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WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 0100 – ELECTRICAL TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Provide material, equipment, labor and technical supervision to perform and complete the electrical field acceptance tests for the electrical equipment and distribution systems specified.

B. Intent

1. The purpose of the tests outlined is to insure the safety of persons and property before and after occupancy by the Owner. These tests are to ensure that the methods and materials used in manufacture, installation and erection have provided equipment that is safe and in an operable condition.

1.2 DEFINITIONS

A. Acceptance Tests

1. Defined as those tests and inspections required to determine that the equipment involved may be energized for operational tests.

B. Operational Tests

1. Defined as those tests and inspections required to determine that equipment performance characteristics comply with the intended design.

1.3 QUALITY ASSURANCE

A. Testing Company Qualifications

1. Independent testing laboratory regularly engaged in the business of electrical acceptance testing, similar to the inspections and tests specified, with a minimum of five years' experience.
2. Testing under this Section shall not be performed by the installing Contractor.



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3. Provide at least one on-site test leader who is a certified NETA (InterNational Electrical Testing Association) or NICET (National Institute of Certified Electrical Technicians) test technician. Provide other test personnel who have had a minimum five years of supervised field experience in acceptance testing.
 - a. Equivalence to certified NETA or NICET is acceptable if approved in advance by WMU Engineering.
- B. The testing firm shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.
- C. The testing firm shall only utilize technicians who are regularly employed by the firm on a full-time basis for electrical services.
- D. The Contractor shall submit proof of the above qualifications with bid proposal.
- E. Acceptable Testing Firms
 1. Utilities Instrumentation Services; Phone (734) 482-1450.
 2. Emerson/High Voltage Maintenance Corporation; Phone (248) 305-5596.
 3. Powertech Services, Inc.; Phone (810) 720-2280.
 4. Michigan Switchgear, Auburn, MI (989) 662-6075.
 5. Solaris Power, Troy, MI (248) 577-0236.
 6. Siemens Service, Grand Rapids, MI (616) 538-1611.
- F. Industry Standards and References
 1. All inspections and tests shall be in accordance with the latest version of the following codes and standards except as provided otherwise herein.
 - a. National Electrical Manufacturer's Association – NEMA
 - b. American Society for Testing and Materials – ASTM
 - c. Institute of Electrical and Electronic Engineering – IEEE
 - d. InterNational Electrical Testing Association – NETA Acceptance Testing Specifications – ATS-1996
 - e. InterNational Electrical Testing Association – NETA Maintenance Testing Specifications-MTS-1997
 - f. American National Standards Institute – ANSI C2: National Electrical Safety Code
 - g. State and Local Codes and Ordinances
 - h. Insulated Cable Engineers Association – ICEA
 - i. Association of Edison Illuminating Companies – AEIC
 - j. Occupation Safety and Health Administration
 - k. National Fire Protection Association
 - 1) ANSI/NFPA 70: National Electrical Code
 - 2) ANSI/NFPA 70B: Electrical Equipment Maintenance
 - 3) NFPA 70E: Electrical Safety Requirements for Employee Workplaces
 - 4) ANSI/NFPA 101: Life Safety Code

1.4 EXAMINATION

- A. Verification of Conditions



1. Review Project electrical documents and ascertain the extent of the Project testing and the conditions and parameters involved in the work.
2. Prior to testing, visually inspect equipment to determine that there is no physical damage, loose bolts or missing parts and the equipment is supplied in agreement with the Contract documents and properly installed and connected.
3. At the option of the Engineer, conduct testing in the presence of the Engineer at the site. Do not ship equipment off-site for testing without the authorization of the Engineer/ Project Manager.
4. Report immediately to the Engineer any system, material, or workmanship which is found defective or not in compliance with the Specifications.

1.5 SUBMITTALS

A. Quality Control Submittals

1. Submit proof of testing company qualifications including the following:
 - a. Name of the test leader and proof of certification.
 - b. Qualifications of testing company.
2. Membership in NETA may be submitted in addition to the above list to substantiate qualifications of other test personnel.

B. Test Report Submittals

1. Incorporate a record of inspections and tests into a test report.
2. Bind and certify the test report by the testing laboratory.
3. Furnish 2 copies of test reports in draft form for review and approval prior to submitting the final reports.
4. Furnish 3 copies of the complete report to the Engineer no later than thirty days after completion of Project. At the discretion of the Engineer, due to installation scheduling of specific items of equipment or for other reasons, testing may be subdivided into several smaller packages. In that case, submit one copy of a test report no later than thirty days after completion of each test package and submit an inclusive test report containing the package reports in the quantity and the time specified above for the complete report.
5. Include in the test report the following:
 - a. Project Name.
 - b. Equipment tested.
 - c. A list of visual and mechanical inspections required by Division 26 Specification Sections in a checklist or similar format.
 - d. Tests performed.
 - e. Test reports, including test values where applicable, for all required electrical tests.
 - f. Summary and interpretation of test results detailing problems located and recommended corrective measures.
 - g. Record of infrared scan and photos showing potential problem locations.
 - h. Signed and dated by testing firm field superintendent stating that all required tests have been completed.
 - i. List of test equipment used and calibration dates.
 - j. Conclusions and recommendations, if any.



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6. Where adjustments, modifications, or repairs are made to equipment in order to meet the equipment and/or system specifications, indicate the "as left" condition in the test report.
7. Report test results for each separate piece of equipment on test forms designed for the purpose. Include on the test forms the following:
 - a. Nameplate catalog number, serial number, impedance, and rating.
 - b. Desired performance or performance range.
 - c. Measured performance.
8. Provide electronic copies of all files.
 - a. Do not password protect information.
 - b. Provide bound hard copy.

C. Scheduling

1. Submit schedule of tests, prior to testing, including:
 - a. Test equipment used,
 - b. Test personnel and date,
 - c. Any discrepancies or projected repairs made.
2. Obtain approval from the Engineer for the use of test forms which are different than NETA-approved test report forms.

1.6 PROJECT CONDITIONS

A. Environmental Requirements

1. Correct test results to 20 degrees C (68 degrees F). Report both the actual ambient temperature test readings and the calculated, corrected to temperature, test values.
2. Do not test any equipment when the insulation temperature is below 0 degrees C (32 degrees F).
3. Do not test any equipment where the relative humidity is above 70 percent. Deviations to this requirement will only be approved by the Architect if the testing laboratory can demonstrate that the higher humidity will not affect the test or that the higher humidity can be accounted for adequately in interpreting the test results.

1.7 SEQUENCING AND SCHEDULING

A. General

1. Schedule tests in cooperation with other affected Contract work. Obtain approval from the Engineer for the testing schedule. Give three days' notice prior to testing, unless otherwise necessary or specified.
2. Advise manufacturer's representatives of tests to be performed on their equipment. Give minimum ten days' time notification to permit the representative of the manufacturer to witness the equipment under test.



PART 2 - NOT USED

PART 3 - EXECUTION

3.1 ACCEPTANCE TESTING METHODS

A. Performance Requirements

1. The Electrical Contractor shall supply a suitable and stable source of electrical power to each test site. The testing firm shall specify the power requirements.
2. The Electrical Contractor shall notify the testing firm when equipment becomes available for acceptance tests. Work shall be coordinated to expedite project scheduling.
3. The testing firm shall notify the Owner's Representative prior to commencement of any testing.
4. Any system, material or workmanship, which is found defective on the basis of acceptance tests, shall be reported to the Engineer. The Electrical Contractor shall correct all defects.
5. The testing organization shall maintain a written record of all tests and shall assemble and certify a final test report.
6. Safety and Precautions
 - a. Safety practices shall include, but are not limited to, the following requirements:
 - 1) Occupational Safety and Health Act.
 - 2) Accident Prevention Manual for Industrial Operations, National Safety Council.
 - 3) Applicable state and local safety operating procedures.
 - 4) NETA Safety/Accident Prevention Program.
 - 5) Owner's safety practices.
 - 6) National Fire Protection Association - NFPA 70E.
 - 7) American National Standards for Personnel Protection.
7. All tests shall be performed with apparatus de-energized except where otherwise specifically required.
8. The testing organization shall have a designated safety representative on the project to supervise operations with respect to safety.

B. Test Instrument Calibration

1. Test Instrument Calibration
 - a. The testing firm shall have a calibration program, which assures that all applicable test instruments are maintained within rated accuracy.
 - b. The accuracy shall be directly traceable to the National Institute of Standards and Technology.
 - c. Instruments shall be calibrated in accordance with the following frequency schedule:
 - 1) Field instruments: Analog - 6 months maximum Digital - 12 months maximum
 - 2) Laboratory instruments: 12 months
 - 3) Leased specialty equipment: 12 months (Where accuracy is guaranteed by Lessor)
 - d. Dated calibration labels shall be visible on all test equipment.



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- e. Records must be kept up-to-date which show date and results of instruments calibrated or tested.
 - f. An up-to-date instrument calibration instruction and procedures shall be maintained for each test instrument.
 - g. Calibrating standard shall be of higher accuracy than that of the instrument tested.
2. Field Test Instrument Standards
- a. All equipment used for testing and calibration procedures shall exhibit the following characteristics:
 - 1) Maintained in good visual and mechanical condition.
 - 2) Maintained in safe, operating condition.
3. Suitability of Test Equipment
- a. All test equipment shall be in good mechanical and electrical condition.
 - b. Selection of metering equipment should be based on knowledge of the waveform of the variable being measured. Digital multi-meters may be average of RMS sensing and may include or exclude the dc component. When the variable contains harmonics of dc offset and, in general, any deviation from a pure sine wave, average sensing, average measuring RMS scaled meters may be misleading. Use of RMS measuring meters is recommended.
 - c. Field test metering used to check power system meter calibration must have any accuracy higher than that of the instrument being checked.
 - d. Accuracy of metering in test equipment shall be appropriate for the test being performed.
 - e. Waveshape and frequency of test equipment output waveforms shall be appropriate for the test and tested equipment.

C. General

- 1. Provide necessary test equipment and be responsible for setting-up test equipment, wire checks of factory wiring and any other preliminary work in preparation for the electrical acceptance tests.
- 2. The testing laboratory shall have a calibration program which maintains applicable test instrumentation within rated accuracy. Accuracy shall be traceable to the national bureau of standards. Calibration frequency shall be in accordance with the following schedule:
 - a. Field instruments - 6 months minimum,
- 3. Laboratory instruments - 12 months minimum. Place dated calibration labels visibly on equipment.
- 4. Certain pieces of equipment have been provided with the services of a manufacturer's service engineer who will assist in performing the tests on the equipment. When this service is provided, the service engineer will also be required to verify and sign each report form.
- 5. Perform tests which do not exceed the manufacturer's recommended limit for the equipment being tested.
- 6. Where required for the validity of tests or safety of equipment and personnel, isolate equipment to be tested from the system.
- 7. Include the ambient temperature and relative humidity existing at the time when performing insulation resistance, dielectric absorption and high potential tests.

