1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.5 DEMONSTRATION

A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:

1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.

2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.

3. Adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION

SECTION 26 05 73.19
OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.2 ACTION SUBMITTALS

A. Action Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.

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

2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Engineer for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

B. Operation and Maintenance Procedures: In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.5 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer.

C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers: Subject to compliance with requirements, provide software by the following:

1. Operation Technology, Inc.

2. SKM Systems Analysis, Inc.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate mandatory features as listed in IEEE 399.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.

2. Cable size and lengths.

3. Transformer kilovolt ampere (kVA) and voltage ratings.

4. Motor and generator designations and kVA ratings.

5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.

b. Calculated symmetrical fault-current magnitude and angle.

c. Fault-point X/R ratio.

d. No AC Decrement (NACD) ratio.

e. Equivalent impedance.

f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.

g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

F. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.

2. Protective device clearing time.

3. Duration of arc.

4. Arc-flash boundary.

5. Working distance.

6. Incident energy.

7. Hazard risk category.

8. Recommendations for arc-flash energy reduction.

G. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.

2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

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

G. The calculations shall include the ac fault-current decay from induction motors and shall apply to low-voltage, three-phase ac systems.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.

2. Switchgear.

3. Low-voltage switchgear.

4. Motor-control centers.

5. Standby generators and automatic transfer switches.

6. Branch circuit panelboards.

7. Variable Frequency Drives.

3.3 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Use the short-circuit study output and the field-verified settings of the overcurrent devices.

C. Calculate fault-current size on utility service and on generator.

1. The utility calculation shall assume that the utility contribution is at a maximum and shall assume all motors running.

2. The generator calculation shall assume no contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

E. Include low-voltage equipment locations, except 240-V ac and 208-V ac systems fed from transformers less than 125 kVA.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

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

1. Fault contribution from induction motors should not be considered beyond three to five cycles.

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.

2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.4 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on the one-line diagram on Drawings. Call discrepancies to the attention of Engineer.

2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

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

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

2. Obtain electrical power utility impedance at the service.

3. Power sources and ties.

4. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.

5. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.

6. Motor horsepower and NEMA MG 1 code letter designation.

7. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

END OF SECTION

SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

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

1. Institute of Electrical and Electronics Engineers (IEEE):
   a. 43, Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
   b. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminators Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5kV through 500kV.
   c. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
   d. 95, Recommended Practice for Insulation Testing of AC Electric Machinery (2300V and Above) with High Direct Voltage.
   e. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
   f. 400, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems.
   h. C2, National Electrical Safety Code.
   i. C37.20.1, Standard for Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear.
   j. C37.20.2, Standard for Metal-Clad Switchgear.
   k. C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear.
   l. C37.23, Standard for Metal-Enclosed Bus.

2. Insulated Cable Engineers Association (ICEA):
   a. S-93-639, 5-46 kV Shielded Power Cables for Use in the Transmission and Distribution of Electric Energy.
   b. S-94-649, Concentric Neutral Cables Rated 5 through 46 kV.
   c. S-97-682, Standard for Utility Shielded Power Cables Rated 5 through 46 kV.
3. National Electrical Manufacturers Association (NEMA):
   a. AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
   b. PB 2, Deadfront Distribution Switchboards.
   c. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.

4. InterNational Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
5. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 70B, Recommended Practice for Electrical Equipment Maintenance.
   c. 70E, Standard for Electrical Safety in the Workplace.
   d. 101, Life Safety Code.
7. National Institute for Certification in Engineering Technologies (NICET).
8. Occupational Safety and Health Administration (OSHA): CFR 29, Part 1910, Occupational Safety and Health Standards.

1.02 SUBMITTALS

A. Action Submittals:

1. Submit 30 days prior to performing inspections or tests:
   a. Schedule for performing inspection and tests.
   b. Sample copy of equipment inspection form(s).
   c. Sample copy of individual device test form.
2. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test:
3. Operation and Maintenance Data:
   a. In accordance with Section 01 78 23, Operation and Maintenance Data.
   b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.

1.03 QUALITY ASSURANCE

A. Testing Firm Qualifications:
1. Corporately and financially independent organization functioning as an unbiased testing authority.
2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.
3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.
4. Registered Professional Engineer to provide comprehensive Project report outlining services performed, results of such services, recommendations, actions taken, and opinions.

B. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.

C. Test instrument calibration shall be in accordance with NETA ATS.

1.04 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment listed herein has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

C. Inspection and electrical tests on energized equipment shall be:

1. Scheduled with Owner prior to de-energization.
2. Minimized to avoid extended period of interruption to the operating plant equipment.

D. Notify Owner at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Perform tests in accordance with requirements of Section 01 91 14, Equipment Testing and Facility Startup.

B. Tests and inspections shall establish:

1. Electrical equipment is operational within industry and manufacturer's tolerances and standards.
2. Installation operates properly.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, NFPA 101, and IEEE C2.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

D. Set, test, and calibrate, circuit breakers, power monitoring meters, and other applicable devices in accordance with values established by short circuit, coordination, and harmonics studies as specified in Section 26 05 73.16, Overcurrent Protective Device Coordination Study.

E. Adjust mechanisms and moving parts of equipment for free mechanical movement.

F. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

G. Verify nameplate data for conformance to contract documents and approved submittals.

H. Realign equipment not properly aligned and correct unlevelness.

I. Properly anchor electrical equipment found to be inadequately anchored.

J. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer's recommendations, or as otherwise specified in NETA ATS.

K. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

L. Provide proper lubrication of applicable moving parts.

M. Inform Engineer of working clearances not in accordance with NFPA 70.

N. Investigate and repair or replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

O. Electrical Enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by Engineer door and panel sections having dented surfaces.
5. Repair or replace, as determined by Engineer poor fitting doors and panel sections.
6. Repair or replace improperly operating latching, locking, or interlocking devices.
7. Replace missing or damaged hardware.
8. Finish:
   a. Provide matching paint and touch up scratches and mars.

b. If required due to extensive damage, as determined by Engineer, refinish entire assembly.

P. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.

3.02 CHECKOUT AND STARTUP

A. Voltage Field Test:

1. Check voltage at service disconnects at Thickening Building and RWI pump station when installation is essentially complete and is in operation.
2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
3. Record supply voltage (all three phases simultaneously on same graph) for 24 hours during normal working day.

B. Equipment Line Current Tests:

1. Check line current in each phase for each piece of equipment.
2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.
3. If phase current for a piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

3.03 PANELBOARDS

A. Visual and Mechanical Inspection: Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
2. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instruction manual.
3. Check panelboard mounting, area clearances, and alignment and fit of components.
4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
5. Perform visual and mechanical inspection for overcurrent protective devices.

B. Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:

1. Insulation Resistance Tests:
    a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
    b. Each phase of each bus section.
    c. Phase-to-phase and phase-to-ground for 1 minute.
    d. With breakers open.
    e. With breakers closed.
    f. Control wiring except that connected to solid state components.
    g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Ground continuity test ground bus to system ground.

3.04 DRY TYPE TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage.
2. Proper winding connections.
3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Removal of shipping brackets, fixtures, or bracing.
7. Free and properly installed resilient mounts.
8. Cleanliness and improper blockage of ventilation passages.
9. Verify tap-changer is set at correct ratio for rated output voltage under normal operating conditions.
10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

3.05 LIQUID FILLED TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage.
2. Proper winding connections.
3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Effective core and equipment grounding.
7. Removal of shipping brackets, fixtures, or bracing.
8. Tank leaks and proper liquid level.
9. Integrity and contamination of bus insulation system.

10. Verify tap-changer is set at correct ratio for rated voltage under normal operating conditions.
11. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

3.06 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed power cable No. 1/0 and larger for:
   a. Physical damage.
   b. Proper connections in accordance with single-line diagram.
   c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
   d. Color coding conformance with specification.
   e. Proper circuit identification.
2. Mechanical Connections For:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
3. Shielded Instrumentation Cables For:
   a. Proper shield grounding.
   b. Proper terminations.
   c. Proper circuit identification.
4. Control Cables For:
   a. Proper termination.
   b. Proper circuit identification.
5. Cables Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 4/0 and Larger:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohmmeter for 600-volt insulated conductors
   b. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
   c. Evaluate ohmic values by comparison with conductors of same length and type.
   d. Investigate values less than 50 megohms.
2. Continuity test by ohmmeter method to ensure proper cable connections.

C. Low-voltage cable tests may be performed by installer in lieu of independent testing firm.

3.07 MEDIUM-VOLTAGE CABLES, 5 KV and 15 KV MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed cable for:
   a. Physical damage plus jacket and insulation condition.
   b. Proper connections in accordance with single-line diagram or approved Submittals.
   c. Proper shield grounding.
   d. Proper cable support.
   e. Proper cable termination.
   f. Cable bends not in conformance with manufacturer's minimum allowable bending radius.
   g. Proper arc and fireproofing in common cable areas.
   h. Proper circuit and phase identification.
2. Mechanical Connections:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturers.
3. Conductors Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 5,000-volt and 15,000-volt megohmmeter for 5 kV and 15 kV conductors.
   b. Test each cable individually with remaining cables and shields grounded.
   c. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
   d. Evaluate ohmic values by comparison with conductors of same length and type.
   e. Investigate values less than 50 megohms.
2. Shield Continuity Tests:
   a. By ohmmeter method on each section of conductor.
   b. Investigate values in excess of 10 ohms per 1,000 feet of conductors.
3. Acceptance Tests:
   a. In accordance with IEEE 400, ICEA S-93-639, NEMA WC 74, ICEA S-94-649, and ICEA S-97-682 for insulated conductors.
   b. Each conductor section tested with:
      1) Splices and terminations in place but disconnected from equipment.

2) Remaining conductors and shields grounded in accordance with IEEE 400.

c. Apply maximum test voltage per NETA ATS, Table 100.6, based on method (DC, AC, PD or VLF) used.

d. Measure only leakage current associated with conductor.

e. Utilize guard ring or field reduction sphere to suppress corona at disconnected terminations.

f. Maximum test voltage shall not exceed limits for terminators specified in IEEE 48, IEEE 386, or manufacturer's specifications.

g. Apply test voltage in a minimum of five equal increments until maximum acceptable test voltage is reached.

1) Increments not to exceed ac voltage rating of conductor.

2) Record dc leakage current at each step after a constant stabilization time consistent with system charging current.

h. Raise conductor to specified maximum test voltage and hold for 15 minutes or as specified by conductor manufacturer. Record leakage current at 30 seconds and 1 minute, and at 1-minute intervals, thereafter.

i. Immediately following test, ground conductor for adequate time period to drain insulation stored charge.

j. Test results evaluated on a pass/fail basis.

3.08 SAFETY SWITCHES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Proper blade pressure and alignment.
2. Proper operation of switch operating handle.
3. Adequate mechanical support for each fuse.
4. Cable connection bolt torque level in accordance with NETA ATS, Table 100.12.
5. Verify fuse sizes and types correspond to one-line diagram or approved Submittals.
6. Perform mechanical operational test to verify mechanical interlocking system operation.

3.09 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 100 amperes and larger and to motor circuit protector breakers rated 100 amperes and larger.

B. Visual and Mechanical Inspection:

1. Proper mounting.
2. Proper conductor size.
3. Feeder designation according to nameplate and one-line diagram.

4. Cracked casings.
5. Connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Operate breaker to verify smooth operation.
7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

3.11 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor control center, and panelboard assemblies for proper connection and tightness.
2. Ground bus connections in motor control center, assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.

B. Electrical Tests:

1. Fall-of-Potential Test:
   a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
   b. Main ground electrode system resistance to ground to be no greater than 5 ohm(s).
2. Two-Point Direct Method Test:
   a. In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
   b. Equipment ground resistance shall not exceed main ground system resistance by 0.50 ohm.

3.12 GROUND FAULT SYSTEMS

A. Inspection and testing limited to:

1. Zero sequence grounding systems.
2. Residual ground fault systems.

B. Visual and Manual Inspection:

1. Neutral main bonding connection to ensure:
   a. Zero sequence sensing system is grounded ahead of neutral disconnect link.
   b. Ground strap sensing system is grounded through sensing device.

c. Neutral ground conductor is solidly grounded.

2. Verify control power has adequate capacity for system.
3. Manually operate monitor panels for:
   a. Trip test.
   b. No trip test.
   c. Nonautomatic rest.
4. Zero sequence system for symmetrical alignment of core balance transformers about current carrying conductors.
5. Relay check for pickup and time under simulated ground fault conditions.
6. Verify nameplate identification by device operation.

