induction motors, except crane motors, will be so constructed that, in an emergency of short duration, they will withstand, without mechanical injury, overspeeds above synchronous

speed in accordance with the table as listed in NEMA MG1-12.48, Overspeeds for Motors.

e. Space Heaters

Space heaters, if required, will be sized as required to maintain the motor internal temperature above the dew point when the motor is idle. Motor space heaters will not cause winding temperatures to exceed rated limiting values or cause thermal protective device over-temperature indication when the motor is not energized.

In general, all motors 25 horsepower or larger will have 120 volt, single-phase, 60 hertz, space heaters. The voltage rating of the heaters shall be at least twice its operating voltage of 120 volts. All 13,200 and 4,000 volt motors will have space heaters. Space heaters rated 1,200 watts and less will be suitable for operation on 120 volts, single-phase, 60 hertz. Heaters rated above 1,200 watts will be suitable for operation on 208 volts, three-phase, 60 hertz.

Space heater leads will be stranded copper cable with 600-volt insulation and shall include terminal connectors. Space heater leads will be wired to a separate terminal housing on 13,200 and 4,000 volt motors.

f. Nameplates

All motor nameplate data will conform to NEMA MG1-20.60 requirements. The following additional nameplate data will be included for 13,200 and 4,000 volt rated motors:

- Frame size number;
- Service factor;
- Starting limitations;
- Direction of rotation and voltage sequence;
- AFBMA bearing identification number for motors furnished with rolling element bearings;
- For motors with connections to an external lubricant recirculating system, or with an integral forced lubrication system, oil pressure and oil flow required; and
- For motors designed for service in hazardous areas:
  - Location class and group designation; and
  - Maximum operating temperature value or operating temperature code number.

g. Environment

Location of individual motors within the project site will determine ambient temperature, corrosive environment, hazardous environment, and humidity to be experienced by the motors. These conditions will be considered in the purchase specification.

Induction Motors

1. 4,000 and 13,200 Volt Squirrel Cage Induction Motors

   a. Design and Construction

   Design and construction of 13,200 and 4,000-volt motors will be coordinated with the driven equipment requirements.
   All motor power lead terminal housings will be adequately sized to terminate the power conductors. For 4,000 volt and 13,200-volt motors, the power lead terminal housing will also be large enough to provide space to contain the stress cones after installation.
   Separate terminal housings will be provided for the following:
   - Motor power leads;
   - Motor accessory leads; and
   - Motor temperature detector leads.

   All leads will be wired into their respective terminal housings. All motor leads and their terminals will be permanently marked in accordance with the requirements of NEMA MG1, Part 2.
   All motors will have the direction of rotation marked by an arrow or on the nameplate and the leads marked for phase sequence T1, T2, T3 to correspond to the direction of rotation and supply voltage sequence. All 13,200 volt and 4,000 volt motors will be totally enclosed fan cooled (TEFC) or NEMA WPII.
   Weather protected NEMA Type II enclosures will have standard space heaters, and removable, cleanable air filters.
   Squirrel-cage induction motors will have rotors of fabricated copper alloy, cast aluminum or fabricated aluminum alloy.

   b. Bearings

   All horizontal motors will be provided with sleeve bearings when available and applicable.
   Sleeve bearings on horizontal motors will be designed and located centrally, with respect to running magnetic center, to prevent the rotor axial thrust from being continuously applied against either end of the bearing. The motors will be capable of withstanding, without damage, the axial thrusts that are developed when the motor is energized.
   Horizontal motors may be furnished with antifriction bearings if standard for motor size, enclosure, and speed.
   Kingsbury type or antifriction thrust bearings will be provided for vertical motors.
   Thrust bearings for vertical motors will be capable of operating for extended periods at any thrust loading imposed by the specific piece of driven equipment. This will be true during starting and normal operation

and will not cause damage to the bearings, the motor frame, or other motor parts.

Bearing lubricants will contain a corrosion inhibitor. The type and grade of lubricant will be indicated on a nameplate attachment to the motor frame or end shield adjacent to the lubricant-filling device.

Insulation will be provided on bearing temperature detectors and on oil piping connections when required to prevent circulation of shaft current through bearings.