D. Visual Inspections



1. Prior to any testing, perform visual inspections to verify the following:
 - a. The equipment is completely and properly installed.
 - b. The equipment is free from damage and defects.
 - c. Shipping blocks and restraints have been removed.
 - d. Electrical terminations are properly tightened.
 - e. The equipment is properly aligned.
 - f. The equipment is properly lubricated.
 - g. The ventilation louvers are open and unobstructed.
 - h. The equipment is ready to be tested.

E. Manual Operation

1. Prior to any testing, operate mechanical devices to verify that they function properly and freely.

F. Insulation Resistance Test

1. Perform test with a voltage source capable of providing a constant direct voltage for the time intervals as specified below. Do not use hand cranked voltage sources for direct voltages greater than 2500 volts.
2. The magnitude of applied direct voltage depends upon the voltage system to which the equipment is connected, as follows:

3.2	System Voltage	Test Voltage
3.3	150 and under	500
3.4	151 – 600	1000
3.5	601 – 15000	2500
3.6	15001 and above	5000

1. Hold 2500-volt and 5000-volt tests for a minimum of five minutes or until three equal consecutive readings one minute apart are obtained. Take and record readings every 30 seconds during the first two minutes and every minute thereafter.
2. Hold 1000-volt and 500-volt insulation resistance tests for a minimum of one minute or until the reading reaches a constant value for 15 seconds unless specified otherwise.
3. Apply tests from phase to ground with the other phases grounded. Test each phase in a similar manner.
4. Check phase matching and phase identification immediately prior to energizing equipment.

B. High Potential Tests



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1. Give cables and bus over 600 volts a high potential dc test after splices, stress cones and/or potheads are completed.
2. Test new cables before cables are connected to terminals.
3. Provide test voltage per the manufacturer's recommendation. Use NETA standards as listed in
4. NETA Acceptance Testing Specifications if manufacturer's recommendations are not available.
5. Apply the dc test potential in at least eight equal increments until maximum test voltage is reached.
6. Do not allow an initial application of voltage greater than the rated voltage of the cable.
7. Record dc leakage current at each step after a constant stabilization time consistent with system charging current delay.
8. Provide a graphic plot of leakage current versus applied potential at each increment.
9. After reaching test voltage, maintain the potential for ten minutes. Record readings of leakage current at 30 seconds, one minute and at one-minute intervals thereafter.
10. Provide a graphic plot of leakage current versus time.
11. Reduce the conductor test potential to zero at the completion of each conductor test and apply grounds for a minimum of thirty minutes.
12. Do not subject switches or other equipment connected to a cable being tested to a test voltage in excess of their test rating. In case of conflict, the Engineer will determine whether to lower the test voltage or to disconnect the equipment.
13. Test each conductor with other conductors grounded and shields grounded.
14. High pot existing cable extensions only to rated cable voltage.

C. Primary Current Testing

1. Prior to testing, set overcurrent devices at the value specified. Do not allow testing to proceed if the set points are not indicated. Obtain set points from the protective device coordination study.
2. Determine the time-current characteristics of circuit breakers by primary current injection whether the device is self-contained or has external current transformers.
3. With the circuit breaker closed, apply a test current through one pole of the circuit breaker and any applicable current transformers. Provide sufficient test current to actuate each mode of the tripping device: long time, short time (if present), and instantaneous (if present).
4. Test each pole.
5. Include in test report, for each pole and each mode:
 - a. Test current used.
 - b. Time to interrupt current.
 - c. Manufacturer's specification interrupt time.
6. Test ground fault time-current characteristics, where applicable, similar to the above.

D. Protective Relays and Solid-State Trip Units

1. Obtain time-current characteristics for each setting or connection. For trip units with long time, short time and/or instantaneous setting, test each mode at specified settings with the other mode(s) set at the specified set point.
2. Determine the time-current characteristics by direct injection of operating current (current transformers are to be used where current transformer is an integral part of unit.)



3. Verify each time-current curve by testing protective relays at a minimum of 2 points and solid-state trip units at a minimum of one point on that portion of the curve that can be altered.
- E. Contact Resistance Test
1. Measure medium voltage switches contacts for micro resistance.
 2. Measure low voltage drawout breakers micro resistance.
- F. Fire Alarm System Test – By Fire Alarm Contractor
1. Fire alarm and smoke detector systems shall be tested by operating each pull station and activating all system sensors to verify proper operation.
 2. Any fire voice communications systems shall be tested to verify correct operation of all voice inputs and all speakers.
 3. Complete system test in presence of WMU and Commissioning Agent.
- G. Ethernet Systems – By Low Voltage Contractor
1. A complete test shall be performed per TIA/EIA TSB 67 on each cable, end to end. A full test report shall be submitted for each cable in hard copy and in electronic thumb drive. Test equipment shall be UL certified for Category 5 testing, fully compliance with TIA TSB-67 Accuracy Level II, utilizing the most recent version of software for the test equipment. Submit proposed test method and equipment for approval prior to testing.
- H. Fiber Optic Systems – By Low Voltage Contractor
1. Upon completion of the system installation, it shall be the responsibility of the Contractor to perform the necessary tests to insure proper system operation. An authorized Owner representative shall be involved during the entire testing phase.
 2. Measurement Plan – a plan shall be presented to the Owner for acceptance, describing the test procedures that the Contractor proposes to follow.
 3. One hundred percent of the optical fibers, splices, and connectors shall meet or exceed the requirements stated in this specification.
 4. Acceptance of the system by the Owner will be determined by the results of a sequence of system measurements performed by the Contractor and submitted to the Owner for approval in an appropriate written report.
 5. The Owner shall receive all original traces.
 6. Testing shall be performed at each building where cable is connectorized. Each connectorized segment of the cable shall be tested in both directions. The following measurements shall be made and documented:
 - a. An OTDR trace for each fiber in both directions after installation. OTDR traces shall be made for single-mode fiber at 1300 nm and 1550 nm wavelengths and for multi-mode fiber at 1300 nm wavelength. Traces shall be conducted after all connectors have been installed and splicing of fibers have been completed.
 - b. The loss of each splice, connector, and total end-to-end attenuation of each fiber shall be measured at 1300 nm for multi-mode fiber and at 1300 nm and 1550 nm for single-mode fiber.



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3.7 THERMOGRAPHIC SURVEY

A. Visual and Mechanical Inspection

1. Remove all necessary covers prior to scanning.
2. Inspect for physical, electrical, and mechanical condition.

B. Equipment to be Scanned

1. All components of the distribution system down to and including branch circuit panelboards and motor control centers. Return 3 months after equipment has been energized and fully loaded to do a final scan of all equipment.

C. Provide report indicating the following:

1. Problem area (location of "hot spot").
2. Temperature rise between "hot spot" and normal or reference area.
3. Cause of heat rise.
4. Phase unbalance, if present.
5. Areas scanned.

D. Test Parameters

1. Scanning distribution system with ability to detect 1 C between subject area and reference at 30 C.
2. Equipment shall detect emitted radiation and convert detected radiation to visual signal.
3. Infrared surveys should be performed during periods of maximum possible loading but not less than twenty percent (20%) of rated load of the electrical equipment being inspected.

E. Test Results

1. Interpretation of temperature gradients requires an experienced technician. Some general guidelines are:
 - a. Temperature gradients of 37 F to 44.6 F indicate possible deficiency and warrant investigation.
 - b. Temperature gradients of 37 F to 59 F indicate deficiency; repair as time permits.
 - c. Temperature gradients of 61 F and above indicate major deficiency; repair immediately.

3.8 EQUIPMENT TO BE TESTED

A. General

1. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.
2. Independent testing laboratory to provide field acceptance tests for the following equipment. Installing Contractor may provide field acceptance tests for equipment not listed below:



- a. Division 26 Section "Electrical General Requirements."
- b. Division 26 Section "Conductors and Cables."
- c. Division 26 Section "Medium Voltage Cables."
- d. Division 26 Section "Grounding and Bonding."
- e. Division 26 Section "Packaged Engine Generators."
- f. Division 26 Section "Secondary Unit Substation."
- g. Division 26 Section "Enclosed Switches."
- h. Division 26 Section "Transfer Switch."
- i. Division 26 Section "Enclosed Controllers."
- j. Division 26 Section "Surge Protective Devices"
- k. Division 26 Section "Panelboards."
- l. Division 26 Section "Motor Control Centers."
- m. Division 26 Section "Dry Type Transformers (600V and Less)."
- n. Division 26 Section "Fuses."
- o. Division 26 Section "Static Uninterruptible Power Supply."
- p. Division 26 Section "Electrical Systems Commissioning."

END OF SECTION 26 0100



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SECTION 26 0400 – BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements specified in Division 26 "Basic Electrical Requirements" apply to this section:
- C. Workmanship
 - 1. The contractor shall employ workmen skilled in the various types of work to be completed. It is intended that the workmen employed shall be the best obtainable, with suitable experience to allow them to perform work of first-class nature. Any workman who does not exhibit these qualifications shall be removed at the request of the University's Representative

1.2 SUMMARY

- A. This Section includes the following electrical materials and methods:
 - 1. Concrete equipment bases.
 - 2. Touchup painting.
- B. Section Includes
 - 1. This Section specifies basic electrical requirements applicable to Divisions 26 and 28 and electrical work specified in other Divisions when referenced to Divisions 26 and 28 for requirements.
- C. Design Intent
 - 1. The Contract documents indicate and specify the electrical design intent. The Contract drawings are schematic and diagrammatic and are not intended to indicate construction details and routing unless specifically indicated. The specifications establish minimum performance, product and installation requirements.



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2. In addition to the specified and indicated performance and quality requirements, furnish products and perform installation work consistent with the design intent and necessary to the provision of complete operating electrical systems.

1.3 REFERENCES

A. American National Standards Institute (ANSI)

1. C2 - National Electrical Safety Code.

B. National Electrical Contractors Association (NECA)

1. 1 - Standard Practices for Good Workmanship in Electrical Construction
2. 500 - Recommended Practice for Installing Indoor Commercial Lighting Systems.

C. National Fire Protection Association (NFPA)

1. 70 - National Electrical Code.

1.4 SYSTEM DESCRIPTION

A. Feeder and Branch Circuit Sizing

1. Provide feeder and branch circuits per the circuit sizing schedules indicated on Drawings.
2. Provide feeders and branch circuits for motors and transformers per the circuit sizing schedules indicated on Drawings.

1.5 SUBMITTALS

A. General

1. Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
2. Refer to Section 01 3300, "Shop Drawings, Product Data and Samples", for basic definitions and requirements for submittals.
3. Submit information substantiating that the products comply with the specified regulatory, testing, code, and standards requirements; including independent testing agency requirements, such as Underwriters Laboratories Inc., and industry standards organization requirements, such as the National Electrical Manufacturers Association.
4. Product Data for each type of product specified.
5. Submit Shop Drawings, Product Data, Samples and other specified submittals on a "system" basis. Retain, and assemble drawings and data from manufacturer or component manufacturers such that each submittal is for a complete system.
6. Shop Drawings detailing fabrication and installation of supports and anchorage for electrical items.