C. Electrical Tests:

1. Test system neutral insulation resistance with neutral ground link removed; minimum 1 megohm.
2. Determine relay pickup by primary current injection at the sensor. Relay pickup current within plus or minus 10 percent of device dial or fixed setting.
3. Test relay timing by injecting 300 percent of pick-up current or as specified by manufacturer. Relay operating time in accordance with manufacturer's time-current characteristic curves.
4. Test system operation at 55 percent rated control voltage, if applicable.
5. Test zone interlock system by simultaneous sensor current injection and monitoring zone blocking functions.

3.13 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 10 horsepower and larger.

B. Visual and Mechanical Inspection:

1. Proper electrical and grounding connections.
2. Shaft alignment.
3. Blockage of ventilating air passageways.
4. Operate motor and check for:
   a. Excessive mechanical and electrical noise.
   b. Overheating.
   c. Correct rotation.
   d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionability and proper operation.
   e. Excessive vibration, in excess of values in NETA ATS, Table 100.10.
5. Check operation of space heaters.

C. Electrical Tests:

1. Insulation Resistance Tests:
    a. All motors greater than 25 hp shall be tested.
    b. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 100.1 for:
        1) Motors above 200 horsepower for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
        2) Motors 200 horsepower and less for 1-minute duration with resistances tabulated at 30 seconds and 60 seconds.
    c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturers.
2. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
3. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes.

3.14 LOW-VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:

1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.
4. Improper blockage of air-cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check door and device interlocking system by:
    a. Closure attempt of device when door is in OPEN position.
    b. Opening attempt of door when device is in ON position.
8. Check key interlocking systems for:
    a. Key captivity when device is in ON position.
    b. Key removal when device is in OFF position.
    c. Closure attempt of device when key has been removed.
    d. Correct number of keys in relationship to number of lock cylinders.
    e. Existence of other keys capable of operating lock cylinders; destroy duplicate sets of keys.
9. Check nameplates for proper identification of:
    a. Equipment title and tag number with latest one-line diagram.
10. Verify fuse and circuit breaker sizes and types conform to Contract Documents.
11. Check operation and sequencing of electrical and mechanical interlock systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.

12. Verify performance of each control device and feature furnished as part of motor control center.
13. Control Wiring:
    a. Check for proper conductor lacing and bundling.
    b. Check for proper conductor identification.
14. Exercise active components.
15. Inspect contactors for:
    a. Correct mechanical operations.
    b. Correct torque of connections.

3.15 AUTOMATIC TRANSFER SWITCHES

A. Visual and Mechanical Inspection:

1. Check doors and panels for proper interlocking.
2. Check connections for high resistance by low-resistance ohmmeter.
3. Check positive mechanical and electrical interlock between normal and alternate sources.
4. Check for proper operation:
    a. Manual transfer function switch.
    b. Generator under load and nonload conditions.
    c. Auto-exerciser of generator under load and no-load conditions.
5. Verify settings and operation of control devices.

3.18 STANDBY GENERATOR SYSTEMS

A. Visual and Mechanical Inspection:

1. Proper grounding.
2. Blockage of ventilating passageways.
3. Proper operation of jack water heaters.
4. Integrity of engine cooling and fuel supply systems.
5. Excessive mechanical and electrical noise.
6. Overheating of engine or generator.
7. Proper installation of vibration isolators.
8. Proper cooling liquid type and level.
9. Operate engine-generator and check for:
    a. Excessive mechanical and electrical noise.
    b. Overheating.
    c. Correct rotation.
    d. Check resistance temperature detectors or generator inherent thermal protectors for functionability and proper operation.
    e. Excessive vibration.
10. Verify voltage regulator and governor operation will cause unit speed and output voltage to stabilize at proper values within reasonable length of time.

11. Proper operation of meters and instruments.
12. Compare generator nameplate rating and connection with one-line diagram or approved Submittal.
13. Verify engine-generator operation with adjustable frequency drives, and active harmonic conditioners energized and operating under normal load conditions.

B. Electrical and Mechanical Tests:

1. Cold start test by interrupting normal power source with test load consisting of connected building load to verify:
   a. Transfer switch operation.
   b. Automatic starting operation.
2. Phase rotation tests.

END OF SECTION

SECTION 26 09 13
ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes PC-based computer and software for monitoring and control of electrical power system.

1.2 ACTION SUBMITTALS

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

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

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

1. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components.

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

3. Provide recommended screens customized for this specific project and coordinated with Owner through interitive design process.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Other Informational Submittals: System installation and setup guides, with data forms to plan and record options and setup decisions.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data:

1. Operating and applications software documentation.

2. Software licenses.

3. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.

2. Software Backup: On compact disc, complete with Owner-selected options.

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

C. Software Upgrade Kit: For Owner to use in modifying software to suit future power system revisions or power monitoring and control revisions.

D. Software licenses and upgrades required by and installed for operating and programming digital and analog devices.

1.5 QUALITY ASSURANCE

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

1.6 SOFTWARE SERVICE AGREEMENT

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

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

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Eaton Corporation

B. General Electric Company

C. Landis+Gyr Inc.

D. Rockwell Automation, Inc.

E. Schneider Electric USA, Inc.

2.2 FUNCTIONAL DESCRIPTION

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

1. Calculate and Record the Following:

a. Load factor.
b. Peak demand periods.

2. Measure and Record Metering Data for the Following:

a. Electricity.

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

1. Voltage regulation and unbalance.

2. Continuous three-phase RMS voltage.

3. Periodic max./min./avg. voltage samples.

4. Harmonics.

5. Voltage excursions.

2.3 SYSTEM REQUIREMENTS

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

1. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors.

2.4 OPERATING SYSTEM

A. Software: Configured to run on a portable laptop computer, a single PC, or a palm computer, with capability for accessing a single meter at a time.

2.5 APPLICATIONS SOFTWARE

A. Basic Requirements:

1. Fully compatible with and based on the approved operating system.

2. Password-protected operator login and access; three levels, minimum.

3. Password-protected setup functions.

4. Context-sensitive online help.

5. Capability of creating, deleting, and copying files; and automatically maintaining a directory of all files, including size and location of each sequential and random-ordered record.

6. Automatic and encrypted backups for database and history; automatically stored at central control PC and encrypted with a nine-character alphanumeric password, which must be used to restore or read data contained in backup.

7. Operator audit trail for recording and reporting all changes made to user-defined system options.

B. Data Formats:

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

2. Option to convert reports and graphics to HTML format.

C. Metered Data: Display metered values in real time.

D. Remote Control:

1. Display circuit-breaker status and allow breaker control.

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

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

1. Phase voltages, phase currents, and residual current.

2. Waveforms ranging in length from 2 cycles to 5 minutes.

3. Disturbance and steady-state waveforms up to 512 points per cycle.

4. Calculated waveform, based on recorded data, on a minimum of four cycles of data of the following:

   a. THD.
   b. RMS magnitudes.
   c. Peak values.
   d. Crest factors.
   e. Magnitude of individual harmonics.

F. Data Sharing: Allow export of recorded displays and tabular data to third-party applications software.

1. Tabular data shall be in the comma-separated values.

G. Reporting: User commands initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.

1. Print a record of user-defined alarm, supervisory, and trouble events on workstation printer.

2. Sort and report by device name and by function.

3. Report type of signal (alarm, supervisory, or trouble), description, date, and time of occurrence.

4. Differentiate alarm signals from other indications.

5. When system is reset, report reset event with same information concerning device, location, date, and time.

2.6 COMMUNICATION COMPONENTS AND NETWORKS

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

2.7 POWER MONITORS

A. Separately mounted, permanently installed instrument for power monitoring and control, complying with UL 1244.

1. Enclosure: NEMA 250, Type 12.

B. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Indoor installation in non-air-conditioned spaces that have environmental controls to maintain ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.

C. RMS Real-Time Measurements:

1. Current: Each phase, neutral, average of three phases, percent unbalance.

2. Voltage: Line-to-line each phase, line-to-line average of three phases, line-to-neutral each phase, line-to-neutral average of three phases, line-to-neutral percent unbalance.

3. Power: Per phase and three-phase total.

4. Reactive Power: Per phase and three-phase total.

5. Power Factor: Per phase and three-phase total.

6. Frequency.

7. THD: Current and voltage.

8. Accumulated Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).

9. Incremental Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).

10. Conditional Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).

D. Demand Current Calculations, per Phase, Three-Phase Average and Neutral:

1. Present.

2. Running average.

3. Last completed interval.

4. Peak.

E. Demand Real Power Calculations, Three-Phase Total:

1. Present.

2. Running average.

3. Last completed interval.

4. Predicted.

5. Peak.

6. Coincident with peak kVA demand.

7. Coincident with kVAR demand.

F. Demand Reactive Power Calculations, Three-Phase Total:

1. Present.

2. Running average.

3. Last completed interval.

4. Predicted.

5. Peak.

6. Coincident with peak kVA demand.

7. Coincident with kVAR demand.

G. Average Power Factor Calculations, Demand Coincident, Three-Phase Total:

1. Last completed interval.

2. Coincident with kW peak.

3. Coincident with kVAR peak.

4. Coincident with kVA peak.

H. Power Demand Calculations: According to one of the following calculation methods, selectable by the user:

1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.

2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:

    a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
    b. Fixed block that calculates demand at end of the interval.
    c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.

3. Demand Calculation Initiated by a Synchronization Signal:

    a. Signal is a pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.
    b. Signal is a communication signal. Calculation shall be configurable as either a block or rolling block calculation.

I. Sampling:

1. Current and voltage shall be digitally sampled at a rate high enough to provide accuracy to 63rd harmonic of 60-Hz fundamental.

2. Power monitor shall provide continuous sampling at a rate of 128 samples per cycle on all voltage and current channels in the meter.

J. Minimum and Maximum Values: Record monthly minimum and maximum values, including date and time of record. For three-phase measurements, identify phase of recorded value. Record the following parameters:

1. Line-to-line voltage.

2. Line-to-neutral voltage.

3. Current per phase.

4. Line-to-line voltage unbalance.

5. Line-to-neutral voltage unbalance.

6. Power factor.

7. Displacement power factor.

8. Total power.

9. Total reactive power.

10. THD voltage L-L.

11. THD voltage L-N.

12. THD current.

13. Frequency.

K. Harmonic Calculation: Display and record the following:

1. Harmonic magnitudes and angles for each phase voltage and current through 31st harmonic. Calculate for all three phases, current and voltage, and residual current. Current and voltage information for all phases shall be obtained simultaneously from same cycle.

2. Harmonic magnitude reported as a percentage of the fundamental or as a percentage of RMS values, as selected by user.

L. Current and Voltage Ratings:

1. Designed for use with current inputs from standard instrument current transformers with 5-A secondary and shall have a metering range of 0-10 A.

2. Withstand ratings shall not be less than 15 A, continuous; 50 A, lasting over 10 seconds, no more frequently than once per hour; 500 A, lasting 1 second, no more frequently than once per hour.

3. Designed for use with voltage inputs from standard instrument potential transformers with a 120-V secondary.

M. Accuracy at full-scale for meters that are circuit-breaker accessories shall not be less than the following:

1. Current: Plus or minus 2.5 percent.

2. Voltage: Plus or minus 1.5 percent.

3. Energy, Demand, and Power: Plus or minus 4.0 percent.

4. Frequency: Plus or minus 1 Hz.

N. Waveform Capture:

1. Capture and store steady-state waveforms of voltage and current channels; initiated manually. Each capture shall be for 3 cycles, 128 data points for each cycle, allowing resolution of harmonics to 31st harmonic of basic 60 Hz.

2. Store captured waveforms in internal nonvolatile memory; available for PC display, archiving, and analysis.

O. Input: One digital input signal(s).

1. Normal mode for on/off signal.

2. Demand interval synchronization pulse, accepting a demand synchronization pulse from a utility demand meter.

3. Conditional energy signal to control conditional energy accumulation.

P. Outputs:

1. Operated either by user command sent via communication link, or set to operate in response to user-defined alarm or event.

2. Closed in either a momentary or latched mode as defined by user.

3. Each output relay used in a momentary contact mode shall have an independent timer that can be set by user.

4. One digital KY pulse to a user-definable increment of energy measurement. Output ratings shall be up to 120-V ac, 300-V dc, 50 mA, and provide 3500-V RMS isolation.

5. One relay output module(s), providing a load voltage range from 20- to 240-V ac or from 20- to 30-V dc, supporting a load current of 2 A.

6. Output Relay Control:

a. Relay outputs shall operate either by user command sent via communication link or in response to user-defined alarm or event.
b. Normally open and normally closed contacts, field configured to operate as follows:

1) Normal contact closure where contacts change state for as long as signal exists.