Bearings and bearing housings will be designed to permit disassembly in the field for inspection of the bearings or removal of the rotor.

c. Bearing Temperature Detectors

Thermocouple type bearing temperature detectors, complete with detector head and holder assemblies as required will be furnished when specified. Thermocouple lead wire insulation will be color coded with standard colors to represent the thermocouple metals.

d. Winding Temperature Detectors

Winding temperature detectors will be furnished, installed, and completely wired when specified. Temperature detectors will normally be three-wire resistance temperature detectors (RTDs).

e. Temperature Detector and Terminal Block Requirements

All temperature detectors will be ungrounded with detector leads wired to terminal blocks furnished in the accessory terminal housings. A grounding terminal for each temperature detector will be included with the detector lead terminals. The grounding terminals will be provided with internal wiring to a common ground connection in each terminal box. The internal wiring will be removable.

2. 460-Volt Integral Horsepower Moto

a. Design and Construction

Design and construction of each 460-volt integral horsepower motor will he coordinated with the driven equipment requirements and the requirements of NEMA MG1 Standards.

The motors shall he totally enclosed, non-ventilated (TENV) or totally enclosed fan cooled (TEFC).

Motors for service in hazardous areas will he individually considered for type of enclosure depending upon the classification, group, and division of the hazardous area in question.

Motor power lead terminal housing will be sized to allow for ease in terminating the incoming power cable. Space heater leads will also be wired into this terminal housing.

b. Bearings

Horizontal motors will he provided with oil or grease lubricated sleeve bearings where required. Antifriction bearings may be furnished if standard for motor size, enclosure, and speed.

Sleeve bearings on horizontal motors will be designed and located centrally, with respect to the running magnetic center, to prevent the rotor axial thrust from being continuously applied against either end of the bearings. The motors will be capable of withstanding without damage the axial thrusts that are developed when the motor is energized.

Thrust bearings for vertical motors will be capable of operating for extended periods at any thrust loading imposed by the specific piece of driven equipment. This will be true during starting and normal operation and will not cause damage to the bearings, the motor frame, or other motor parts.

Bearings and bearing housings will be designed to permit disassembly in the field for inspection of the bearings or removal of the rotor.

3. Direct Current Machines

a. Design and Construction

All direct current machines will be designed and constructed for continuous operation and in accordance with the requirements of NEMA MG1.

b. Service Factor

For motors furnished with a service factor greater than 1.0, the motor nameplate will indicate the horsepower rating at 1.0 service factor, and the service factor. The motor will be designed to provide a continuous horsepower capacity equal to the rated horsepower at 1.0 service factor without exceeding the total limiting temperature rise stated in these specifications for the insulation system and enclosure specified.

c. Insulation and Windings

All insulated windings will have a minimum of Class B nonhygroscopic, or acceptable equivalent, sealed insulation system. All insulated winding conductors will be copper.

d. Bearings

Sleeve bearings for horizontal motors will be oil ring lubricated types or grease lubricated type unless otherwise required. The oil ring will be one piece construction.

4. Fractional Horsepower Motors

   Type, design and construction of each general, special and definite purpose fractional horsepower motor will be coordinated with the driven equipment requirements and will be in accordance with the requirements of NEMA MG1. Motors for service in hazardous areas will be individually considered for type of enclosure depending upon the classification, group and division of the hazardous area in question. All bearings will be self-lubricating with provisions for re-lubrication, and will be designed to operate in any position or any angle.

5. Motor Operators for Non-modulating Valve, Gate, Or Damper Service

   The following requirements are applicable to all electric operators required for non-modulating motor operators.

   a. Rating, Design, and Construction

      Motors will be designed for high torque, reversing service in a 50°C ambient temperature. Motors will have Class B or higher non-hygroscopic standard insulation plus two coats of epoxy resin. Requirements of NEMA MG1 and MG2 will apply.
      Motors will be rated 460 volts, three-phase, 60 hertz unless otherwise required. The DC motors will be rated 120 volts DC to operate from a nominal 125 volt battery.
      The motor time rating for normal opening and closing service will not be less than whichever of the following is greatest:
      - As required for three successive open-close operations
      - As required for the service
      - Not less than 15 minutes

      Sufficient torque will be provided to operate against system torque at 90 percent nominal voltage for AC motors and at 85 percent nominal voltage for DC motors.
      Motors will be totally enclosed unless specified otherwise.
      Motors for service in hazardous areas will be individually considered for type of enclosure depending upon the classification, group, and division of the hazardous area in question.

   b. Bearings

      Double-shielded, grease prelubricated, regreaseable, antifriction bearings will be furnished. Motor leads will be terminated in the limit switch compartment.

   c. Space Heaters

      All motor operators will be supplied with 120 volt AC, single-phase, space heaters. Space heater leads will be terminated in the limit switch compartment.