7. Coordination Drawings for electrical installation in accordance with Division 26 Basic Electrical Requirements."
8. Samples of color, lettering style, and other graphic representation required for each identification product for Project.

B. Quality Control Submittals

1. Submit results of factory tests two weeks prior to product shipment from factory.
2. Submit results of field tests immediately upon completion of the field test.

C. Contract Closeout Submittals

1. Refer to Division 01, "Record Documents", for basic definitions and requirements for record documents.
2. Submit, at the completion of the work, record drawings in hard copy per Division 01 and in an approved electronic format matching the electronic format in which the construction documents were produced. Indicate the actual electrical installation, size and construction details. Include the following information:
 - a. Lighting layout, type, circuit designation and control, including each conduit and wire as installed.
 - b. Power distribution system, including distribution equipment and each conduit and wire size installed.
 - c. Layout and circuiting for wiring devices, surface raceways and related equipment, including location of all outlets, junction boxes, and conduit runs; including conduit size, circuit numbers, and number of wires in each run.
 - d. Layout and circuitry for power circuits to mechanical equipment and other electrified building equipment, including each conduit and wire size.
 - e. Supporting and mounting details.
 - f. Special systems layouts such as fire alarm, security, lighting control, and telecommunications systems.
 - g. Layout, cabling and circuiting of site electrical systems such as underground duct banks, manholes, hand holes and site lighting fixtures. Include system and cable identification of communication systems such as telephone, data, fiber optic, fire alarm, security system and other cabling systems.
 - h. Panel schedule drawings consisting of each panelboard. Schedules shall indicate the "as built" circuiting with loads and room numbers identified. Room numbers on schedules shall include the architectural room number indicated on the Drawings and the signage room numbers from the signage schedules. Provide electronic editable version.

1.6 QUALITY ASSURANCE

- A. Comply with NFPA 7C for components and installation.
- B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
1. The Terms "Listed and Labeled": As defined in the National Electrical Code. Article 100.



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C. Regulatory Requirements

1. Comply with the applicable requirements of ANSI C2 and the latest NFPA 70, and NFPA 70e.
 - a. Requirements of ANSI C2, NFPA 70 and NFPA 70e shall be minimum standards of products and installation work. Furnish products and perform installation work which exceed the standards of ANSI C2, NFPA 70 and NFPA 70e when specified or indicated.
2. Comply with applicable requirements of city, county, and state laws, ordinances and regulations including modifications and supplements to ANSI C2 and NFPA 70.
3. Comply with the applicable requirements of U.S. Department of Labor, Occupational Safety and Health Administration Standards (OSHA).
4. All materials shall conform with the standards of the Underwriter's Laboratories in every case where such standards have been established for the particular type of material in question.
5. All material and equipment shall be UL listed and bear the UL label where such listing and labeling exists.
6. The complete electrical installation shall comply with all the requirements of the M.I.O.S.H.A.
7. Codes shall be used as minimum requirements, and where the Specifications or Plans call for an installation that exceeds and does not violate the Code requirements, the Specifications and Plans shall be followed.

D. Character of Work

1. The installation shall be executed in a workmanlike manner and shall present a neat mechanical appearance when completed.

E. Permits and Inspections

1. The Electrical Contractor shall obtain and pay for all permits from the State of Michigan Labor Department, Electrical Division.
2. The Electrical Contractor shall submit a copy of the Certificate of Electrical Inspection from the State of Michigan, prior to request for final payment.

F. Utilities Coordination

1. Coordinate work related to utility services with the appropriate utility companies. Comply with the requirements of the following companies:
 - a. Electrical power: Western Michigan University – (269) 387-8514
 - b. Telephone: Western Michigan University – (269) 387-4357.
2. Provide 10 business days' notice to Owner for any electrical outages.



1.7 PROJECT CONDITIONS

A. Conditions Affecting Selective Demolition: The following project conditions apply:

1. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
2. Locate, identify, and protect electrical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.

B. Conditions Affecting Excavations: The following project conditions apply:

1. Maintain and protect existing building services which transit the area affected by selective demolition.
2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.
3. Site Information: Subsurface conditions were investigated during the design of the Project. Reports of these investigations are available for information only; data in the reports are not intended as representations or warranties of accuracy or continuity of conditions. The Owner will not be responsible for interpretations or conclusions drawn from this information.
4. Existing Utilities: Locate existing underground utilities in excavation areas. If utilities are indicated to remain, support and protect services during excavation operations.
5. Remove existing underground utilities indicated to be removed.
 - a. Uncharted or Incorrectly Charted Utilities: Contact utility owner immediately for instructions.
 - b. Provide temporary utility services to affected areas. Provide minimum of 48-hour notice to Engineer prior to utility interruption.
6. Use of explosives is not permitted.

1.8 PROJECT/SITE CONDITIONS

A. Environmental Requirements

1. Provide products suitable for operation under the following environmental conditions:
 - a. Temperature: -18 to 38 degrees C (0 to 100 degrees F).
 - b. Humidity: 0 to 95 relative percent, non-condensing.
 - c. Altitude: 2010 meters (6600 feet) above sea level.

1.9 SEQUENCING AND SCHEDULING

- A. Coordinate electrical equipment installation with other building components.
- B. Arrange for chases, slots, and openings in building structure during progress of construction to allow for electrical installations.



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- C. Coordinate installing required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- D. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning prior to closing in the building.
- E. Coordinate connecting electrical service to components furnished under other Sections.
- F. Coordinate connecting electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.
- G. Coordinate requirements for access panels and doors where electrical items requiring access are concealed by finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors."
- H. Coordinate installing electrical identification after completion of finishing where identification is applied to field-finished surfaces.
- I. Coordinate installing electrical identifying devices and markings prior to installing acoustical ceilings and similar finishes that conceal such items.
- J. Coordinate the shut-off and disconnection of electrical service with the Owner and the utility company.
- K. Perform demolition in phases as indicated.

1.10 MAINTENANCE

- A. General
 - 1. Retain portable and detachable portions of the installation such as tool, tool kits, instruction books, wiring diagrams, service manuals, operating handles and keys until the completion of work.
 - 2. Transmit the above items to the Owner when the work has been accepted and an itemized receipt obtained.
- B. Operations and Maintenance Manuals
 - 1. Prior to final acceptance of Project, furnish and deliver to Owner three set(s) of bound manual(s) of instructions for operation and maintenance of all pieces of equipment and systems furnished under this Division of Specifications.
 - 2. Bind manuals in a hard-backed, three-hole binder and assemble as follows:
 - a. First page: title of job, Owner, address, date of submittal, name of Contractor and Architect.
 - b. Second page: index.
 - c. Third page: introduction to First Section containing a complete description of the system.
 - d. First Section: written description of system contents, location in building, how each part functions individually, how system works as whole. Conclude with list of items



requiring service and either state the service needed or refer to the manufacturer's data, in binder, that describes the proper service.

- 1) Routine maintenance procedures.
 - 2) Lubrication chart listing all types of lubricants to be used for each piece of equipment and the recommended frequency of lubrication.
 - 3) Trouble-shooting procedures.
 - 4) Recommended spare parts lists.
- e. Second Section: a copy of each Product Data and Shop Drawing submittal with an index at the beginning of the Section.
 - f. Third Section: a copy of each manufacturer's operating instructions with an index at the beginning of the Section.
 - g. Fourth Section: a list of all equipment used on the job, Contractor's purchase order numbers, supplier's name, address and telephone numbers.
3. Provide a separate binder(s) for each system.

C. Extra Materials

1. Furnish keys to the Owner together with any duplicates which may have been made. Securely wire keys for each lock together and plainly tag and mark the keys to indicate the lock number or piece of equipment they operate. Also indicate the physical location of the lock by building name or number, panel number, or room name or number.
2. Provide wiring diagrams, instruction books, installation books, and service manuals to the Owner. Clearly identify each item as to which product it applies and the equipment location.
3. Provide special tools as specified and required for equipment maintenance to the Owner. Clearly identify each item as to which piece of equipment it applies and the equipment location.

1.11 SYSTEMS INTEGRATION

- A. Coordinate with equipment suppliers and ensure integration of systems comprised of disparate equipment which work together to form a complete system.
- B. Provide systems which maintain the U.L. rating of the individual pieces of equipment.
- C. Submit system integration wiring diagrams, control diagrams and sequence of operation as needed for the following systems.
 1. Lighting Control Systems including all devices comprising the system (e.g. occupancy sensor, photocells, dimming ballasts, etc).



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PART 2 - PRODUCTS

2.1 CONCRETE EQUIPMENT BASES

- A. Forms and Reinforcing Materials: As specified in Division 3 Section "Cast-in-Place Concrete."
- B. Concrete: 3000-psi (20.7-MPa), 28-day compressive strength as specified in Division 3 Section "Cast-in-Place Concrete."

2.2 TOUCHUP PAINT

- A. For Equipment: Provided by equipment manufacturer and selected to match equipment finish.
- B. For Nonequipment Surfaces: Matching type and color of undamaged, existing adjacent finish.
- C. For Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

2.3 MANUFACTURERS

- A. General
 - 1. Furnish products by one of the equipment manufacturers listed under the heading "Manufacturers" within the applicable sections. When given, furnish the specified product model or brand for the selected manufacturer.
 - 2. Provide products, for which quantities of two or more are to be furnished, from the same manufacturer and of the same product or model series.
 - 3. Furnish product components designed to be used together and which are physically and electrically compatible.
- B. Product Substitutions
 - 1. Product substitutions may be requested when the "or as approved" clause is specified under the heading "Manufacturers". Submit product substitutions for approval per Division 01, "Product Options and Substitutions".

2.4 PRODUCTS

- A. Product Listing and Labeling
 - 1. Provide listed and labeled product for which listings and labelings exist by Underwriters Laboratories Inc. (UL), Factory Mutual (FM), or similar independent testing organizations recognized by the authorities having jurisdiction. For products for which there are no such listings and labelings, provide listed and labeled components of those products, for which component listing and labelings exist.



B. PCB Content Prohibited

1. Provide products which do not contain any amounts of polychlorinated biphenyl (PCB) compounds.

C. Asbestos Content Prohibited

1. Provide products which do not contain any amounts of asbestos.

D. Firestop Systems

1. Provide products suitable for the application as specified in Division 07, unless otherwise specified or indicated.
2. Cable Pathway Firestop Device
 - a. Provide heavy gauge galvanized steel pathway, per UL 1479, with wall plates lined with intumescent material.
 - b. Provide unit with a built-in firestopping system that automatically adjusts to the number of cables installed and provides maximum fire resistance at any fill percentage.
 - c. Provide fire rating as required for installation complete with wall plate, positioning clamps and other needed hardware.
 - d. Manufacturers
 - 1) Specified Technologies, Inc. (STI): EZ-Path System.
 - 2) Wiremold Flame Stopper: Thru-wall/floor fittings.
3. Firestop for Sleeved and Core-Drilled Holes
 - a. Provide firestop plugs in sleeved and core-drilled holes in walls and floors. Install in accordance with manufacturer's recommendations.
 - b. Plug un-used sleeves and holes.
 - c. Plug around cables after installation of all cables.
 - d. Manufacturers
 - 1) Hilti CP 658T Firestop Plug.