2) Latched mode when contacts change state on receipts of a pickup signal; changed state is held until a dropout signal is received.
3) Timed mode when contacts change state on receipt of a pickup signal; changed state is held for a preprogrammed duration.
4) End of power demand interval when relay operates as synchronization pulse for other devices.
5) Energy Pulse Output: Relay pulses quantities used for absolute kWh, absolute kVARh, kVAh, kWh In, kVARh In, kWh Out, and kVARh Out.
6) Output controlled by multiple alarms using Boolean-type logic.

Q. Onboard Data Logging:

1. Store logged data, alarms, events, and waveforms in 800 KB of onboard nonvolatile memory.

2. Stored Data:

a. Custom Data Logs: Three user-defined log(s) holding up to 96 parameters. Date and time stamp each entry to the second and include the following user definitions:

1) Schedule interval.
2) Event definition.
3) Configured as "fill-and-hold" or "circular, first-in first-out."

b. Alarm Log: Include time, date, event information, and coincident information for each defined alarm or event.
c. Waveform Log: Store captured waveforms configured as "fill-and-hold" or "circular, first-in first-out."

3. Default values for all logs shall be initially set at factory, with logging to begin on device power up.

R. Alarms.

1. User Options:

a. Define pickup, dropout, and delay.
b. Assign one of four severity levels to make it easier for user to respond to the most important events first.
c. Allow for combining up to four alarms using Boolean-type logic statements for outputting a single alarm.

2. Alarm Events:

a. Over/undercurrent.
b. Over/undervoltage.
c. Current imbalance.
d. Phase loss, current.
e. Phase loss, voltage.
f. Voltage imbalance.
g. Over kW demand.
h. Phase reversal.
i. Digital input off/on.
j. End of incremental energy interval.
k. End of demand interval.

S. Control Power: 90- to 457-V ac or 100- to 300-V dc.

T. Communications: Local plug-in connections shall be for RS-232 and 100 Base-T Ethernet.

U. Display Monitor:

1. Backlit LCD to display metered data with touch-screen selecting device.

2. Touch-screen display shall be a minimum 12-inch diagonal, resolution of 800 by 600 RGB pixels, 256 colors; NEMA 250, Type 1 display enclosure.

3. Display four values on one screen at same time.

a. Current, per phase RMS, three-phase average and neutral.
b. Voltage, phase to phase, phase to neutral, and three-phase averages of phase to phase and phase to neutral.
c. Real power, per phase and three-phase total.
d. Reactive power, per phase and three-phase total.
e. Apparent power, per phase and three-phase total.
f. Power factor, per phase and three-phase total.
g. Frequency.
h. Demand current, per phase and three-phase average.
i. Demand real power, three-phase total.
j. Accumulated energy (MWh and MVARh).
k. THD, current and voltage, per phase.

4. Reset: Allow reset of the following parameters at the display:

a. Peak demand current.

b. Peak demand power (kW) and peak demand apparent power (kVA).
c. Energy (MWh) and reactive energy (MVARh).

2.8 LOW-VOLTAGE WIRING

A. Comply with Section 26 05 05 "Conductors."

B. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.

1. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.

2. Ordinary Switching Circuits: Three conductors unless otherwise indicated.

3. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.

PART 3 - EXECUTION

3.1 SYSTEM SETUP

Working with Owner in an interitive process to provide complete system setup as follows:

A. Provide initial softwater installation licensing and setup.

B. Setup communication interfaces.

C. Provide customized software screens (20).

D. Provide customized reports (5).

3.2 CABLING

A. Comply with NECA 1.

B. Install cables and wiring according to requirements in Section 26 05 05 "Conductors" and Section 26 05 33 “Raceways and Boxes.”

C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Section 26 05 53 "Identification for Electrical Systems."

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

3.4 GROUNDING

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

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

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

2. Continuity tests of circuits.

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

a. Coordinate testing required by this Section with that required by Sections specifying equipment being monitored and controlled.
b. Test LANs according to requirements in Section 26 05 05 "Conductors."
c. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of calculated battery operating time.
d. Verify accuracy of graphic screens and icons.
e. Metering Test: Load feeders, measure loads on feeder conductor with an RMS reading clamp-on ammeter, and simultaneously read indicated current on the same phase at central-processing workstation. Record and compare values measured at the two

locations. Resolve discrepancies greater than 5 percent and record resolution method and results.

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

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

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

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

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

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

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

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

END OF SECTION

SECTION 26 12 00
MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following types of transformers with medium-voltage primaries:

1. Liquid-filled distribution and power transformers.

2. Dry-type distribution and power transformers.

1.3 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.

B. Shop Drawings: Diagram power signal and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Underground primary and secondary conduit stub-up location.

2. Dimensioned concrete base, outline of transformer, and required clearances.

3. Ground rod and grounding cable locations.

B. Qualification Data: For testing agency.

C. Source quality-control test reports.

D. Field quality-control test reports.

E. Follow-up service reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

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

C. Comply with IEEE C2.

D. Comply with ANSI C57.12.10, ANSI C57.12.28, IEEE C57.12.70, and IEEE C57.12.80.

E. Comply with NFPA 70.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store transformers protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

1.9 PROJECT CONDITIONS

A. Service Conditions: IEEE C37.121, usual service conditions except for the following:

1. Exposure to significant solar radiation.

2. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.

3. Exposure to excessively high or low temperatures.

1.10 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Coordinate installation of louvers, doors, spill retention areas, and sumps. Coordinate installation so no piping or conduits are installed in space allocated for medium-voltage transformers except those directly associated with transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Industries.
2. Cutler-Hammer.
3. GE Electrical Distribution & Control.
4. Pioneer Transformers.
5. Siemens Energy & Automation, Inc.
6. Square D; Schneider Electric.
7. Virginia Transformer Corp.

2.2 LIQUID-FILLED DISTRIBUTION AND POWER TRANSFORMERS

A. Description: IEEE C57.12.00 and UL 1062, liquid-filled, 2-winding transformers.

B. Insulating Liquid: Less flammable, dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.

C. Insulation Temperature Rise: 65 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C.

D. Basic Impulse Level: See Drawings.

E. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

F. Cooling System: Class OA, self-cooled. Cooling systems shall include auxiliary cooling equipment, automatic controls, and status indicating lights.

G. Provisions for Future Forced Air Cooling: Include the following provisions for future forced air cooling:

1. Top-Liquid Temperature Sensing on Liquid-Filled Transformers: Thermally operated control device with thermal element mounted in a well, and provisions for mounting control cabinet, conduit, and fans.

H. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.

I. Impedance: 6.5 percent.

J. SCADA system inputs:

1. Oil Temperature High
2. Oil Level Low
3. Pressure Vacuum
4. Pressure

K. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap. Include the following additional accessories:

1. Liquid-level gage.
2. Pressure-vacuum gage.
3. Liquid temperature indicator.
4. Drain and filter valves.
5. Pressure relief device.

2.3 DRY-TYPE DISTRIBUTION AND POWER TRANSFORMERS

A. Description: NEMA ST 20, IEEE C57.12.01, ANSI C57.12.50, dry-type, 2-winding transformers.

1. Indoor, ventilated, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.

B. Primary Connection: Air terminal compartment with hinged door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.

C. Primary Connection: Transition terminal compartment with connection pattern to match switchgear.

D. Secondary Connection: Air terminal compartment with hinged door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.

E. Secondary Connection: Transition terminal compartment with connection pattern to match switchgear.

F. Insulation Materials: IEEE C57.12.01, rated at 220 deg C.

G. Insulation Temperature Rise: 150 deg C, maximum rise above 40 deg C.

H. Basic Impulse Level: 95 kV.

I. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage.

J. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps below rated primary voltage.

K. Cooling System: Class AA/FFA, self-cooled, and with provisions for future forced-air-cooled rating, complying with IEEE C57.12.01.

1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.

2. Include mounting provision for fans.

L. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.

M. Impedance: 5.75 percent unless otherwise indicated.

N. Surge Arresters: Low flash-over type, factory installed and connected to high-voltage terminals, complying with NEMA Standard LA 1. Provide metal-oxide type with ethylene propylene housing.

O. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 05 53 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to ANSI C57.12.50 or ANSI C57.12.51.

B. Factory Tests: Perform the following factory-certified tests on each transformer:

1. Resistance measurements of all windings on rated-voltage connection and on tap extreme connections.

2. Ratios on rated-voltage connection and on tap extreme connections.

3. Polarity and phase relation on rated-voltage connection.

4. No-load loss at rated voltage on rated-voltage connection.

5. Excitation current at rated voltage on rated-voltage connection.

6. Impedance and load loss at rated current on rated-voltage connection and on tap extreme connections.

7. Applied potential.

8. Induced potential.

9. Temperature Test: If transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class OA/FA or Class AA/FA rating.

   a. Temperature test is not required if record of temperature test on an essentially duplicate unit is available.

10. Owner will witness all required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for medium-voltage transformers.

B. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.

2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and that requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install transformers on concrete bases.

1. Anchor transformers to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems."

2. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit and 4 inches high.

3. Use 4000-psi, 28-day compressive-strength concrete and reinforcement as specified in Section 03 30 00 "Cast-in-Place Concrete."

4. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.

5. Install epoxy-coated anchor bolts, for supported equipment, that extend through concrete base and anchor into structural concrete floor.

6. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

7. Tack-weld or bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Section 26 05 53 "Identification for Electrical Systems."

3.4 CONNECTIONS

A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 26 05 05 " Conductors."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

C. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

D. Perform the following field tests and inspections and prepare test reports:

1. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.

2. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.

3. Perform visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Remove and replace malfunctioning units and retest as specified above.

F. Test Reports: Prepare written reports to record the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.

END OF SECTION

SECTION 26 13 00
MEDIUM-VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes metal-enclosed interrupter switchgear with the following optional components, features, and accessories:

1. Communication modules.
2. Analog instruments.
3. Relays.
4. Surge arresters.
5. Provisions for future devices.
6. Fungus proofing.
7. Control battery system.
8. Mimic bus.

1.3 DEFINITIONS

A. ATS: Acceptance Testing Specifications.

B. GFCI: Ground-Fault Circuit Interrupter.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of switchgear and related equipment, include the following:

1. Rated capacities, operating characteristics, furnished specialties, and accessories for individual interrupter switches and circuit breakers.

2. Time-current characteristic curves for overcurrent protective devices, including circuit-breaker relay trip devices and fusible devices.

B. Shop Drawings: For each type of switchgear and related equipment, include the following:

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show method of field

assembly and location and size of each field connection. Include the following:

a. Tabulation of installed devices with features and ratings.
b. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
c. Drawing of cable termination compartments showing preferred locations for conduits and indicating space available for cable terminations.
d. Floor plan drawing showing locations for anchor bolts and leveling channels.
e. Current ratings of buses.
f. Short-time and short-circuit ratings of switchgear assembly.
g. Nameplate legends.
h. Mimic-bus diagram.
i. Utility company's metering provisions with indication of approval by utility company.
j. PLC layout.
k. Modbus Network Diagram.
l. Connection Diagram (indicating all connections to Switchgear Enclosure)

2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting seismic restraints.

3. Wiring Diagrams: For each type of switchgear and related equipment, include the following:

a. Power, signal, and control wiring.
b. Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.
c. Schematic control diagrams.
d. Diagrams showing connections of component devices and equipment.
e. Schematic diagrams showing connections to remote devices including SCADA remote terminal unit.

C. Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where piping and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support

locations, type of support, and weight on each support. Identify field measurements.

B. Manufacturer Seismic Qualification Certification: Submit certification that switchgear, accessories, and components will withstand seismic forces defined in the local Building Code. Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Source quality-control test reports.

D. Modbus Address Mapping Table.

E. PLC Address Mapping Table.

F. Operation and Maintenance Data: For switchgear and switchgear components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of switchgear and associated components through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated. Refer to Section 016100 "Common Product Requirements."

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

D. Comply with IEEE C2.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver in sections of lengths that can be moved past obstructions in delivery path as indicated.

B. Store switchgear indoors in clean dry space to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

1.8 COORDINATION

A. Coordinate layout and installation of switchgear and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.

B. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.9 EXTRA MATERIALS

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

1. Fuses: Six of each type and rating used. Include spares for future transformers, control power circuits, and fusible devices.

2. Indicating Lights: Six of each type installed.

3. Touchup Paint: Three containers of paint matching enclosure finish, each 0.5 pint.

B. Maintenance Tools: Furnish tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include the following:

1. Fuse-handling tool.

2. Extension rails, lifting device, transport or dockable dolly or mobile lift, and all other items necessary to remove circuit breaker from housing and transport to remote location.