E. Access Doors

1. Provide access doors necessary to access devices, whether for control or maintenance, governed by these Basic Electrical Materials and Methods. Comply with access door requirements specified in Division 08.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests

1. Permit Architect, Engineer (and Owner) to observe factory tests. Provide minimum five working days' notice of factory tests.
2. Schedule no more than one equipment or system factory test per week, unless approved in advance.



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PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION REQUIREMENTS

- A. Install components and equipment to provide the maximum possible headroom where mounting heights or other location criteria are not indicated.
- B. Install items level, plumb, and parallel and perpendicular to other building systems and components, except where otherwise indicated.
- C. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.
- D. Give right of way to raceways and piping systems installed at a required slope.

3.2 INSTALLATION

A. Wiring Installation

- 1. Install wiring for control systems, power feeder and branch circuits, lighting branch circuits, communication and auxiliary systems, such as fire alarm and security, in separate raceways unless otherwise indicated.

B. Device Location

- 1. Allow for relocation prior to installation of wiring devices and other control devices, for example, receptacles, switches, occupancy sensors, fire alarm devices and access control devices, within a 10- foot radius of indicated location without additional cost.

C. NECA Compliance

- 1. Install products in accordance with NECA 1 and 500, unless otherwise specified or indicated.

D. Wet, Damp, or Dry Location Work

- 1. Provide products as appropriate for wet, damp, or dry locations as defined by NFPA 70.

E. Manufacturer Installation Instructions

- 1. Install equipment in accordance with the manufacturer's installation instructions and recommendations.

F. Fire and Smoke Barrier Penetrations



1. Install firestopping to raceways, boxes and electrical equipment installed in or penetrating fire-rated floor and wall assemblies and smoke barrier assemblies, in a manner which maintains the fire resistance rating or barrier intent.

G. Field Painting

1. Refer to Division 09 for prime and finish field painting requirements.
2. In a manner satisfactory to the Owner, touch-up or refinish factory-applied paints or finishes which are chipped, defaced, scratched, or in any other way disturbed due to handling, installation, or general construction work.

H. Personnel Protection From Suspended Work

1. Where suspended equipment, piping or ductwork or any of their supporting or reinforcing members extend 2.1 meters (7 feet) or less above the floor or any other walking surface, cover all edges, projecting surfaces and sharp corners with pre-fabricated soft rubber pads, elastomeric insulation, caps or equivalent to prevent injury to personnel.

I. Sleeves: Install for cable and raceway penetrations of concrete slabs and walls, except where core-drilled holes are used. Install for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls

1. Where outside lighting raceways cross under sidewalks install a spare, straight, empty conduit the width of the sidewalk.
2. Where outside lighting raceways cross under roads, provide at least one spare 2" PVC conduit across road and identify its location.
3. Comply with Req of 260500

J. Fastening: Unless otherwise indicated, securely fasten electrical items and their supporting hardware to the building structure. Perform fastening according to the following:

1. Fasten by means of wood screws or screw-type nails on wood; toggle bolts on hollow masonry units; concrete inserts or expansion bolts on concrete or solid masonry; and by machine screws, welded threaded studs, or spring-tension clamps on steel.
2. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts, machine screws, or wood screws.
3. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or any other items.
4. In partitions of light steel construction use sheet-metal screws.
5. Drill holes in concrete beams so holes more than 1-1/2 inches (38 mm) deep do not cut main reinforcing bars.
6. Drill holes in concrete so holes more than 3/4 inch (19 mm) deep do not cut main reinforcing bars.
7. Fill and seal holes drilled in concrete and not used.
8. Select fasteners so the load applied to any fastener does not exceed 25 percent of the proof-test load.



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9. "E-Z Anchor" type drywall anchors shall not be used in ceiling applications or subject to downward forces.

3.3 CONCRETE EQUIPMENT BASES

- A. All switchgear (primary and secondary), transformers, motor control centers, and large distribution panels shall sit on a 4" high concrete mop base.
- B. Install concrete pads and bases according to requirements of Division 3 Section "Cast-in-Place Concrete."

3.4 DEMOLITION WORK

- A. All demolition of existing electrical equipment and materials will be done by this Contractor unless otherwise indicated. Include all items such as, but not limited to, electrical equipment, devices, lighting fixtures, conduit, and wiring called out on the Drawings and as necessary whether such items are actually indicated on the Drawings or not in order to accomplish the installation of the specified new work.
- B. In general, demolition work is indicated on the Drawings. However, the Contractor shall visit the job site to determine the full extent and character of this work.
- C. Unless specifically noted to the contrary, removed materials shall not be reused in the work. Salvaged materials that are to be reused shall be stored safe against damage and turned over to the appropriate trade for reuse. Salvaged materials of value that are not to be reused shall remain the property of the Owner unless such ownership is waived. Items on which the Owner waives ownership shall become the property of the Contractor, who shall remove and legally dispose of same, away from premises.
- D. Where equipment or fixtures are removed, outlets shall be properly blanked off, and conduits capped. After alterations are done, the entire installation shall present a "finished" look, as approved by the Architect/Engineer. The original function of the present electrical work to be modified shall not be changed unless required by the specific revisions to the system as specified or as indicated.
- E. Reroute signal wires, lighting and power wiring as required to maintain service. All dead-end conduit runs shall be plugged at the remaining line outlet boxes or at the panelboards.
- F. Where new walls and/or floors are installed which interfere with existing outlets, devices, etc., adjust, extend and reconnect such items as required to maintain continuity of same.

3.5 TOUCHUP PAINTING

- A. Thoroughly clean damaged areas and provide primer, intermediate, and finish coats to suit the degree of damage at each location.
- B. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.



3.6 FIELD QUALITY CONTROL

A. Field Tests

1. Permit Architect (and Owner) to observe field tests. Provide minimum three working days' notice of field test.
2. Schedule tests in coordination with other Contract work. Schedule no more than one equipment or system field test per day, unless scheduled in advance.

3.7 TRAINING

A. General

1. Provide training for Owner's personnel in the operation and maintenance of equipment as specified in the applicable Section for the particular equipment and system.
2. Develop training schedule which is acceptable to the Owner. Submit schedule for approval.
3. Provide instruction books, manuals, and other classroom material required as part of the training sessions.
4. Provide instructors who are certified by the equipment and system manufacturers.
5. Provide training for a minimum of three of the Owner's personnel, or as specified in the applicable section.
6. Provide additional training at the Project site after initial training at manufacturer's training center and after the equipment has been installed.

B. Operations and Maintenance Training

1. Train personnel in all aspects of normal operation of the equipment, including starting, adjustments while running, and shutdown.
 - a. Train personnel to recognize incipient problems, including inefficient or dangerous modes of operation, and provide instruction in corrective actions to be taken.
2. Train personnel to perform all recommended maintenance on the equipment.

3.8 EXCAVATION

- A. Slope sides of excavations to comply with local codes and ordinances. Shore and brace as required for stability of excavation.
- B. Shoring and Bracing: Establish requirements for trench shoring and bracing to comply with local codes and authorities. Maintain shoring and bracing in excavations regardless of time period excavations will be open.
 1. Remove shoring and bracing when no longer required. Where sheeting is allowed to remain, cut top of sheeting at an elevation of 30 inches below finished grade elevation.



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- C. Install sediment and erosion control measures in accordance with local codes and ordinances.
- D. Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.
 - 1. Do not allow water to accumulate in excavations. Remove water to prevent softening of bearing materials. Provide and maintain dewatering system components necessary to convey water away from excavations.
 - 2. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey surface water to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.
- E. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade, and shape stockpiles for proper drainage.
 - 1. Locate and retain soil materials away from edge of excavations. Do not store within drip-line of trees indicated to remain.
 - 2. Remove and legally dispose of excess excavated materials and materials not acceptable for use as backfill or fill.
- F. Excavation for Underground Vaults and Electrical Structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot; plus a sufficient distance to permit placing and removal of concrete formwork, installation of services, other construction, and for inspection.
 - 1. Take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed.
- G. Trenching: Excavate trenches for electrical installations as follows:
 - 1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches clearance on both sides of raceways and equipment.
 - 2. Excavate trenches to depth indicated or required.
 - 3. Limit the length of open trench to that in which installations can be made and the trench backfilled within the same day.
 - 4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of raceways and equipment. Provide a minimum of 6 inches of stone or gravel cushion between rock bearing surface and electrical installations.
- H. Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35 deg F (1 deg C).
- I. Backfilling and Filling: Place soil materials in layers to required subgrade elevations for each area classification listed below, using materials specified in Part 2 of this Section.



1. Under walks and pavements, use a combination of subbase materials and excavated or borrowed materials.
 2. Under building slabs, use drainage fill materials.
 3. Under piping and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation.
 4. For raceways less than 30 inches below surface of roadways, provide 4-inch-thick concrete base slab support. After installation of raceways, provide a 4-inch thick concrete encasement (sides and top) prior to backfilling and placement of roadway subbase.
 5. Other areas, use excavated or borrowed materials.
- J. Backfill excavations as promptly as work permits, but not until completion of the following:
1. Inspection, testing, approval, and locations of underground utilities have been recorded.
 2. Removal of concrete formwork.
 3. Removal of shoring and bracing, and backfilling of voids.
 4. Removal of trash and debris.
- K. Placement and Compaction: Place backfill and fill materials in layers of not more than 8 inches in loose depth for material compacted by heavy equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- L. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification specified below. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
- M. Place backfill and fill materials evenly adjacent to structures, piping, and equipment to required elevations. Prevent displacement of raceways and equipment by carrying material uniformly around them to approximately same elevation in each lift.
- N. Compaction: Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below.
1. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture-density relationship (cohesive soils), determined in accordance with ASTM D 1557 and not less than the following percentages of relative density, determined in accordance with ASTM D 2049, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).
 - a. Areas Under Structures. Building Slabs and Steps, Pavements: Compact top 12 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
 - b. Areas Under Walkways: Compact top 6 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
 - c. Other Areas: Compact top 6 inches of subgrade and each layer of backfill or fill material to 85 percent maximum density for cohesive soils, and 90 percent relative density for cohesionless soils.



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- 2. Moisture Control: Where subgrade or layer of soft material must be moisture conditioned before compaction, uniformly apply water. Apply water in minimum quantity necessary to achieve required moisture content and to prevent water appearing on surface during, or subsequent to, compaction operations.
- O. Subsidence: Where subsidence occurs at electrical installation excavations during the period 12 months after Substantial Completion, remove surface treatment (i.e., pavement, lawn, or other finish), add backfill material, compact to specified conditions, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent areas.