3. Racking handle to move circuit breaker manually between connected and disconnected positions, and a secondary test coupler to permit testing of circuit breaker without removal from switchgear.

4. Remote operated racking device.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 MANUFACTURED UNITS

A. Description: Factory assembled and tested, and complying with IEEE C37.20.1.

B. Ratings: Suitable for application in 3-phase, 60-Hz, solidly grounded-neutral system.

C. System Voltage: 4.16 kV nominal; 4.76 kV maximum and 13.8 kV nominal; 15 kV maximum.

2.3 METAL-ENCLOSED INTERRUPTER SWITCHGEAR

A. Manufacturers:

1. ABB Control, Inc.
2. Eaton Corporation.
3. S&C Electric Company.
4. Siemens Industry, Inc.
5. Square D; by Schneider Electric.

B. Equipment shall by front access only and not require any rear access.

C. Comply with IEEE C37.20.3.

D. Ratings: Comply with standard ratings designated in IEEE C37.20.3 for maximum-rated voltage specified.

1. Main-Bus Rating: See Drawings.

E. Interrupter Switches: Stationary, gang operated, and suitable for application at maximum short-circuit rating of integrated switchgear assembly.

1. Rating: See drawing for continuous duty and load break.

2. Duty-Cycle, Fault Closing: 40,000 asymmetrical A.

3. Switch Action: No external arc and no significant quantities of ionized gas released into the enclosure.

4. Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.

5. Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.

6. Protective Shields: Cover live components and terminals.

7. Fuses: De-energized if switch is open.

F. Mechanical Interlock: Prevent opening switch compartment door unless switchblades are open, and prevent closing switch if door is open.

G. Window: Permit viewing switchblade positions if door is closed.

H. Power Fuses: Comply with the following and with applicable requirements in NEMA SG 2:

1. Indicator: Integral with each fuse to indicate when it has blown.

2. Mounting: Positively held in position with provision for easy removal and replacement from front without special tools.

3. Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.

4. Expulsion Fuses: Furnished in disconnect-type mountings and renewable with replacement fuse units. Gases emitted on interruption are controlled and silenced by chambers designed for that purpose.

I. Circuit Breakers: Three-pole, single-throw, electrically operated, drawout-mounting units using three individual, vacuum-sealed interrupter modules and including the following features:

1. Designed to operate at rated voltage to interrupt fault current within its rating within three cycles of trip initiation.

2. For systems with X/R ratio 17 or less, the transient voltage upon such interruption shall not exceed twice-rated line-to-ground voltage of system.

3. Contact-Wear Indicator: Readily accessible to field maintenance personnel.

4. The switchgear manufacturer shall furnish and install for each circuit breaker, the type and rating of protection relays as indicated on Drawings and described in this Specification.

5. Minimum of six Type A and six Type B spare contacts.

6. Microprocessor based solid-state, multi-functional type protective relay shall be used, consisting of current transformers, a solid-state unit to interpret output of current transformers, and a tripping solenoid acting directly to trip breaker. Time delay and pick-up characteristics shall be variable in field. Device shall be designed such that performance at any setting is repeatable. A ground detection device shall be provided when shown on Drawing.

   a. See system One-line for Circuit Breaker protective relay type.
   b. The protective relay shall contain, as a minimum, the functionality for adjustable phase time over-current, instantaneous over-current and ground fault protection, ANSI 50/51, and selectable 50/51G or 50/51N into a single device.
   c. The protective relay shall provide true rms sensing circuit protection by analyzing each phase and ground of the secondary current signals received from the circuit breaker current sensors. The protective relay shall initiate trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached. Ground element shall be capable of being utilized in residual, zero sequence, or ground source connection schemes, or deactivated.
   d. The protective relay shall provide ANSI 50/51N and other specified protective functions for each of the 3 phases, and ANSI 50/51N or 50/51G ground fault protection functions as shown on Drawings or as determined by Coordination Study.
   e. The primary current transformer rating being used for phase and ground protection feeding the protective relay shall be

programmable for current transformers with primary current ratings from 5 through 5,000 amperes.

f. Both the phase and ground protection curves shall be independently field selectable and programmable with or without load. Curves shall be selectable from the following:
   1) IEEE: Moderately inverse, very inverse, extremely inverse time.
   2) Thermal: Flat, It, I2t, I4t.

g. Thermal curves shall be similar to those on low voltage trip units for close coordination with downstream devices. Selectable short delay pick-up and short delay time settings shall also be provided. The phase instantaneous over-current trip shall have field programmable pick-up points from 1.0 to 25 times current transformer primary rating.

h. The protective relay shall have a Type "A" contact assigned to the ANSI 51/50 phase protection function and a second Type "A" contact assigned to the 51/50 ground protection function.

i. The protective relay shall have a built-in alphanumeric display capable of displaying the following information with metering accuracy of plus or minus 1 percent of full scale:
   1) Individual phase currents.
   2) Ground current.
   3) Cause of trip.
   4) Magnitude and phase of current causing trip.
   5) Peak current demand for each phase and ground since last reset.
   6) Current transformer primary rating.
   7) Programmed phase and ground setpoints.

j. The protective relay shall have the following features:
   1) Integral manual testing capability for both phase and ground.
   2) Zone selective interlocking capability for short time and ground fault protection. This function shall be provided and factory wired. Where zone selective interlocking is not an integral part of the protective device; a full bus differential scheme shall be required for both phase and ground in addition to specified time over-current and instantaneous over-current phase and ground fault protection. Bus differential scheme shall be provided with separate differential current transformers for all incoming and outgoing loads as well as appropriate differential relays (ANSI 87 and 87G) as approved by ENGINEER.
   3) Continuous self-testing of internal circuitry.
   4) Unit failure alarm contact for customer use.
   5) Programmable lockout/self-reset after trip function.
   6) Programmable setpoints for device curve selection.

7) Programmable inputs, such as current transformer ratios.

k. Relay shall be suitable for operating temperatures from -30 to 55 degrees C. Relay shall be suitable for operating with humidity from 0 to 95 percent relative humidity (non-condensing).

7. Where AC control power schemes are shown on Drawings, in addition to control power transformer or remote control power shown or herein specified, a single phase uninterruptible power supply shall be included to supply control power to protective devices.

8. Ratings: MVA interrupting rating class and momentary and short-time current ratings same as switchgear. Current rating of breakers shall be as indicated.

9. Interchangeability: Circuit breakers are interchangeable with vacuum circuit breakers of same current and interrupting ratings.

   a. Current Rating of Main Circuit Breaker: See drawings.
   b. Continuous Current Rating of Tie Circuit Breaker: See drawings.
   c. Continuous Current Rating of Feeder Circuit Breaker: See drawings.

10. Operating Mechanism: Electrically charged, mechanically and electrically trip-free, stored-energy operated.

    a. Closing speed of moving contacts shall be independent of both control and operator.
    b. Provision included for manual charging of mechanism and for slow closing of contacts for inspection or adjustment.
    c. Control Power: 48-V dc for closing and tripping.
    d. Provide shunt trip capability independent of overcurrent trip.

11. Indicating Lights: In each circuit breaker circuit provide a red "closed" indicator, a green "tripped" indicator, and a blue "lockout" indicator.

12. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits. Nameplates shall be laminated plastic, black characters on white background, and secured with screws. Characters shall be 3/16-inch high, minimum. Nameplates shall give item designation and circuit number as well as frame ampere size and appropriate trip rating. Nameplates for feeder breakers shall also indicate which substation is being fed. Furnish master nameplate giving switchgear designation, voltage ampere rating, short circuit rating, manufacturer's name, general order number, and item number.

J. Test Accessories: Relay and meter test plugs.

2.4 NETWORK

A. Master programmable logic controller (PLC)-based digital controller shall provide automatic control of circuit breakers upon detection of loss of the utility source.

B. An advanced network shall link all the circuit breakers within the switchgear to the Master PLC. The Master PLC shall communicate and receive all metering values and diagnostic information for each breaker. The Master PLC shall be a Siemens S7 (S7-1200 with network card). Register mapping table and PLC program shall be provided to ENGINEER and SCADA Programmer for integration. See network drawing for network layout.

C. Manual overrides shall be included to allow opening and closing of all breakers. When in manual operations, hardwired interlocks shall prevent both main breakers and the tie breaker to be closed at the same time.

D. Network cabling shall be in RMC.

2.5 CONTROL STATION

A. Quantity: 2

B. Control station shall be provided to remotely open, close and monitor breakers within the medium voltage switchgear. Station shall incorporate visual software to display power oneline and energy status.

C. Control Station shall provide the following:

1. Monitoring
2. Control
3. Alarming
4. Trending
5. Data archiving

2.6 FABRICATION

A. Indoor Enclosure: Steel.

B. Finish: Manufacturer's standard gray finish over rust-inhibiting primer on phosphatizing-treated metal surfaces.

C. Bus Transition Unit: Arranged to suit bus and adjacent units.

D. Incoming-Line Unit: Arranged to suit incoming line.

E. Outgoing Feeder Units: Arranged to suit distribution feeders.

F. Auxiliary Compartments: Arranged to suit house meters, relays, controls, and auxiliary equipment; isolated from medium-voltage components.

G. Key Interlocks: Arranged to effect interlocking schemes indicated.

H. Provisions for Future Key Interlocks: Mountings and hardware required for future installation of locks, where indicated.

2.7 COMPONENTS

A. Main Bus: Copper, tin plated; full length of switchgear.

B. Ground Bus: Copper, silver plated or copper, tin plated; minimum size 1/4 by 2 inches; full length of switchgear.

C. Bus Insulation: Covered with flame-retardant insulation.

D. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.

2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

E. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems, listed and labeled by an NRTL, and with the following features:

1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.

2. Switch-selectable digital display with the following features:

a. Phase Currents, Each Phase: Plus or minus 1 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Three-Phase Real Power: Plus or minus 2 percent.
e. Three-Phase Reactive Power: Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
i. Accumulated energy, in megawatt hours, plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Alarm Functions:
a. Voltage Phase Loss.

b. Current Phase Loss.
c. Phase Voltage Unbalance (5 to 40 percent).
d. Phase Voltage Reversal.
e. Overvoltage (105 to 140 percent).
f. Undervoltage (95 to 60 percent).
g. Time Delay for Overvoltage (0 to 20 seconds).
h. Time Delay for Undervoltage (0 to 20 seconds).
i. Time Delay for Phase Unbalance (0 to 20 seconds).

4. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements according to Section 260913 "Electrical Power Monitoring and Control."

5. Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.

F. Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs.

G. Surge Arresters: Distribution class, metal-oxide-varistor type. Comply with NEMA LA 1.

1. Install in cable termination compartments in each phase of circuit.

2. Coordinate rating with circuit voltage.

H. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

I. Fungus Proofing: Permanent fungicidal treatment for switchgear interior, including instruments and instrument transformers.

J. Control Power Supply: Control power transformer supplies 120-V control circuits through secondary disconnect devices. Include the following features:

1. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.

2. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.

a. Secondary windings connected through relay(s) to control bus to affect an automatic transfer scheme.
b. Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.

3. Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.

K. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2. Conductors sized according to NFPA 70 for duty required.

2.8 IDENTIFICATION

A. Materials: Refer to Section 260553 "Identification for Electrical Systems." Identify units, devices, controls, and wiring.

B. Mimic Bus: Continuous mimic bus applied to front of switchgear, arranged in single-line diagram format, using symbols and lettered designations consistent with approved final mimic-bus diagram.

1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.

2. Medium: Painted graphics, as approved.

3. Color: Contrasting with factory-finish background; selected by Engineer.

2.9 SOURCE QUALITY CONTROL

A. Before shipment of equipment, perform the following tests and prepare test reports:

1. Production tests on circuit breakers according to ANSI C37.09.

2. Production tests on completed switchgear assembly according to IEEE C37.20.2.

B. Assemble switchgear and equipment in manufacturer's plant and perform the following:

1. Functional tests of all relays, instruments, meters, and control devices by application of secondary three-phase voltage to voltage circuits and injection of current in current transformer secondary circuits.

2. Functional test of all control and trip circuits. Connect test devices into circuits to simulate operation of controlled remote equipment such as

circuit-breaker trip coils, close coils, and auxiliary contacts. Test proper operation of relay targets.

C. Prepare equipment for shipment.

1. Provide suitable crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.

2. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.

2.10 FACTORY FINISHES

A. Finish: Manufacturer's standard color finish applied to equipment before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive switchgear for compliance with requirements for installation tolerances, required clearances, and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Anchor switchgear assembly to 4-inch, channel-iron sill embedded in concrete base and attach by bolting.

1. Sills: Select to suit switchgear; level and grout flush into concrete base.

2. Design each fastener and support to carry load indicated by seismic requirements.

3. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no less than 3 inches in all directions beyond the maximum dimensions of switchgear, unless otherwise indicated or unless required for seismic anchor support.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchgear units and components.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 260553 "Identification for Electrical Systems."

B. Diagram and Instructions:

1. Frame under clear acrylic plastic on front of switchgear.

a. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.

2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

3.4 CONNECTIONS

A. Cable terminations at switchgear are specified in Section 26 05 05 "Conductors."

B. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect switchgear, wiring, components, connections, and equipment installation. Test and adjust components and equipment.

2. Assist in field testing of equipment including pretesting and adjusting of automatic power factor correction units.

3. Report results in writing.

C. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

D. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:

a. Switchgear.
b. Circuit breakers.
c. Protective relays.
d. Instrument transformers.
e. Metering and instrumentation.
f. Ground-fault systems.
g. Surge arresters.
h. Capacitors.

E. Remove and replace malfunctioning units and retest as specified above.

3.6 ADJUSTING

A. Set field-adjustable, protective-relay trip characteristics according to results in Section 26 05 73.16 "Overcurrent Protective Devices Coordination Study."

3.7 CLEANING

A. On completion of installation, inspect interior and exterior of switchgear. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair damaged finishes.

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear.

END OF SECTION

SECTION 26 19 00
MEDIUM-VOLTAGE INDUCTION MOTORS

PART 1 GENERAL

1.01 REFERENCES

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

1. American Bearing Manufacturers Association (ABMA).
2. American Petroleum Institute (API):
   a. 541, Form-Wound Squirrel-Cage Induction Motors-500 Horsepower and Larger.
   b. 670, Vibration, Axial Position, and Bearing Temperature Monitoring Systems.
3. Institute of Electrica1 and Electronics Engineers (IEEE):
   a. 43, Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
   b. 112, Standard Test Procedures for Polyphase Induction Motors and Generators.
4. National Electronics Manufacturers Association (NEMA): MG 1, Motors and Generators.

1.02 DEFINITIONS

A. CT: Current Transformer.

B. IPS RMS: Inches Per Second, Root Mean Squared.

C. PIV: Peak Inverse Voltage.

D. RTD: Resistance temperature detector.

1.03 SUBMITTALS

A. Action Submittals:

1. Submit complete motor data with driven equipment Shop Drawings.
2. Induction motor name and specification number of driven equipment.
3. Rated motor horsepower.
4. Voltage, phase and frequency ratings.
5. Design full load current at rated horsepower for utilization (motor) voltage.
6. Number of poles and full-load speed.
7. Service factor.

8. Power factor at full, 3/4-load and 1/2-load.
9. Locked rotor, pull-up, breakdown, and full-load torque.
10. Guaranteed minimum full-load efficiency, include nominal efficiencies at 1/2-load and 3/4-load.
11. Maximum number of successive cold and hot starts.
12. Code letter for locked-rotor kVa/HP.
13. Locked-rotor inrush in percent of full-load current.
14. Motor thermal performance-hot and cold start curves.
15. Winding insulation class and temperature rise class.
16. Frame size.
17. Enclosure.
18. Motor type/model and dimension drawing. Include motor component weights.
19. Current transformers, surge arrestors, and surge capacitors.
20. Motor terminal box, RTD box, vibration detector box, and space heater box dimensions, location on motor, and wiring.
21. Motor lead termination support insulators.
22. Schematic wiring diagram for motor and for devices such as resistance temperature detectors, vibration sensors, zero speed switches, leak detectors, space heaters, differential pressure switches, current transformers, as applicable.
23. Bearing Data:
    a. Identify type and manufacturer of radial journal bearings to be installed, antifriction bearings to be installed, and thrust bearing to be installed, as applicable per motor/pump design.
    b. Specify proposed bearing insulation materials and methods and recommended bearing lubricant(s).
    c. Bearing protection data including shaft sensing proximity vibration probes, bearing housing vibration sensors, for vertical motors, axial position probes, and resistance temperature detectors, as applicable per pump/motor design.
24. Complete lube oil system requirements.
25. Anticipated maximum maintenance weights for rotors and removable housing elements.
26. Assembly clearances; this requirement includes, but is not limited to diametrical bearing clearances, air gap, coupling interference fit to shaft and bearing housing interference fit.
27. Shaft radial and axial runout tolerances at various lateral locations.
28. Motor shaft grounding pickup method shall be via readily accessible, spring-loaded contact brush.
29. Instrumentation, including but not limited to, vibration transducers, vibration monitoring system, RTDs, leak detectors, differential pressure switches, and zero speed switches. Provide detailed catalog information indicating complete model number derivation and wiring diagrams for each motor application.
30. Water or oil cooling if required for motor thrust bearings.

B. Informational Submittals:

1. Name, address, telephone number, and contact name for factory-trained and authorized service organization representing motor manufacturer.
5. Written installation, connection, and commissioning instructions for specific motor(s) to be furnished.
6. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
7. Factory test results.

1.04 QUALITY ASSURANCE

A. Production Facility: Motor manufacturer shall produce the medium voltage, induction motors at a facility manufacturer owns or operates under its own supervision.

B. Requisite Experience: Induction motor manufacturer shall be experienced in manufacture of medium voltage induction motors for at least 10 years. At least 10 of manufacturer's synchronous motors of comparable capacity and complexity shall have been successfully operating in similar condition as ones specified in this section for at least 5 years in the USA.

C. Service Organizations: Synchronous motor manufacturer shall have a factory-owned or authorized service organization.

1.05 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of Work specified in this Specification section found defective during a period of 5 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

PART2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. ABB Motors, Inc.
2. General Electric

3. Reliance Electric
4. Siemens
5. TECO-Westinghouse Motor Company.
6. Toshiba International Corporation.
7. US Motors.

2.02 GENERAL

A. Provisions of this Section apply to induction motors 300 hp and larger and rated 4,160 volts.

B. Electric motors driving identical machines shall be identical.

C. Maximum motor loading at any point on driven load operating curve shall not exceed nameplate horsepower rating, and as verified with approved submittal data of driven machinery. Motor shall be required to conform to NEMA standard ratings.

D. Lateral and Torsional Analysis:

1. Driven equipment supplier with system responsibility shall perform a complete lateral and torsional analysis of each distinct equipment-coupling motor system provided on Project.
2. Identify dry and wet lateral critical(s) plus torsional critical(s) speeds.
3. Produce critical speed maps; no active critical speed shall be allowed within 20 percent of operating speed range.
4. Analysis shall be performed, submitted, reviewed, and approved by Engineer prior to fabrication of machinery.
5. Mass Elastic Data: Used for independent evaluation of lateral and torsional natural frequency analysis. Encroachment by plus or minus 20 percent of any active critical speeds upon operating speed range must be eliminated to satisfaction of Engineer.

E. Vertical motor dimensions shall conform to the following:

1. Regardless of the limits on motor dimensions specified herein, all vertical motors and appurtenances shall be configured such that a minimum of 6 feet of horizontal clearance is provided to any adjacent motor or motor appurtenance.

F. Horizontal motor dimensions shall conform to the following:

1. Regardless of the limits on motor dimensions specified herein, all horizontal motors and appurtenances shall be configured such that a minimum of 6 feet of horizontal clearance is provided to any adjacent motor or motor appurtenance.

G. Provide flywheel(s), keyed to motor shaft, of required geometry and mass or provide suitably oversized rotor diameter design to provide additional rotational moment of inertia as specified in driven equipment specification.

2.03 DESIGN REQUIREMENTS

A. Electric motors shall be in accordance with NEMA MG 1, constant speed induction motors having starting torque and starting current sufficient to ramp up to speed of driven equipment. In no case shall locked rotor, pull-up or breakdown torque be less than value specified in NEMA MG 1.

B. Motor Voltage Ratings: 4,160 volts, three-phase, 60Hz, for use on a 4,160-volt (nominal), three-phase, 60-Hz system as indicated.

C. Service Factor: 1.15 minimum.

D. Insulation: Furnish motors with Class F insulation, rated to operate at a maximum ambient temperature of 40 degrees C, and at an altitude of 600 feet above sea level, without exceeding Class B temperature rise limits stated in NEMA MG 1-20.8 at rated full load and service factor. Motors shall comply with NEMA MG1-1993, Rev. 1, Part 31, Definite Purpose Inverter-Fed Motors whether used with variable frequency drives or not.

E. The motors shall have a horsepower rating based on continuous operation (24 hours per day) at full load without exceeding the rated temperature rise above an ambient of 40 degrees C, and at an altitude of 500 feet above sea level, without exceeding Class B temperature rise limits stated in NEMA MG 1-20.8 at rated full load and service factor. The horsepower rating shall be adequate to operate the driven equipment under all normally expected operating conditions without overloading. Motor shaft loading shall not exceed rated horsepower. Motor insulation shall be full Class F. Coils shall be form wound, vacuum pressure impregnated and compactly shaped to fill the slots. Vacuum pressure impregnation shall be done by treating the entire stator with a minimum of 2 impregnations after the coils are placed in the lots. Winding and end connections shall be fully sealed against contaminants. The stator complete with winding shall be given additional dips and brakes. Motor end turns shall be adequately braced with nonshrinking material and shall withstand the stresses caused by full voltage starting.

F. Motor manufacturer shall be responsible for obtaining the speed-torque characteristics of the driven equipment. Speed-torque curves showing the torque characteristics of both the motor and the driven equipment on the same graph together with WK^2 of both the motor and the driven equipment shall be submitted to ENGINEER. This information is to be included with submittal of outline Drawing for approval. Motors shall be capable of accelerating driven equipment

without excessive temperature rises. Motor acceleration time at specified reduced voltage should not exceed locked rotor safe stall time.

G. Bearing shall be of adequate size to take the load of the rotor, together with that of such parts of the shaft not carried by the driven machinery. A suitable base of high-grade cast iron shall be provided for mounting the motor.

H. Motors shall have oversized terminal boxes of adequate size for the construction of stress cones on incoming cable, surge arrestors and capacitors, and power factor correction capacitors. Terminal leads shall be minimum of 12 inches long and shall be equipped without lugs. Provide six main leads fitted with solderless lug terminals with two holes minimum each. Hole spacing and size shall meet NEMA standards. Leads shall be brought out to main terminal box for all motors. Terminal boxes for motor leads shall have the following minimum dimensions: 20-inch H, 15-inch W, 10-inch D. They shall be diagonally split and furnished undrilled for conduit. The boxes shall be gasketed and suitable for mounting in any direction without allowing water to enter. Each motor shall be equipped with surge arrestor and capacitor overvoltage protection or equal. A power factor correcting capacitor shall be provided for full load power factor correction of 0.90 minimum. Power factor correction capacitors may be floor-mounted with all connections to the motor terminal box being made through flexible conduit (Not shown on drawings, contractor will be required to coordinate conduit when providing separate enclosure for capacitors). The box shall be arranged so that conduit can enter from the bottom, and shall be completely rotatable 360° in 90° increments, without obstruction.

I. Motor leads in the terminal box shall be sized in accordance with NEC suggested minimum ampacity values using a minimum of 125°C insulated lead wire. The wiring shall be clearly identified every inch or the lead shall have a metal band in accordance with ANSI C6.1, latest revision. Nameplates shall be supplied stating the above data and permanently attached to the motor. Leads are to be numbered for clockwise rotation when facing opposite the shaft end.

J. Motors shall be provided with a compression type grounding lug, the same size as motor leads, mounted in the conduit box by drilling and tapping into the motor frame or by a double ended silicon bronze cap screw.

K. Motor Leads and Terminations:

1. Provide six main leads fitted with solderless lug terminals with two holes minimum each.
2. Hole spacing and size shall meet NEMA standards.
3. Leads shall be brought out to main terminal box for all motors.
4. Motor leads shall be arranged in main terminal box for use with three, self-balancing CTs for differential protection. Provide shorting blocks.

L. Rotor Bars:

1. Copper or copper alloy; designed to meet starting and accelerating torque characteristics of NEMA MG 1-20.4.3.2 for Variable Torque Square applications.
2. Select materials and processes used for fabricated rotor bars to minimize hydrogen embrittlement.
3. Size to assure tight bar construction to eliminate bar vibration.
4. Replaceable without damage to air passages or laminations.

M. Stator:

1. Iron laminations shall utilize C5 core-plate minimum, on both sides, capable of withstanding 1,400 degrees F without deterioration.
2. Brace and support to eliminate any detrimental winding movement.