END OF SECTION 26 0400



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 0500 - COMMON WORK RESULTS FOR ELECTRICAL

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

DESIGNER NOTE: The information presented herein for the Electrical section of the Construction Standards is, with few exceptions, the Electrical Specification of the WMU Maintenance and Engineering Department in its entirety. In some places, opposite or contradictory statements may appear. These paragraphs are alternatives from which selections are intended to be made by the designer. In other cases items of equipment are not specified in detail, only guidance being given. This equipment is typically a part of major new construction and not specified during the customary design activity of WMU Campus Maintenance and Engineering

- A. This section Includes requirements for providing Electrical Systems and materials specified herein. The Electrical System supplier shall provide a complete "Turnkey" package including all materials, labor, equipment, services and incidental work, including cutting, channeling, excavating and backfilling, required to provide complete functional electrical systems.
- B. The following requirements are included in this Section to expand the requirements specified in Division 1:
 - 1. Scope of work
 - 2. Submittals
 - 3. Coordination
 - 4. Sleeves for raceways and cables.
 - 5. Grout.
 - 6. Rough-in
 - 7. Electrical Demolition
 - 8. Common electrical installation requirements.



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1.3 SCOPE OF WORK

- A. Provide complete installation of the electrical systems indicated on the Drawings and specified herein including but not limited to the following:
1. Obtain all electrical construction permits and inspections from State of Michigan.
 2. Remove existing electrical equipment and transport to Owners storage.
 3. Install primary switch, may be owner supplied.
 4. Install unit substation equipment, switchboards and all associated auxiliary equipment. May be owner supplied. Refer to bid documents for details.
 5. Modify and extent existing circuits to new switchgear as required.
 6. Provide new 15kV primary cable and revise existing distribution as indicated on the Drawings.
 7. Provide raceway and wiring for metering.
 8. Modify and extend existing metering and monitoring system as required.
 9. Provide complete electrical installation including all components, i.e. conduit, wire, etc. as indicated on the drawings and specified herein.
 10. The Work shall be phased as indicated herein and on the Drawings.
 11. Provide selective demolition of electrical systems and equipment as indicated on the drawings.
 12. Submit documentation such as shop drawings, record documents, maintenance manuals, infrared scan results, systems test results, etc. as specified.
 13. Provide Short Circuit, Coordination and Arc-Flash Analysis and apply all labels.

1.4 SUBMITTALS

- A. General: Follow the procedures specified in Division 1 Section "Product Requirements".
- B. Submittal of shop drawings, product data, and samples will be accepted only when submitted by The Contractor. Data submitted from subcontractors and material suppliers directly to the Architect/Engineer will not be processed. Do not submit copied facsimile (fax) material for review. Only original first-generation copies are acceptable.
- C. Submittals shall be provided for the following (refer to specific specification section for submittal requirements):
1. Primary Switchgear.
 2. Primary Cable and Termination and splice kits
 3. Medium Voltage Cables
 4. Low Voltage Cable
 5. Enclosed Switches and Circuit Breakers
 6. Enclosed Controllers
 7. Panelboards
 8. Transformers
 9. Interior Lighting
 10. Electricity Monitoring and Control Equipment
 11. Medium Voltage Splices



12. Disconnect Switches
13. Fuses
14. Secondary Unit Substation
15. Fire Alarm equipment with wiring in raceway.
16. Others as specified

1.5 RECORD DOCUMENTS

- A. Prepare record documents in accordance with the requirements in Division 1 Section "Closeout Procedures." Provide record documents within 30 days after date of system acceptance. Indicate installed conditions for:
 1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
 2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.6 COORDINATION

- A. Coordinate outages of any system with Owner. Coordinate any outage of main electrical service with Owner. Provide minimum fourteen (14) days written notice to Owner.
- B. Coordinate all work to minimize down time of systems during conversion from old system to new.
- C. Coordinate all Phased Work. Protect all initial work and existing systems during performance of subsequent phased work. Provide all temporary equipment, connections, supports, protection, etc. as necessary to provide safe, workman like transition between Phases.
- D. Coordinate arrangement, mounting, and support of electrical equipment:
 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 3. To allow right of way for piping and conduit installed at required slope.
 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- E. Coordinate electrical systems, equipment and materials installation with other building components.
- F. Coordinate connection of electrical systems with exterior underground work.
- G. Coordinate sleeve selection and application with selection and application of firestopping.



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- H. Coordinate installation of panelboard tubs, backboxes and concealed conduit and tubing with masonry/concrete work.
- I. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies and controlling agencies. Provide required connection for each service.
- J. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- K. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

1.7 DELIVERY, STORAGE AND HANDLING

- A. Deliver all materials in original, unbroken brand marked containers or wrapping as applicable.
- B. Handle and store materials in a manner which will prevent deterioration or damage, contamination with foreign matter, damage by weather or elements, and in accordance with Manufacturer's directions.
- C. Store materials indoors and protect from weather. When necessary to store outdoors, elevate materials above grade and enclose with durable, watertight wrapping.
- D. Reject damaged, deteriorated or contaminated materials and immediately remove from the Site. Replace rejected materials with new materials at no additional cost to Owner.

1.8 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the standards of the following organizations as applicable to materials, construction and testing of wire cables.
 - 1. NEMA – National Electrical Manufacturer Association Standards.
 - 2. IEEE Standards
 - 3. Insulated Cable Engineers Association – Standards.
 - 4. ASTM Standards
 - 5. NEC – National Electric Code

1.9 INTERPRETATIONS

- A. It is the intent of these Drawings and Specifications to result in a complete electrical installation in complete accordance with applicable code and ordinances.
- B. Drawings are diagrammatic in character and do not necessarily indicate every required junction box, pull box, ell, etc. Items not specifically mentioned in the specification or noted on the Drawings, but which are necessary to make a complete working installation, shall be included.



- C. Drawings and Specifications are complimentary. Whatever is called for in either is binding as though called for in both. The more stringent requirement shall govern.

1.10 RECORD DRAWINGS

- A. Submit record drawings in compliance with Division 1.
- B. Contractor shall submit to the Architect/Engineer, record drawings on electronic media which have been neatly marked to represent as-built conditions for all new electrical work.
- C. The Contractor shall keep accurate note of all deviations from the construction documents and discrepancies in the underground concealed conditions and other items of construction on field drawings as they occur. The marked-up field documents shall be available for review by the Architect, Engineer and Owner at their request.

1.11 WARRANTY

- A. Warranty: Comply with the requirements in Division 1 Specification Sections. Contractor shall warranty that the electrical installation is free from defects and agrees to replace or repair, to the Owner's satisfaction, any part of this electrical installation which becomes defective within a period of one year (unless specified otherwise in other Division 26 sections) from the date of substantial completion following final acceptance, provided that such failure is due to defects in the equipment, material, workmanship or failure to follow the contract documents.
- B. Contractor shall be responsible for any temporary services including equipment and installation required to maintain operation as a result of any equipment failure or defect during warranty period.
- C. File with the Owner any and all warranties from the equipment manufacturers including operating conditions and performance capacities that they are based on.

1.12 USE OF EQUIPMENT

- A. The use of any equipment, or any part thereof for purposes other than testing even with the Owner's consent, shall not be construed to be an acceptance of the work on the part of the Owner, nor be construed to obligate the Owner in any way to accept improper work or defective materials.
- B. Do not use Owner's lamps for temporary lighting except as allowed and directed by the Owner. Equip lighting fixtures with new lamps when the project is turned over to the Owner.



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PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- B. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, bushings on both ends.
- C. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe", equivalent to ductile-iron pressure pipe, with plain ends and integral water stop, unless otherwise indicated.
- D. Sleeves for Rectangular Openings: Galvanized sheet steel

2.2 SLEEVE SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - 1. Manufacturers. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Advance Products Systems Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and insulator, inc.
 - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 3. Pressure Plates: Plastic
 - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

- A. Nonshrink: recommended for interior and exterior for sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5,000 psi, 28 day compressive strength.
- D. Packaging: Premix and factory packaged.



2.4 DUCT SEAL

- A. Description: UL listed, pliable, non-hardening, non-corrosive, weather-proof putty material, designed as a moisture barrier for weather-sealing service entries, electrical cables and conduit ducts.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work include, but are not limited to the following:
 - a. Lisco Corp. – DS Duct Seal
 - b. OZ/Gedney Co. – DUX
 - c. RectorSeal – Duct Seal Compound.
 - d. Thomas & Betts Corp. – DX.

PART 3 - EXECUTION

3.1 ELECTRICAL DEMOLITION

- A. Coordinate all service disruptions to systems, with Owner prior to disconnecting and/or modifying system.
- B. Disconnect, demolish, and remove electrical system equipment and components indicated to be removed.
- C. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.
- D. Inaccessible Work: Cut and remove buried raceway and wiring, indicated to be demolished, 2 inches below the surface of adjacent construction. Cap raceways and patch surface to match existing finish.
- E. All existing fixtures, equipment, etc., that are removed and not indicated to be relocated, or reused, shall first be offered to the Owner, after Owner has approved, the remaining removed items shall become property of the Contractor and shall be removed from the building site.
- F. Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.
- G. Protect existing electrical equipment and installations not indicated to be removed. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.
- H. Contractor shall examine the Drawings and Specifications, and existing conditions. All costs relating to maintaining existing services or relocating existing circuits and/or equipment shall be included in the bid. Contractor is required to complete all work necessary to meet these requirements without additional expense to the Owner or his Representative.



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3.2 SALVAGE

- A. University retains right to salvage items from demolition area. This will be coordinated with contractor.

3.3 ROUGH-IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to equipment specifications in Divisions 02 through 49 for rough-in requirements.

3.4 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1, Standard Practices for Good Workmanship in Electrical Construction.
- B. Contractor shall be responsible for all slots, openings, etc. in building components as required for electrical installations.
- C. Sequence, coordinate and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to installation of large equipment requiring pre-positioning or blocking of Owners use of building. This work shall be scheduled and coordinated with Owner to minimize interruption to Owners operations.
- D. Install systems, materials and equipment level and plumb, parallel and perpendicular to other building systems and components.
- E. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- F. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- G. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- H. Right of Way: Give to piping systems installed at slope.

3.5 INSTALLATION OF EQUIPMENT

- A. Install all equipment in strict accordance with all directions and recommendations furnished by the manufacturer. Where such directions are in conflict with the Drawings and Specifications, report such conflicts to the Architect/Engineer for resolution.
- B. Device Location:



1. Allow for relocation prior to installation of wiring devices and other control devices, for example, receptacles, switches, fire alarm devices, light fixtures and access control devices within a 10-foot radius of indicated location without additional cost.