N. Shafts:

1. Material: Hot-rolled C1045, minimum.
2. Stiff-shaft design.
3. Shaft Dimensions: Manufacturer's standard.
4. Provide extended shaft, tapered shaft, double shaft, or short shaft as required.
5. Permanently mark shaft on drive end and indicate magnetic center with a pointed indicator mounted off drive-end bearing cap.
6. Include reference measurement to locate magnetic center in the event of a broken pointer on motor outline drawing.
7. Provide drive shaft extension with open-ended keyway and key.

O. Torque:

1. Motor manufacturer shall review start-up load curve for driven equipment to determine minimum motor capabilities for locked-rotor torque, pull-up torque, and breakdown torque.
2. Motor speed-torque curve shall exceed driven equipment speed-torque curve by a minimum margin of 10 percent at all points from zero speed to pull-up speed.
3. Motor shall also be able to start and accelerate, to rated-speed of driven equipment during a 20 percent under-voltage or reduced voltage start condition.

P. wk^2:

1. Motors shall be capable of accelerating driven equipment and flywheel without excessive temperature rises.

2. Motor acceleration time at specified reduced voltage should not exceed locked rotor safe stall time.

Q. Number of Starts: Each motor shall be capable of two successive cold starts or one hot start according to NEMA MG 1.

R. Motor Power Factor: 0.80 minimum.

S. Motor Efficiency:

1. Guaranteed Minimum Efficiency: 95.5
2. Stamp nameplate with tested efficiency.
3. In accordance with IEEE 112.

T. Capable of operating at 120 percent of full-speed in reverse rotation direction, with no power applied to motor.

U. Starting: Motors shall be suitable for full-voltage starting.

V. Enclosures:

1. Mechanical protection and method of ventilation or cooling as listed below and as defined in NEMA MG 1-26 for Totally Enclosed Machines.
2. Cooling Air:
   a. Internal cooling air shall circulate from end(s) of motor towards center of rotor and stator lamination stacks, then through vents in rotor and stator laminations (symmetrical cooling) to exhaust openings or heat exchanger.
   b. Internal air shall circulate through rotor and stator in a symmetrical manner to minimize hotspots.
3. Hardware: Corrosion-resistant stainless steel hardware for screens and associated fasteners.
4. Provide openings in stator endplates with access covers for checking motor air gap.

2.04 ACCESSORIES

A. Connection Box:

1. Cast or fabricated steel connection box.
2. Fabricated steel connection boxes shall have hinged covers secured by knurled screws.
3. Gasketed and provisions for grounding.

B. Main Terminal Boxes:

1. Size:
    a. For six main leads and neutral, incoming cable glands, and accessories.
    b. To accommodate components and accept power supply conductors, all per NEMA requirements.
2. Construction comparable with degree of enclosure indicated for motor itself.
3. Allot space for mounting of auxiliary devices such as surge arrestors, surge capacitors, current transformers for differential protection, stress cones, and neutral bar.

C. Equipment Grounding Lugs: Provide within main terminal box, suitable to terminate equipment ground wire, sized as indicated. Ground path shall be direct to stator frame.

D. Auxiliary Terminal Boxes:

1. Provide separate boxes for termination of space heaters, stator and bearing RTD or thermocouple leads, vibration probe leads, and other factory-mounted instrumentation.
2. Space heater terminations shall be in a terminal box that is separate from control signal terminations.
3. Wire devices to auxiliary terminal boxes and terminate on suitable terminal blocks.

E. Surge Protection:

1. Provide suitably sized station-class surge capacitors and lightning arrestors on each medium voltage motor terminal, mounted on insulated block.
2. Design to protect motor insulation from voltage surges caused by lightning strikes or switching.
3. Conductors:
    a. Between arrestor and point of attachment on stator frame shall be at least No. 4/0 AWG stranded copper conductor or larger.
    b. Keep as short and straight as possible.
    c. Lead length of connecting conductors shall be less than 36 inches.
4. Surge capacitors and lightning arrestors shall have a single-point quick disconnect connection to ground bus.

F. Current Transformers:

1. Provide three 50/5A zero-sequence current transformers in main terminal box. These current transformers shall be used for motor balanced flux differential protection.

2. Provide and channel six leads through appropriate current transformer. Current transformer leads shall be prewired to shorting-type blocks inside connection box positioned outside motor power terminal box.
3. CT connections shall be shorted during factory testing and transportation to Site with a suitable warning label.

G. Space Heaters:

1. Provide to keep motor windings at least 5 degrees C to 10 degrees C above dew point during de-energized conditions.
2. Grid type in base of stator with easy access for maintenance.
3. Rated for 240V ac, single-phase power, but suitable for use on 120 Vac, single-phase power.
4. Prewired to terminal junction box mounted on motor.
5. Provide warning label on space heater junction box and motor indicating space heater wiring is energized when motor is not running.

H. Provide manufacturer's standard antireverse rotation ratchet.

I. Equipment Identification Plates: Provide 16-gauge stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 1/4-inch high engraved die-stamped block type black enamel filled equipment identification number and letters indicated in this Specification and as shown.

J. Frame Grounding Pads: Provide two stainless steel faced grounding pads and locate on opposite sides of motor frame diagonally apart. Grounding pads shall feature a tapped 1/2 inch national coarse (NC) thread drilling into motor frame.

K. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

2.05 MOTOR BEARINGS

A. Bearings shall conform to provisions of driven equipment Specification, except as supplemented or modified by requirements of this Specification. Unless otherwise specified, hydrodynamic radial bearings shall be provided on horizontal machines. Antifriction bearings shall be used for vertical machines provided the following conditions are met:

1. dN factor is less than 300,000.
2. Antifriction bearings meet ABMA L10 rating life of 100,000 hours with continuous operation at rated conditions or 50,000 hours at maximum axial and radial loads and rated speed.
3. Antifriction thrust bearings for vertical machines shall be rated for ABMA L10 life of 5,000 hours.

B. Vertical Motor Thrust Bearings:

1. Provide plate type, load-equalizing, thrust bearings located in oil reservoir at top of motor frame. Bearings shall be Kingsbury, Renk, or Waukesha.
2. Bearing Capacity: Rated for weight of pump motor rotating assembly plus maximum hydraulic down-thrust developed by pump. Capable of operating at this rating in either direction of rotation up to runaway speed.
3. Up-thrust Capacity: As required for any operating condition.
4. Oil Lubrication System:
    a. Self-contained and self-circulating.
    b. Oil Reservoir:
        1) Cooling Coils:
            a) Sized to maintain a 40 degrees C, maximum, oil temperature rise.
            b) 90110 Cu-Ni tube.
            c) Design for 30 degrees C, inlet water at 50 psig, and 0.001 fouling factor.
            d) 90110 Cu-Ni threaded pipe connections.
        2) Contain an RTD to sense oil temperature.
        3) Water-cooling shall only be used with approval of Engineer.
5. Provide oil level sight glass, and threaded oil fill and drain plugs.
6. Thrust Bearing Temperature Elements:
    a. Provide each bearing with two 100-ohm platinum RTD each which shall be prewired to a terminal junction box mounted on motor.
    b. Elements shall be installed in two opposite thrust shoes of thrust bearing.
    c. Metal of bearings and mountings shall be drilled, milled, and tapped to place element at hottest points of bearings and within 1/16 inch of bearing metal.

C. Vertical Motor Guide Bearings:

1. Upper Guide Bearing: Antifriction type meeting performance criteria listed above.
2. Lower Guide Bearing: Antifriction type meeting performance criteria listed above.
3. Upper and lower bearings shall have spring-loaded RTDs to sense bearing metal temperature.

D. Hydrodynamic Radial Bearing Temperature: 93 degrees C, maximum.

E. Bearing Insulation: Electrically insulated in a manner to prevent circulating currents from passing through bearing surfaces. Provide grounding device in bearing housing on drive end.

2.06 VIBRATION MONITORING

A. Vibration Transducers:

1. Bearing Housing Velocity Transducers:
   a. Velocity transducers shall be installed by the motor manufacturer.
   b. The elements shall be velocity transducers with velocity output in Inches Per Second, Root Mean Squared (IPS RMS).
   c. Minimum rated operating frequency shall be less than minimum motor operating speed.
   d. Vibrations elements shall include shielded signal cable and enclosed in a NEMA 4X housing.
   e. Provide velocity transducers on top and bottom bearing housings. Provide each bearing housing with two transducers at 90-degrees radially. One of the transducers at each bearing shall be in line with the pump discharge.
   f. Manufacturer and Product: Bently Nevada Corporation; Velomitor, piezo-velocity sensor.
2. Thrust Position Transducers: For vertical motors, axial shaft position proximity probes shall be permanently installed by the motor manufacturer. Dual Bently Nevada Corporation 3300 Series probes or the latest model shall be installed at each thrust bearing. The probes shall observe the thrust collar or the top end of the shaft. The probes shall contain a minimum 8-millimenter tip diameter mounted in a 0.375 inch by 24 threads per inch stainless steel body. Each transducer shall consist of a BNC probe, calibrated extension cable, and Proximitor. All elements shall be fully protected in sealed weatherproof conduit and housings.
3. Timing Transducer: For all motor, a Keyphasor timing probe shall be provided. This shall be a 3300 Series radial proximity probe by Bently Nevada Corporation. The probe will contain a minimum 8 millimeter tip diameter mounted in a 0.375 inch by 24 threads per inch stainless body. This timing transducer shall consist of a BNC probe, calibrated extension cable, and Proximitor. All elements shall be fully protected in sealed weatherproof conduit and housings.
4. Vibration transducers shall be prewired to terminal junction boxes mounted on motor.

2.07 MOTOR TEMPERATURE DETECTION

A. RTDs:

1. 100 ohm, 3 wire, platinum, and prewired to terminal junction box mounted on motor base.
2. Provide two bearing RTDs (one per bearing) and six stator winding RTDs (two per phase).

3. For motors with thrust bearings, provide two RTDs per thrust bearing.
4. For water-cooled motors, provide one air circuit RTD.

2.08 FACTORY TESTING

A. General:

1. Factory test motors in conformance with IEEE 112, IEEE 43, and NEMA MG 1.
2. Notify Construction Manager a minimum of 5 weeks prior to test.
3. No equipment shall be shipped until Construction Manager has approved test data.
4. Acceptance:
   a. In the event motor fails to meet above requirements or efficiencies make necessary modifications, repairs, or replace entire motor.
   b. Retest motor until found satisfactory.
5. Test Reports:
   a. Include documentation and results.
   b. Indicate test procedure and instrumentation used to measure and record data.
   c. Certified, signed, and dated by motor manufacturer's test personnel and a registered Professional Engineer.

B. Tests:

1. Routine:
   a. Measurement of winding resistance.
   b. No-load motoring readings of current, power, and speed at rated voltage and frequency.
   c. Measure and record air gap during assembly.
   d. Visually inspect bearing and bearing insulation.
   e. High potential test in accordance with NEMA MG 1-20.17.
2. Surge: Test stator coils individually after insertion into stator core, but prior to coil-to-coil connection, to ensure no tum-to-tum shorts. Repeat surge test after coil-to-coil connections are complete.
3. High Potential: High pot stator coils individually after insertion into stator core, but prior to coil-to-coil connection, to ensure no turn-to-turn shorts. Repeat high potential test after all coil-to-coil connections are complete.
4. Efficiency and Loss: Use any IEEE 112 Method B only. Included the following in determining efficiency per NEMA MG 1-20.21.
   a. Stator I^2R.
   b. Rotor I^2R.
   c. Core loss.
   d. Stray load losses.
   e. Friction and windage loss.
5. Phase Rotation:

a. Apply phase sequence as called for on the outline drawing and check for correct direction of rotation.
b. Record direction of rotation and phase sequence.

6. Temperature:
   a. Perform heat run tests on motors via embedded detector, using either of the IEEE 112 8.2.3 methods of loading.
   b. Record stator and bearing temperatures every 30 minutes until machine reaches constant temperature.
   c. Determine temperature rise for service factor loading.
7. Blocked Rotor Test: With rotor blocked, take the following readings at highest voltage possible: line voltage, current, kW, torque, and induced field current.
8. Noise:
   a. In accordance with NEMA MG 1, Part 9.
   b. Mean A-weighted sound pressure level measured at one meter from major machine surface shall not exceed 85 dB (A) with motor operating at no-load, and rated frequency and voltage applied.
9. Vibration:
   a. Radial Shaft at Full Operating Speed: 2.0 mils peak-to-peak, maximum.
   b. Take vibration data at cold and hot operating conditions, at no-load during factory testing.
   c. Transient Shaft Vibration: 3.5 mils peak-to-peak, maximum, throughout normal startup and shutdown speed range.
   d. Values shall include shaft surface runout sensed by probes.
   e. Shaft Runout: At slow roll speeds of less than 100 rpm shall be less than 0.25 mils peak-to-peak, maximum. For areas to be observed by axial-position probes, combined total electrical and mechanical runout shall not exceed 0.5 mil.
   f. Bearing Housing Vibration:
      1) At full operating speed shall be 0.15 inches per second (RMS), maximum.
      2) Take vibration data at cold and hot conditions, at no-load.
      3) Transient Vibration: 0.5 IPS RMS, maximum, throughout normal startup and shutdown speed range.
   g. Vibration Frequency:
      1) Record during vibration testing at cold and hot conditions.
      2) Record frequencies up to seven times line frequency.
      3) When operated uncoupled at rated speed, machinery shall not exhibit unusual or abnormal frequency components on either shaft or casing vibration measurements.
      4) Normal frequency components are defined as excitations such as rotational speed, synchronous and multiples of synchronous frequency, or blade passing frequency that are inherent with mechanical construction of machinery.

5) Unusual or abnormal frequency components are excitations that are nonsynchronous or not related to known geometry of machinery.

10. Starting Characteristics: Determine speed-torque characteristics using any of the four IEEE 112-7.3.2 recommended methods.
11. Final Factory AC High Potential Test:
    a. Perform after above tests are completed to assure no damage to insulation during setup and testing.
    b. Apply 1,000 volts plus twice rated machine voltage across stator insulation and 2,500 volts across rotor insulation for one minute, per NEMA MG 1, Part 3.
12. Final Insulation Resistance: Take reading of armature insulation with mega-ohmmeter for one minute after high potential test has been completed.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with motor manufacturer's written recommendations and written requirements of manufacturer of driven equipment.

B. Perform electrical work involving connections, controls, and switches in accordance with the applicable Sections of Division 26.

3.02 INSTALLATION TESTING

A. Installation Check: Manufacturer shall provide the services of a factory-trained representative to check the installation of all equipment installed in this Section. Equipment supplier's representative shall revisit Site as often as necessary until all trouble is corrected and equipment installation and operation is satisfactory to ENGINEER.

B. Manufacturer's representative shall provide all necessary tools and testing equipment required including noise level and vibration sensing equipment.

C. Inspection Report: A written report of the installation check shall be submitted to ENGINEER. The report shall certify that the equipment:

1. Has been properly installed and lubricated;
2. Is in accurate alignment;
3. Is free from any undue stress imposed by any connection or anchor bolts;
4. Has visually inspected motor mounting and coupling to driven equipment;
5. Has visually checked for proper phase and ground connections.

6. Has tested insulation of all winding (accordance with NEMA MG 1) and bearing temperature detectors and space heaters.
7. Has bumped motor to test for proper rotation.
8. Has tested motors for proper noise, temperature, and vibratory behavior following no less than 4 hours at maximum available load and full operating speed. Noise and vibration limits used for factory testing with temporary machinery support shall also be applicable to field testing condition with proper rigid support structure below machinery.
9. Has been operated under full load condition and that it operated satisfactorily to ENGINEER; and
10. That OWNER's representative has been instructed in the proper maintenance and operation of the equipment.
11. Furnish OWNER a copy of all test data recorded during the installation check including noise level and vibration readings.

3.02 FIELD TESTING

A. Functional Tests: Perform the following prior to connection to driven equipment:

1. Check electrical supply at motor feeder cable terminations for any deviation from rated voltage, phase, or frequency.
2. Visually inspect motor mounting and coupling to driven equipment.
3. Visually check for proper phase and ground connections. Verify multi-voltage motors are connected for proper voltage.
4. Test insulation of all winding and bearing temperature detectors and space heaters.
5. Bump motor to test for proper rotation.
6. Test motor insulation in accordance with NEMA MG 1.
7. Test insulation after motor has arrived at Site via an AC high potential test performed for same duration as final factory high potential test, but at 75 percent of specified voltage.
8. Take vibration data at no-load and maximum available load.

END OF SECTION

SECTION 26 20 00
LOW-VOLTAGE AC INDUCTION MOTORS

PART 1 GENERAL

1.01 RELATED SECTIONS

A. This section applies to all motor-driven equipment. Application, horsepower, enclosure type, mounting, shaft type, synchronous speed, and deviations from this section will be listed in the equipment specification. Where such deviations occur, they shall take precedence over this section.

1.01 REFERENCES

A. The following standards are required by reference:

1. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Ratings and Fatigue Life for Roller Bearings.
2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   b. 620, Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Machines.
   c. 841, Standard for Petroleum and Chemical Industry—Premium Efficiency Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors—Up to and Including 370 kW (500 hp).
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. C50.41, Polyphase Induction Motors for Power Generating Stations.
   c. MG 1, Motors and Generators.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories (UL):
   a. 83, Standard for Safety for Thermoplastic-Insulated Wire and Cables.
   b. 674, Standard for Safety for Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.
   c. 2111, Standard for Safety for Overheating Protection for Motors.

1.02 DEFINITIONS

A. CISD-TEFC: Chemical industry, severe-duty enclosure.

B. DIP: Dust-ignition-proof enclosure.

C. EXP: Explosion-proof enclosure.

D. Inverter Duty Motor: Motor meeting applicable requirements of NEMA MG 1, Section IV, Parts 30 and 31.

E. Motor Nameplate Horsepower: That rating after any derating required to allow for extra heating caused by the harmonic content in the voltage applied to the motor by its controller.

F. ODP: Open drip-proof enclosure.

G. TEFC: Totally enclosed, fan-cooled enclosure.

H. TENV: Totally enclosed, nonventilated enclosure.

I. WPI: Open weather protected enclosure, Type I.

J. WPII: Open weather protected enclosure, Type

1.03 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Nameplate data in accordance with NEMA MG 1.
3. Additional Rating Information:
   a. Service factor.
   b. Locked rotor current.
   c. Multispeed load classification (for example, variable torque).
   d. Adjustable frequency drive motor load classification (for example, variable torque) and minimum allowable motor speed for that load classification.
   e. Guaranteed minimum full load efficiency and power factor.
4. Enclosure type and mounting (such as, horizontal, vertical).
5. Dimensions and total weight.
6. Conduit box dimensions and usable volume as defined in NEMA MG 1 and NFPA 70.
7. Bearing type.
8. Bearing lubrication.
9. Bearing life.
10. Space heater voltage and watts.
11. Description, ratings, and wiring diagram of motor thermal protection.
12. Motor sound power level in accordance with NEMA MG 1.

13. Maximum brake horsepower required by the equipment driven by the motor.
14. Description and rating of submersible motor moisture sensing system.

B. Informational Submittals:

1. Factory test reports.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection and Testing.
3. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. General Electric.
2. Reliance Electric.
3. Siemens Energy and Automation, Inc., Motors and Drives Division.
4. U.S. Electrical Motors.
5. TECO-Westinghouse Motor Co.
6. Toshiba International Corp., Industrial Division.
7. WEG Electric Motors Corp.

2.02 GENERAL

A. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.

B. In order to obtain single source responsibility, utilize a single supplier to provide drive motor, its driven equipment, and specified motor accessories.

C. Comply with requirements of NEMA MG 1.

D. For motors used in hazardous (classified) locations, Class I, Division 1, Groups B, C, and D, and Class II, Division 1, Groups E, F, and G provide motors that conform to UL 674 and have an applied UL listing mark.

E. Motors shall be specifically designed for the use and conditions intended, with a NEMA design letter classification to fit the application.

F. Motors 50 horsepower and larger shall have embedded passive temperature switches in the windings for use in the motor control circuit to limit the winding temperature as defined by NEMA Standard MG1-12.53 Type 1. The contact shall be normally closed and rated to operate a 120 volt AC control relay (40 VA).

G. Provide lifting lugs on motors weighing 100 pounds or more.

H. Operating Conditions:

1. Maximum ambient temperature not greater than 40 degrees C.
2. Motors shall be suitable for operating conditions without reduction being required in nameplate rated horsepower or exceeding rated temperature rise.
3. Overspeed in either direction in accordance with NEMA MG 1.

2.03 HORSEPOWER RATING

A. Refer to individual motor-driven equipment Specification.

B. Constant Speed Applications: Brake horsepower of driven equipment at any operating condition not to exceed motor nameplate horsepower rating, excluding service factor.

C. Adjustable Frequency and Adjustable Speed Applications (Inverter Duty Motor): Driven equipment brake horsepower at any operating condition not to exceed motor nameplate horsepower rating, excluding service factor.

2.04 SERVICE FACTOR

A. Inverter-duty Motors: 1.0 at rated ambient temperature, unless otherwise noted.

B. Other Motors: 1.15 minimum at rated ambient temperature, unless otherwise noted.

2.05 VOLTAGE AND FREQUENCY RATING

A. System Frequency: 60 Hz.

B. Voltage Rating: Unless otherwise indicated in motor-driven equipment specification or specifically in plan set:

Voltage Rating		
Size	**Voltage**	**Phase**
1/2 hp and smaller	115	1
3/4 hp through 400 hp	460	3

C. Suitable for full voltage starting.

D. Suitable for accelerating the connected load with supply voltage at motor starter supply terminals dipping to 90 percent of motor rated voltage.

2.06 EFFICIENCY AND POWER FACTOR

A. For all motors except single-phase, under 1 hp, multispeed, short-time rated and submersible motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists:

1. Efficiency:
   a. Tested in accordance with NEMA MG 1, Paragraph 12.59.
   b. Guaranteed minimum at full load in accordance with NEMA MG 1 Table 12-12, Full-load Efficiencies for NEMA Premium Efficiency Electric Motors Rated 600 Volts or Less (Random Wound), or as indicated in motor-driven equipment specification.

2. Power Factor: Guaranteed minimum at full load shall be manufacturer's standard or as indicated in motor-driven equipment specification.

2.07 LOCKED ROTOR RATINGS

A. Locked rotor kVA Code F or lower, if motor horsepower not covered by NEMA MG 1 tables.

2.08 INSULATION SYSTEMS

A. Single-Phase, Fractional Horsepower Motors: Manufacturer's standard winding insulation system.

B. Motors Rated Over 600 Volts: Sealed windings in accordance with NEMA MG 1.

C. Three-phase and Integral Horsepower Motors: Unless otherwise indicated in motor-driven equipment specification, Class B or Class F at nameplate horsepower and designated operating conditions, except EXP and DIP motors which must be Class B with Class B rise.

2.09 ENCLOSURES

A. Enclosures to conform to NEMA MG 1.

B. TEFC and TENV: Furnish with drain hole with porous drain/weather plug.

C. Explosion-Proof (EXP):

1. TEFC listed to meet UL 674 and NFPA 70 requirements for Class I, Division 1, Group D hazardous locations.
2. Drain holes with drain and breather fittings.
3. Integral thermostat opening on excessive motor temperature in accordance with UL 2111 and NFPA 70.
4. Terminate thermostat leads in terminal box separate from main terminal box.

D. Submersible: In accordance with Paragraph 2.16 "Special Motors" of this Section.

2.10 TERMINAL (CONDUIT) BOXES

A. Where offered by manufacturer as an option, oversize main terminal boxes for all motors.

B. Diagonally split, rotatable to each of four 90-degree positions. Threaded hubs for conduit attachment.

C. Furnish gaskets between box halves and between box and motor frame.

D. Minimum usable volume in percentage of that specified in NEMA MG 1, Section 1, Paragraph 4.19 and NFPA 70, Article 430:

Terminal Box Usable Values		
Voltage	**Horsepower**	**Percentage**
Below 600	15 through 125	500
Below 600	150 through 300	275
Below 600	350 through 600	225
Above 600	All sizes	200

E. Terminal for connection of equipment grounding wire in each terminal box.

2.11 BEARINGS AND LUBRICATION

A. Horizontal Motors:
1. 3/4 hp and Smaller: Permanently lubricated and sealed ball bearings, or regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
2. 1 hp through 400 hp: Regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
3. Minimum 100,000 hours L-10 bearing life for ball and roller bearings as defined in ABMA 9 and ABMA 11.

B. Vertical Motors:
   1. Thrust Bearings:
      a. Antifriction bearing.
      b. Manufacturer's standard lubrication 100 hp and smaller.
      c. Oil lubricated 125 hp and larger.
      d. Minimum 50,000 hours L-10 bearing life.
   2. Guide Bearings:
      a. Manufacturer's standard bearing type.
      b. Manufacturer's standard lubrication 200 hp and smaller.
      c. Oil lubricated 250 hp and larger.
      d. Minimum 100,000 hours L-10 bearing life.