3.6 WORK IN EXISTING BUILDINGS

- A. The Owner will provide access to existing buildings as required. Access requirements to occupied buildings shall be identified on the project schedule. The Contractor, once Work is started in the existing building, shall complete same without interruption so as to return work areas as soon as possible to Owner.
- B. Adequately protect and preserve all existing and newly installed Work. Promptly repair any damage to same at Contractor's expense.
- C. Consult with the Owner's Representative as to the methods of carrying on the Work so as not to interfere with the Owner's operation any more than absolutely necessary. Accordingly, all service lines shall be kept in operation as long as possible and the services shall only be interrupted at such time as will be designated by the Owner's Representative.

3.7 TEMPORARY SERVICES

- A. Provide and remove upon completion of the project, in accordance with the general conditions and as described in Division 1, a complete temporary electrical and telephone service during construction. Provide temporary emergency power source for remaining buildings connected to the removed generator. Temporary electrical service shall be metered.

3.8 EXTRA WORK

- A. For any extra electrical work which may be proposed, this Contractor shall furnish to the Construction Manager, an itemized breakdown of the estimated cost of the materials and labor required to complete this work. The Contractor shall proceed only after receiving a written order from the Construction Manager establishing the agreed price and describing the work to be done. Prior to any extra work which may be proposed, the Electrical Contractor shall submit unit prices (same prices for increase/decrease of work) for the following items: 1/2", 3/4", 1", 1-1/2" conduit; #12, #10, #8, #6, #2 wire; receptacle, i.e. receptacle, data box, fire alarm combination visual/audible notification appliance, fire alarm visual notification appliance, or other devices which may be required for any proposed extra work.

3.9 DRAWINGS AND MEASUREMENTS

- A. These Specifications and accompanying Drawings are intended to describe and provide for finished work. They are intended to be cooperative, and what is called for by either shall be as binding as if called for by both. The contractor understands that the work herein described shall be complete in every detail.
- B. The Drawings are not intended to be scaled for rough-in measurements nor to serve as Shop Drawings. Field measurements necessary for ordering materials and fitting the installation to the building construction and arrangement are the Contractor's responsibility. The Contractor



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shall check latest Architectural Drawings and locate light switches from same where door swings are different from Electrical Drawings.

3.10 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for **ALL** penetrations. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches above finished floor level.
- G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
- J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 7.
- K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.11 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.



- B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve.

3.12 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping.", when specification supplied.

3.13 DUCT SEAL INSTALLATION

- A. Where conduits penetrate into the building, seal duct openings at conduit termination points with duct seal for all conduits entering the building to prevent migration of water and gases into the building and to prevent the condensation of water vapor inside the enclosures where the conduits terminate.
- B. Duct seal shall be applied after all cables have been installed.
- C. Install sealing material in strict accordance with the sealant Manufacturer's printed instructions.
- D. Where conduit will be simultaneously exposed to different temperatures, such as where it passes through the outside wall of a heated building or between two different rooms, the inside of the conduit shall be sealed with duct seal. Silicone or similar caulking shall not be used as a substitute for duct seal.

3.14 FIELD QUALITY CONTROL

- A. Inspect installed sleeve installations and associated firestopping for damage and faulty work.

END OF SECTION 26 0500



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 0513 - MEDIUM-VOLTAGE CABLES

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 cables, splices, terminations, and accessories for medium-voltage (2,001 to 15,000V) electrical distribution systems.

1.3 DEFINITIONS

- A. NETA ATS: Acceptance Testing Specification

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of cable, splice, termination and cable accessories.
- B. Samples: 16-inch lengths for each type of cable specified.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Source quality-control test reports.
- C. Material Certificates: For each cable and accessory type, signed by manufacturers, certifying that cables comply with requirements specified in Part 2 Article "Source Quality Control."
- D. Field quality-control test reports.



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1.6 QUALITY ASSURANCE

- A. 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.
- B. Comply with IEEE C2 and NFPA 70.
- C. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.
- D. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or a member company of the InterNational Electrical Testing Association (NETA) and that is acceptable to authorities having jurisdiction and to Owner.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association (NETA) to supervise testing specified in Part 3.
- E. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.

1.7 PROJECT CONDITIONS

- A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Owner's Construction Manager no fewer than fourteen days in advance of proposed interruption of electric service.
 - 2. Do not proceed with interruption of electric service without Owner's Construction Manager's written permission.

1.8 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Architect at least two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Architect's written permission.

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. Cables:
 - a. General Cable Corporation.
 - b. Okonite Company (The).
 - c. Pirelli Cables & Systems NA.
 - d. Southwire Company.
 - e. Rome Cable

2.2 CABLES

A. Cable Construction

1. Cable shall be 250 kCMIL as noted on the drawing, 1/C, copper power cable, 15kV ungrounded (133% insulation level) suitable for normal installation, indoors or outdoors, in conduit or underground ducts, intermittent or continuous submersion in water and direct burial.
2. Single-power conductor, 98% conductivity soft drawn bare annealed copper, concentric-lay, class B, round standard, sized as indicated.
3. Single-ground conductors, 98% conductivity soft drawn bare annealed copper, class B, standard or compacted strand, sized per NFPA 70 for equipment grounding.
4. Extruded over each conductor shall be a non-conducting energy suppression layer at a minimum average thickness of 18 mils. The layer shall be tested during manufacture at a minimum 1 kV DC between electrodes and conductor to prove its electrical integrity.
5. Extruded over the stress control layer shall be the primary insulation at a thickness of 220 mils. The insulation shall be a high-quality ozone and discharge resistant, High Temperature Kerite ethylene-propylene-rubber compound containing no more than a maximum of 55% ethylene. The entire insulation system shall be suitable for normal use at 90 degrees Centigrade continuous conductor temperature, 130 degree C. for emergency overload conditions, and 250 degree C. for short circuit operation.

- B. Cable Type: MV105, with copper conductor and compact round, concentric lay, class B stranding.

- C. Comply with UL-1072, AEIC CS8, ICEA S-93-639, and ICEA S-97-682]

- D. Conductor Insulation: Ethylene-propylene rubber.

1. Voltage Rating: 15kV as indicated on the Drawings
2. Insulation Thickness: 133 percent insulation level.

- E. Cable Jacket: Sunlight-resistant PVC.

- F. Conductor: Uncoated soft copper, Class B, stranded compressed compact round, per ASTM B-8.

- G. Insulation: The insulation shall be a flexible thermosetting dielectric based on an ethylene propylene elastomer (EPR). The insulation shall be – 15kV cable 220 MILS thick (133%), 5kV cable 115 MILS thick (133%). The minimum thickness at any point shall not be less than 90% of the average thickness.



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- H. Insulation Screen: The insulation screen shall be of the same material and qualifications as the conductor screen. The screen shall be clean stripping. The outer surface of the screen shall be continuously printed with contrasting colored ink - ~semi-conduction – remove when splicing or terminating. The thickness of the extruded screen shall be as follows in Table II with a 80% minimum point.

Table II

Dia. Over Insulation Inches	Insulation Screen-Thickness (mils) Minimum Average
0 – 1.000	30
1.001 – 1.500	40
1.501 – 2.000	50
2.001 & over	50

- I. Metallic Shield: The outer screen/insulated core shall be covered with an uncoated copper tape. The shield shall have a minimum average thickness of 5 MILS. It shall be applied helically with 20% nominal overlap.
- J. Over the shield apply an 80 mil polyethylene jacket.
- K. Identification: Print the following information on the cable jacket at maximum 36-inch intervals along the entire length:
1. Manufacturer's name and type.
 2. Conductor size – American wire gauge (AWG) or circular mils (CM).
 3. Conductor material.
 4. Insulation type (not trade name).
 5. Insulation thickness.
 6. Rated voltage.
 7. Jacket type.
 8. Type of insulation shield.
 9. Date of manufacture.
 10. Length marker.
- L. Jacket: The overall jacket shall be PVC and shall have a minimum average thickness in accordance with the requirements of I.C.E.A. 5-68-516, section 4, Table 4-3 of the Standard. The minimum thickness at any point shall not be less than 80% of the specified minimum average thickness.
- M. Identification: The following shall be a minimum requirement for an identifying legend, printed in contrasting ink on the jacket of two (2) foot intervals.
1. Company Name
 2. Plant Number
 3. Number of Conductors and Conductor Size
 4. Length in feet
 5. Conductor Material
 6. Voltage Rating
 7. Insulation
 8. Type and Level
 9. Insulation Thickness
 10. UL Listing



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11. Date of manufacture

N. Production Tests: The following specific production tests shall be performed:

1. Each length of cable provided will be tested in accordance with the following tests.
2. After the application of the primary insulation system, and before any other layers or coverings are applied, each production length of cable shall be immersed in water at room temperature and tested at a minimum of 70kV DC for 5 minutes after 16 hours minimum immersion time, and then a minimum of 35kV AC for 5 minutes after 24 hours minimum immersion time. While still immersed in water the insulation resistance shall be measured. The insulation resistance constant shall not be less than 21,000 megohms/1000 ft. at 60 degrees C.
3. The complete cable, while on the shipping reel, shall be tested at room temperature at a minimum of 35 kV AC for one minute. The insulation resistance shall also be measured, and the insulation resistance constant shall not be less than 21,000 megohms/1000 ft. corrected to 60 degrees C.
4. The conductor resistance and shield continuity shall be measured on each shipping length of cable and recorded. Each end of every shipping length shall also be inspected for water in strands and checked dimensionally for conformance with the above standards.
5. Conductors shall meet the electrical resistance requirements of ICEA-69-51 6 Section 2.5.
6. Insulation Resistance test shall be performed in accordance with the requirements of ICEA S-68-516, Part 6.28. Each cable shall have an insulation resistance not less than that corresponding to the insulation resistance constant of at least 25,000 megohms-1000 ft. at 15.6C.
7. Perform a high voltage AC and DC test in accordance with Part 6.27 of ICEA 8-68-516 at 35 KV for the 5 minute AC withstand test and at 70 KV for the 15 minute DC withstand test.
8. Measure and record shield resistance from end to end on the completed cable.

O. Corona Test; Each reel of completed shield power cable shall comply with the maximum partial discharge in picocoulombs specified in Table III.

Table III

Vt/Vg ration	1.0	1.5	2.0	2.5	3.0	4.0
AEIC CS-6 Regmts(pc)	5	5	20	35	50	No value
Guaranteed values(pc)	5	5	5	5	10	20
Cable Voltage Rating in KV	Test Voltages (Vt) in Kv Corresponding to Vt/Vg Ration					
5	3.0	4.5	6.0	7.0	9.0	11.5
8	4.5	7.0	9.0	11.5	14.0	18.5
15	8.5	13.0	17.5	21.5	26.0	35.0
25	14.5	22.0	29.0	36.0	43.5	*57.5
28	16.0	24.0	32.5	40.5	48.5	*65.0
35	20.0	30.5	40.5	50.5	60.5	*81.0
46	26.5	40.0	53.0	66.5	80.0	*106.0

* The AC test voltages of 200 V/mil for the specified walls shall not be exceeded.