C. Regreasable Antifriction Bearings:
   1. Readily accessible, grease injection fittings.
   2. Readily accessible, removable grease relief plugs.

D. Oil Lubrication Systems:
   1. Oil reservoirs with sight level gauge.
   2. Oil fill and drain openings with opening plugs.
   3. Provisions for necessary oil circulation and cooling.

E. Inverter Duty Rated Motors, Bearing Isolation: Motors larger than 50 hp shall have electrically isolated bearings to prevent stray current damage.

2.12 NOISE

A. Measured in accordance with NEMA MG 1.

B. Motors controlled by adjustable frequency drive systems shall not exceed sound levels of 3 dBA higher than NEMA MG 1.

2.13 BALANCE AND VIBRATION CONTROL

A. In accordance with NEMA MG 1, Part 7.

2.14 EQUIPMENT FINISH

A. External Finish: Prime and finish coat manufacturer's standard. Field painting in accordance with Section 09 90 00, Painting and Coating.

B. Internal Finish: Bore and end turns coated with clear polyester or epoxy varnish.

2.15 SPECIAL FEATURES AND ACCESSORIES

A. Screen Over Air Openings: Stainless steel on motors with ODP, WPI, and WPII enclosures meeting requirements for guarded machine in NEMA MG 1, and attached with stainless steel screws.

B. Space Heaters:
   1. On motors 50 hp and larger, provide winding space heaters with leads wired out to motor terminal box.
   2. Provide extra hole or hub on motor terminal box as required.
   3. Unless shown otherwise, heater shall be suitable for 120V ac supply, with wattage suitable for motor frame size.

C. Nameplates:
   1. Raised or stamped letters on stainless steel or aluminum.
   2. Display motor data required by NEMA MG 1, Paragraph 10.39 and Paragraph 10.40 in addition to bearing numbers for both bearings.
   3. Premium efficiency motor nameplates to display NEMA nominal efficiency, guaranteed minimum efficiency, full load power factor, and maximum allowable kVAR for power factor correction capacitors.

D. Anchor Bolts: Provide bolts that meet manufacturer's recommendations and are sufficient in size and number for local seismic condition.

2.16 SPECIAL MOTORS

A. Requirements in this article take precedence over conflicting features specified elsewhere in this section.

B. Inverter Duty Motor:
   1. Motor supplied power by adjustable voltage and adjustable frequency drives shall be inverter duty rated.
   2. Suitable for operation over entire speed range indicated.
   3. Provide forced ventilation where speed ratio is greater than published range for motor provided.
   4. When installed in Division 1 hazardous (classified) location shall be identified as acceptable for variable speed when used in Division 1 location.
   5. Shaft Grounding Device: Motors larger than 30 hp shall be provided with shaft grounding brush or conductive micro fiber shaft grounding ring. Shaft grounding device shall be solidly bonded to grounded motor frame per manufacturer's recommendations.
      a. Manufacturers:
         1) Grounding Brush: Sohre Turbomachinery, Inc.
         2) Grounding Ring: EST-Aegis.

E. Submersible Pump Motor:

1. Manufacturers:
   a. Reliance Electric.
   b. ITT Flygt Corp.
2. At 100 Percent Load:

Submersible Pump Motors		
Horsepower	**Guaranteed Minimum Efficiency**	**Guaranteed Minimum Power Factor**
5 through 10	80	82
10.1 through 50	85	82
50.1 through 100	87	82
Over 100	89	82

3. Insulation System: Manufacturer's standard Class B or Class F.
4. Motor capable of running dry continuously.
5. Enclosure:
   a. Hermetically sealed, watertight, for continuous submergence up to 65-foot depth.
   b. Listed to meet UL 674 and NFPA 70 requirements for Class I, Division 1, Group D hazardous atmosphere.
   c. Seals: Tandem mechanical.
6. Bearing and Lubrication:
   a. Permanently sealed and lubricated, replaceable antifriction guide and thrust bearings.
   b. Minimum 15,000 hours L-10 bearing life.
7. Inrush kVA/horsepower no greater than NEMA MG 1 and NFPA 70, Code F.
8. Winding Thermal Protection:
   a. Thermal sensor and switch assembly, one each phase, embedded in stator windings and wired in series.
   b. Switches normally closed, open upon excessive winding temperature, and automatically reclose when temperature has cooled to safe operating level.
   c. Switch contacts rated at 5 amps, 120V ac.
9. Motor Seal Failure Moisture Detection:
   a. Probes or sensors to detect moisture beyond seals.
   b. Probe or sensor monitoring module for mounting in motor controller, suitable for operation from 120V ac supply.
   c. Monitoring module with control power transformer, probe test switch and test light, and two independent 120V ac contacts, one opening and one closing when flux of moisture is detected.
10. Bearing Overtemperature Protection for Motors Larger than 100 hp:

a. Sensor on lower bearing housing monitoring bearing temperature.
b. Any monitoring relay necessary to provide 120V ac contact opening on bearing overtemperature.

11. Winding thermal protection, moisture detection, and bearing overtemperature specified above may be monitored by single device providing two independent 120V ac contacts, one closing and one opening on malfunction.
12. Connecting Cables:
    a. One cable containing power, control, and grounding conductors. Each cable suitable for hard service, submersible duty with watertight seal where cable enters motor.
    b. Length: 30 feet minimum.
    c. UL 83 listed and sized in accordance with NFPA 70.

2.17 FACTORY TESTING

A. Tests:

1. In accordance with IEEE 112 for polyphase motors.
2. Routine (production) tests in accordance with NEMA MG 1. Test multispeed motors at all speeds.
3. For energy efficient motors, test efficiency and power factor at 50 percent, 75 percent, and 100 percent of rated horsepower:
    a. In accordance with IEEE 112, Test Method B, and NEMA MG 1, Paragraph 12.59. and Paragraph 12.60.
    b. For motors 500 hp and larger where facilities are not available to test by dynamometer (Test Method B), determine efficiency by IEEE 112, Test Method F.
    c. On motors of 100 hp and smaller, furnish copy of motor efficiency test report on an identical motor.
4. Provide test reports for polyphase motors.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with motor manufacturer's written recommendations and written requirements of manufacturer of driven equipment.

B. Perform electrical work involving connections, controls, and switches in accordance with the applicable Sections of Division 26.

3.02 INSTALLATION TESTING

A. Installation Check for motors 50 hp and larger: Manufacturer shall provide the services of a factory-trained representative to check the installation of all equipment installed in this Section. Equipment supplier's representative shall revisit Site as often as necessary until all trouble is corrected and equipment installation and operation is satisfactory to ENGINEER. For motors 5 – 25 hp, the local factory representative may provide checks.

B. Manufacturer's representative shall provide all necessary tools and testing equipment required including noise level and vibration sensing equipment.

C. Inspection Report: A written report of the installation check shall be submitted to ENGINEER. The report shall certify that the equipment:

1. Has been properly installed and lubricated;
2. Is in accurate alignment;
3. Is free from any undue stress imposed by any connection or anchor bolts;
4. Has visually inspected motor mounting and coupling to driven equipment;
5. Has visually checked for proper phase and ground connections.
6. For motors 50 hp and larger, has tested insulation of all winding (accordance with NEMA MG 1) and bearing temperature detectors and space heaters.
7. Has bumped motor to test for proper rotation.
8. Has tested motors for proper noise, temperature, and vibratory behavior following no less than 4 hours at maximum available load and full operating speed. Noise and vibration limits used for factory testing with temporary machinery support shall also be applicable to field testing condition with proper rigid support structure below machinery.
9. Has been operated under full load condition and that it operated satisfactorily to ENGINEER; and
10. That OWNER's representative has been instructed in the proper maintenance and operation of the equipment.
11. Furnish OWNER a copy of all test data recorded during the installation check including noise level and vibration readings.

END OF SECTION

SECTION 26 22 00
LOW VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Dry-type transformers.

1.02 SUBMITTALS

A. Shop Drawings: Submit the items included under this Section in accordance with Section 01 33 00. Shop Drawing submittals shall include:

1. Product Data: Submit manufacturer's technical product data, including rated kVA, frequency, primary and secondary voltages, percent taps, polarity, impedance, average temperature rise above 40 degrees C ambient temperature, sound level in decibels, and standard published data.
2. Submit manufacturer's Drawings indicating dimensions and weight loadings for transformer installations.
3. Wiring Diagrams: Submit wiring diagrams for power distribution transformers.

1.03 QUALITY ASSURANCE

A. Codes and Standards:

1. NEMA Compliance: Comply with NEMA Standard Pub/Nos. ST 20, "Dry-Type Transformers for General Applications," TR 1, and TR 27.
2. UL Compliance: Comply with applicable portions of ANSI/UL 506, "Safety Standard for Specialty Transformers. Provide power/distribution transformers and components which are UL listed and labeled.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with specified requirements, manufacturers offering products which may be incorporated in Work include:

1. Cutler-Hammer.

2. General Electric Company.
3. Hevi-Duty Electric Div., General Signal Corp.
4. Square D Company.

2.02 POWER/DISTRIBUTION TRANSFORMERS

A. Except as otherwise indicated, provide manufacturer's standard materials and components as indicated by published product information, designed and constructed as recommended by manufacturer, and as required for complete installation.

B. Dry-Type Distribution Transformers (112.5 kVA or less): Provide factory assembled, general purpose, air cooled, dry-type distribution transformers of sizes, characteristics, and rated capacities indicated, single phase, 60 hertz, 10 kV BIL, with 480 volts primary and 240/120 volts secondary; or K-rated 13, three-phase, 60 hertz, 10 kV BIL, with 480-volts delta connection primary and 208/120 volts secondary wye connected. Provide primary winding with 4 taps; 2 to 2-1/2 percent increments above and below full-rated voltage for de-energized tap-changing operation. Insulate with Class 150 or 220 degree C insulation and rate for continuous operation at rated kVA, and limit transformer temperature rise to maximum of 150 degrees C. Provide 75 degree C terminal enclosure, with cover, to accommodate primary and secondary coil wiring connections and electrical supply raceway terminal connector. Provide wiring connectors suitable for copper or aluminum wiring. Electrically ground core and coils to transformer enclosure. Provide transformers with fully enclosed sheet steel enclosures.

C. Finishes: Coat interior and exterior surfaces of transformer, including bolted joints, with manufacturer's standard color baked-on enamel.

2.03 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate. Nameplates are specified in Section 26 05 53 "Identification for Electrical Systems."

PART 3 EXECUTION

3.01 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

3.02 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

3.03 ADJUSTING

A. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

END OF SECTION

SECTION 26 24 00
PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes distribution panelboards and lighting/appliance branch-circuit panelboards.

1.2 ACTION SUBMITTALS

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

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations and details. Show tabulations of installed devices, equipment features, and ratings.

2. Detail enclosure types and details for types other than NEMA 250, Type 1.

3. Detail bus configuration, current, and voltage ratings.

4. Short-circuit current rating of panelboards and overcurrent protective devices.

5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

6. Include wiring diagrams for power, signal, and control wiring.

7. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Panelboard schedules for installation in panelboards.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

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

B. Comply with NEMA PB 1.

C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Enclosures: Surface-mounted cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

3. Directory Card: Inside panelboard door, mounted in transparent card holder.

B. Incoming Mains Location: Top and bottom.

C. Phase, Neutral, and Ground Buses: Tin-plated copper.

D. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Tin-plated suitable for Cu/Al terminations.

2. Main and Neutral Lugs: Mechanical type.

3. Ground Lugs and Bus Configured Terminators: Mechanical type.

E. Service Equipment Label: NRTL labeled for use as service equipment for panelboards with one or more main service disconnecting and overcurrent protective devices.

F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 PERFORMANCE REQUIREMENTS

A. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 2.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cutler-Hammer Products.

2. General Electric Company.

3. Siemens, Inc.

4. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:

1. Cutler-Hammer Products.

2. General Electric Company.

3. Siemens, Inc.

4. Square D; a brand of Schneider Electric.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
3. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
4. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
    c. Application Listing: Appropriate for application; Type SWD for switching lighting loads.
    d. Ground-Fault Protection: Remote-mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
    f. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in off position.
    g. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Receive, inspect, handle, store and install panelboards and accessories according to NEMA PB 1.1.

B. Mount top of trim 78 inches above finished floor unless otherwise indicated.

C. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

D. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

E. Install filler plates in unused spaces.

F. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.