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- P. The partial discharge test shall be performed in accordance with the procedures of Section G of AEIC CS-6-82 and a X-Y recording graph will be furnished showing the corona test results. The test shall be made on #2 (7u) AWG copper or aluminum conductor insulated with an 18 mil stress control layer over the conductor and 175 mils of thermosetting rubber based compound (insulation as specified above), over the stress control layer.
- Q. In lieu of the Partial Discharge Test perform the U-Bend test for discharge resistance in ICEA 8-68-516, and test production samples to determine compliance with the U-Bend test for discharge resistance in the appropriate ICEA Publication. For the U-Bend Test. Samples of insulated cable shall be prepared by either removing the overlying extruded insulation shield material or using insulated cable before the extruded insulation shield material is applied. The sample shall be mounted as described in the appropriate ICEA Publication and subjected to a voltage stress of 250 volts per mu of nominal insulation thickness. The sample shall support this voltage stress, and not show evidence of erosion on the surface of the insulation, for a minimum of 100 hours. The test shall be performed at least once on each 5,000 feet of cable produced or major fraction thereof, or at least once per insulation extruder run.

2.3 SPLICE KITS

- A. Manufacturers:
 - 1. RTE Components; Cooper Power Systems, Inc.
 - 2. Thomas & Betts Corporation.
 - 3. 3M; Electrical Markets Division.
 - 4. Tyco Electronics, Raychem Products
- B. Description: Power cable splices for shielded solid dielectric plastic cables shall be factory engineered kits containing all necessary components to reinstate primary cable insulation, metallic shielding and grounding systems and overall jacket to the equivalent of the cable itself. Splices shall be engineered to properly splice conductor sizes indicated.
- C. Splices shall be of a uniform cross-section, heat or cold-shrinkable polymeric construction utilizing linear stress relief and high dielectric strength insulating layers. The outer insulating layer shall be bonded to the conducting layer for shielding. The splice shall be rejacketed with a heavy-wall, heat or cold-shrinkable lined sleeve to provide a waterproof seal.
- D. The splice shall accommodate a range of cable sizes and be completely independent of cable manufactures' tolerances.
- E. When assembled on cables, the splice shall be capable of passing the electrical test requirements of IEEE-48-1 975, IEEE-404-1 986 and water immersion tests of ANSI-C 119.2-1974.
- F. Splice manufacturer shall provide a test report demonstrating compliance with the above requirements.
- G. Cable manufacturer shall provide a test report demonstrating compliance with the above requirements.
- H. Cable splice kit shall include a 60" minimum moisture blocked ground braid and solderless ground clamp, and cable preparation kit.



2.4 CABLE TERMINATION KITS

A. Manufacturers:

1. RTE Components; Cooper Power Systems, Inc.
2. Thomas & Betts Corporation.
3. 3M; Electrical Markets Division.
4. Tyco Electronics, Raychem Products

- B. Description: termination kits supplied shall be capable of properly terminating conductors as indicated. Kits shall meet Class I requirements and be design-proof tested per IEEE 48-1975 and be capable of passing a test sequence per draft and revisions of IEEE 404-1986. Kits as specified shall accommodate any common form of cable shielding/construction without the need for special adaptors or accessories and shall accommodate a wide range of cable size and, also, be capable of being properly installed on out-of-round or out-of-tolerance cable as per relevant ICEA standards. Kits shall accommodate commercially available connectors. Termination for single-conductor cables shall consist of heat or cold-shrinkable stress control and outer silicone non-tracking insulation tubings along with high relative permittivity stress relief mastic for insulation shield cutback treatment. Three-conductor kits shall contain necessary materials to seal the cable jacket, phase conductors, and any ground wires, as well as re-jacket phases and ground conductors.
- C. Termination kits shall include skirts for outdoor installations. A 60" minimum moisture blocked ground braid and solderless ground clamp shall be included with all terminations.
- D. All cable termination kits shall include a cable preparation kit containing solvent wipes and non-conductive abrasive.
- E. Cable terminations in switchgear shall be outdoor type, Class 1 terminations. Terminations shall be Raychem HVT-150-SJ series or 3M 7640-T series.

2.5 CONNECTORS

- A. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.
- B. Copper-Conductor Connectors: Copper barrel crimped connectors.

2.6 SEPERABLE INSULATED CONNECTORS

- A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
- B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
- C. Dead-Break Cable Terminators: Elbow-type unit with 600A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor



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size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

- D. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless steel mounting brackets and attaching hardware.
 - 1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
 - 2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
 - 3. Grounding Kit: jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phase of feeders and carrying case.
 - 4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.
- E. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.
- F. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool and carrying case.

2.7 ARC-PROOFING MATERIALS

- A. Tape for First Course on Metal Objects: 10-mil- thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
- B. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch thick, compatible with cable jacket.
 - 1. Scotch model 77
- C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2 inch wide.

2.8 BANDING TAPE

- A. Scotch model 69.

2.9 LIVE END SEALS

- A. Live end seals for cable shall be Raychem HVES-1520D series.

2.10 CABLE SUPPORTS

- A. Porcelain slotted strut saddles secured in place.



2.11 SOURCE QUALITY CONTROL

- A. Test and inspect cables according to ICEA S-97-682 before shipping.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Minimum conduit size: 4".
- B. Prior to cutting any cable, cable shall be tested with "Cable Spike" to assure cable is de-energized.
- C. Install cables according to IEEE 576.
- D. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inches on the pull rope.
 - 1. Wire Brush Mandrel: Consists of a length of brush approximately the size of a conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
 - 2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.
- E. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
 - 1. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
 - 2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
- F. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- G. Support cables according to Division 26 Section "Common Work Results for Electrical."
- H. Install "buried-cable" warning tape 12 inches above cables/ducts with metallic strip.
- I. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag. Coordinate vault support and accessory requirements with civil trades. All vault accessories shall be non-metallic or stainless steel.



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- J. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.
- K. Install cable splices at pull points and elsewhere as indicated; use standard kits.
- L. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits.
- M. Install separable insulated-connector components as follows:
 - 1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
 - 2. Portable Feed-Through Accessory: Three.
 - 3. Standoff Insulator: Three.
 - 4. Provide capacitive test point.
- N. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:
 - 1. Clean cable sheath.
 - 2. Wrap metallic cable components with 10-mil pipe-wrapping tape, 3M Scotch 77.
 - 3. Smooth surface contours with electrical insulation putty.
 - 4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
 - 5. Band arc-proofing tape with 1-inch wide bands of half-lapped, adhesive, glass-cloth tape 2 inches o.c.
- O. Seal around cables passing through fire-rated elements. Use fittings that match cable contour.
- P. Provide with factory installed fault indicators on each phase where indicated.
 - 1. EO Schweitzer with individual phase and remote alarm contacts.
 - 2. Wire alarm contacts to metering system.
- Q. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.
- R. Cables shall be tagged at each conduit, junction box and manhole and at building entry points as follows:
 - 1. Identify cables with 3 inch by 4 inch engraved lamacoid tags with 3/8" high white lettering on black background indicating the following information.
 - a. Feeder name.
 - b. Conductor size and insulation.
 - c. Cable type.
 - d. Date of Installation.
 - e. To and From Manhole or switch number where feeder is terminated.
 - 2. Tags shall be horizontal orientation, tie wrapped to cable.
 - 3. Tags shall be approved by Owner prior to installation.
 - a. Refer to specification section "Identification for Electrical Systems."



- S. Arrange cable in manholes to avoid interference with duct entrances.
- T. Fireproof cables in manholes, vaults and in buildings using fireproofing tape in half-lapped wrapping with a minimum of 4 layers, two layers half lapped in each direction. Extend fireproofing one inch into duct. Use 3M Scotch 77 arc and fire proofing tape.
- U. Do not install cables if reel of cable has been stored in an area where the ambient temperature has dropped below 14°F in the past 24 hours.
- V. Provide cable-racking system (arms, insulator, racks and inserts) in manholes to support cabling, maximum spacing between supports is 5 feet and a minimum of 2 points of support (not including ductbank entrance) for each cable.
- W. Install each cable in the duct in the same relative position throughout the underground system. Install cable so that spare ducts are accessible for use in the future.
- X. Band the fire proofing tape with $\frac{3}{4}$ inch wide pressure-sensitive fiberglass cloth banding tape, at the end and the beginning of a roll with No. 69 tape. Construct bands of not less than six turns of banding tape so applied that not more than three turns are in contact with the elastomer backing of the arc-proofing tape.
- Y. All cable exposed in buildings shall be supported from cable brackets using porcelain or maple insulating blocks under cable at each bracket.
- Z. Install ground fault indicators on each phase where indicated.
 - 1. EO Schweitzer with individual phase indication and remote alarm contacts, within a single display.

3.2 CABLE ENERGIZING AND LOOP PHASING

- A. Cables shall not be energized without notification and approval of the following individuals:
 - 1. Campus Construction Project Manager: 269-387-8543
 - 2. Physical Plant Electrical Engineer: 269-387-8520
 - 3. Physical Plant Manager – Electrical: 269-387-8547
 - 4. University Power Plant: 269-387-8686
- B. Loop phasing, new cables shall be phased to existing system in presence of University Physical Plant representative. Equipment required to perform this activity shall be provided by electrical contractor. Written documentation must be provided for this operation.

3.3 FIELD QUALITY CONTROL

- A. Testing: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- B. Testing: Perform the following field quality control tests:



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1. Visual and Mechanical Inspection

- a. Inspect exposed sections for physical damage.
- b. Verify cable is supplied and connected in accordance with one line diagram.
- c. Inspect for shield grounding, cable support, and termination.
- d. Check for visible cable bends against I.C.E.A. minimum allowable bending radius.
- e. Inspect fireproofing in common cable areas.
- f. Visually inspect jacket and insulation condition.
- g. Inspect for proper phase identification and arrangement.
- h. If cables are terminated through window type CT's, make an inspection to verify that neutrals and grounds are properly terminated for proper operation of protective devices.

2. Electrical Tests

- a. Perform a shield continuity test on each new power cable. Ohmic value shall be recorded.
- b. Perform a dc high potential test on all cables. Adhere to all precautions and limits as specified in the applicable NEMNICEA Standard for the specific cable. Perform tests in accordance with ANSI/IEEE Std. 400. Test procedure shall be as follows and the results for each cable test shall be recorded as specified herein. Test voltages for new cables shall not exceed 80% of cable manufacturer's factory test value, or maximum test voltage indicated in N.E.T.A. Acceptance Testing Specifications, Table 10.6 Test voltages for aged cables shall not exceed 60% of cable manufacturer's factory test value, or maximum test voltage indicated in N.E.T.A. Maintenance Testing Specifications, Table 10.6.
 - 1) Current sensing circuits in test equipment shall measure only the leakage current associated with the cable under test and shall not include internal leakage of the test equipment.
 - 2) Record wet and dry bulb temperatures of relative humidity and temperature.
 - 3) Test each section of cable individually.
 - 4) Individually test each conductor with all other conductors grounded. Ground all shields.
 - 5) Terminations shall be properly corona suppressed by guard ring, field reduction sphere, or other suitable methods.
 - 6) Ensure that the maximum test voltage does not exceed the limits for terminators specified in IEEE Standard 48 or manufacturer's Specifications.
 - 7) Apply a dc high potential test in at least five equal increments until maximum test voltage is reached. No increment shall exceed the voltage rating of the cable. Record dc leakage current at each step after a constant stabilization time consistent with system charging current.
 - 8) Raise the conductor to the specified maximum test voltage and hold for a minimum of fifteen minutes for new power cable and five minutes for aged power cable. Record readings of leakage current at 30 seconds and one minute and at one-minute intervals, thereafter.
 - 9) Reduce the conductor test potential to zero and measure residual voltage at discrete intervals.
 - 10) Apply grounds for a time period adequate to drain all insulation stored charge. Proper notification must be made to all concerned parties if grounds are left in place.
 - 11) When new cables are spliced into existing cables, the dc high-potential test shall not be performed. After the splice is completed, an insulation-



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resistance test and a shield-continuity test shall be performed on the length of new and existing cable including the splice. Insulation resistance test shall be performed at 5kV.

- 12) Provide partial discharge test on cables spliced to existing.
- 13) Prior to energization of any cable perform phase rotation test. Test must be performed in the presents of the Owner.
- 14) Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice and connection. Remove box and equipment covers so splices are accessible to portable scanner.
 - a) Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - b) Record of Infrared Scanning: Prepare a certified report that identifies splices and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

C. Test Reports: Prepare a written report 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 action taken to achieve compliance with requirements.
4. All test reports shall be submitted to the Owners Engineer prior to energization of cables or equipment. Tests shall be submitted electronically along with two (2) printed copies.
5. After completion of project submit combined copy of all tests results. Final test report shall be submitted electronically, clearly indicating cable tested, date of test and manufacture of cable. Also provide two (2) printed copies in a three ring binder with each test separated by tabs by feeder number.

D. Test Values

1. Shielding must exhibit continuity. Investigate resistance values in excess of 10 ohms per 1000 feet of cable.
2. A graphic plot shall be made with leakage current (X axis) versus voltage (Y axis) at each increment.
 - a. The step voltage slope should be reasonably linear.
 - b. Absorption slope should be flat or negative. In no case should slope exhibit a positive characteristic.
 - c. Compare test results to previously obtained results if applicable.

E. Medium-voltage cables will be considered defective if they do not pass tests and inspections.

F. Remove malfunctioning units, replace with new units, and retest as specified above.

END OF SECTION 26 0513



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

B. Related Sections include the following:

1. Division 26 Section "Undercarpet Cables" for flat cables for undercabinet installations.
2. Division 26 Section "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices and terminations for electrical distribution systems with 2001 to 35,000V.
3. Division 26 Section "Electrical Identification" for conductor and cable color-coding.

1.2 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the standards of the following organizations as applicable to materials, construction and testing of wire cables.

1. NEMS – National Electrical Manufacturer Association Standards
2. IEEE Standards
3. Insulated Cable Engineers Association – Standards
4. ASTM Standards
5. NEC – National Electric Code

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Qualification Data: For testing agency



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1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.5 RELATED DOCUMENTS

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

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or a member company of the International Electrical Testing Association 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 NFPA 70.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Deliver all materials in original, unbroken, brand marked containers or wrapping as applicable.
- B. Handle and store materials in a manner which will prevent deterioration or damage, contamination with foreign matter, damage by weather or elements, and in accordance with Manufacturer's directions.
- C. Store materials indoors and protect from weather. When necessary to store outdoors, elevate materials above grade and enclose with durable, watertight wrapping.
- D. Reject damaged, deteriorated, or contaminated materials and immediately remove from the Site. Replace rejected materials with new materials at no additional cost to Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.



2.2 CONDUCTORS AND CABLES

- A. Manufacturers:
 - 1. Alcan Products Corporation; Alcan Cable Division
 - 2. American Insulated Wire Corp.: a Leviton Company
 - 3. General Cable Corporation
 - 4. Southwire Company.
- B. Refer to Part 3 "Conductor and Insulation Applications" Article for insulation type, cable construction, and ratings.
- C. Conductor Material: Copper complying with NEMA WC 5 or 7 stranded conductor.
- D. Conductor Insulation Types: Type THHN-THWN and SO complying with NEMA WC 5 or 7.
- E. Power Wire:
 - 1. All conductors and cables shall be new with a minimum wire size of No 12 AWG. Manufacturer's name, type, and size shall be permanently marked on the outer covering at regular intervals and delivered in complete coils or reels.
 - 2. Provide factory fabricated conductors of size, rating, material, and type as indicated for each service. Where not indicated, provide proper selection as determined by installer to comply with installation requirements and the NEC standards, from only following types and conductors:
 - a. Type THHN/THWN, 600 Volt, 75/90 Degrees C Rated with Nylon Jacket: Stranded copper for all sizes.
 - b. Bare Conductors: Stranded copper for all sizes.
- F. Metal Clad (Type MC) Cables
 - 1. Type THHN/THWN insulated copper conductors with insulated green grounding conductor routed with the circuit conductors.
 - 2. High strength, lightweight, galvanized steel flexible interlocking armor, UL listed and labeled for UL Standards 1569 and 83.
 - 3. Thermoplastic insulated bushing for each cable end.
 - 4. Manufacturers: MCTUFF Lightweight Steel MC Metal Clad Cables by AFC Cable Systems or equal.
- G. Control Cable: No 14 AWG minimum, type THHN/THWN.
- H. Power Wiring Cable Accessories: For Connectors:
 - 1. Wing nuts by Ideal
 - 2. Stan-Kon by Thomas & Betts
 - 3. Scotchlox Spring by Minnesota Mining & Manufacturing Company
 - 4. Compression Type 53200 by Thomas & Betts
 - 5. Insulated multi-cable mechanical connector blocks by Polaris, or IIsco.
- I. Power Cable for Variable Frequency Controlled Motors: 600V and 2000V, three conductor, XLPE cable with three symmetrical positioned ground conductors and a continuous impervious



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corrugated aluminum armor and overall PVC jacket. Cable shield transfer impedance shall be less than 10 ohms per meter up to 30 MHz when tested in accordance with NEMA WC 61.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following approved manufactures for VFC power cables:
 - a. Southwire Armor-X
 - b. Draka USA

2.3 CONNECTORS AND SPLICES

- A. Manufacturers:
 1. Hubbell Power Systems, Inc.
 2. 3M; Electrical Products Division.
 3. T&B.
 4. Burndy.
- B. Taps and splices in all feeder and branch circuit conductors larger than no. 8 AWG shall be made with approved solderless, pressure type bolted connectors. Splices in conductors no. 8 AWG and smaller may be made with preinsulated Scotchlock or Ideal Wing-Nut spring tension connectors.
- C. Termination of motor leads to branch circuit conductors shall be made with Burndy Clear UNITAP inspectable insulated multiple tap connectors sized for the conductors being terminated.

PART 3 - EXECUTION

3.1 CONDUCTOR AND INSULATION APPLICATIONS

- A. Minimum conductor size for power wiring: #12 AWG.
- B. Minimum conductor size for control circuits: #14 AWG supplied by Electrical Contractor.
- C. Service Entrance: Type THHN-2-THWN-2, single conductors in raceway.
- D. Exposed Feeders: Type THHN-2-THWN-2, single conductors in raceway.
- E. Feeders Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.
- F. Feeders Concealed in Concrete, below Slabs-on-Grade, and in Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- G. Power Feeder and Branch Circuit Wiring



1. Install no more than three ungrounded conductors, three grounded (neutral) conductors, and one equipment grounding conductor, in a single conduit or cable assembly, unless otherwise indicated.
 2. Install dedicated neutral conductor for each 120 and 277 volt branch circuit.
- H. **All wiring** shall be installed in rigid galvanized conduit, intermediate metal conduit (I.M.C.), flexible conduit, electrical metallic tubing (E.M.T.) or other approved raceway.
- I. Fire Pump Feeder and Control: Provide a listed electrical circuit protective system with a minimum 2-hour fire rating. THHN-2 or XHHW as applicable.
- J. Emergency Power Feeder: Provide a listed electrical circuit protective system with a minimum 1-hour fire rating.
- K. Emergency Power Branch Circuits: Provide a listed electrical circuit protective system with a minimum 1-hour fire rating, where indicated on plans.
- L. Exposed Branch Circuits, including in Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- M. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.
- N. Fixture Whips: Type MC cable may be used for light fixture whips only, with a maximum length of 6 feet for connecting light fixtures in accessible ceiling space.
- O. Branch Circuits Concealed in Concrete and below Slabs-on-Grade: Type THHN-2-THWN-2, single conductors in raceway.
- P. Underground Feeders and Branch Circuits: Type XHHW, single conductors in raceway.
- Q. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- R. Fire Alarm Circuits: Type THHN-2-THWN-2, in raceway or Power-limited, fire-protective, signaling circuit cable where raceway is not specified.
- S. Class 1 Control Circuits: Type THHN-2-THWN-2, in raceway.
- T. Class 2 Control Circuits: Type THHN-2-THWN-2, in raceway or Power-limited cable, concealed in building finishes where raceway is not specified.
- U. Cable types AC, MC, MI, NM, NMC or NMS shall not be used unless specifically noted on drawings or in the specifications.
1. MC cable may be used for lighting fixture whips (maximum six feet), where accessible.
- V. Aluminum conductors shall not be used.
- W. Conductor insulation shall be provided with continuous phase colors as indicated in section 26 0553 for all sizes.



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3.2 INSTALLATION

- A. Install electrical conductors, cables and connectors as indicated on the Drawings, in accordance with the Manufacturer's written instructions, the applicable requirements of NEC and the National Electrical Contractors Association's "Standard of Installation," and in accordance with recognized industry practices to ensure that products serve the intended functions.
- B. Conductors and cables shall be sized in accordance with the Drawings or, in the absence thereof, in accordance with NEC requirements. Except where indicated herein, conductor sizes greater than No. 12 AWG are indicated on the Drawings.
- C. Provide a dedicated grounded conductor (neutral) for each circuit that requires a neutral for proper operation. Unless indicated otherwise on the Drawings, shared neutrals are not allowed.
- D. Provide an equipment grounding conductor in all raceways. Conductor shall be sized in accordance with the National Electrical Code.
- E. Install interior conductors after building is enclosed and water tight.
- F. Each conduit shall be free of moisture and debris before conductors are installed.
- G. Remove moisture from conduits by swabbing.
- H. Pull conductors together where more than 1 conductor is being installed in a raceway.
- I. Use heat shrink tubing for all instrument signal cable terminations.
- J. Keep conductor splices to a minimum.
- K. Install splices and taps which have equivalent or better mechanical strength and insulation as the conductor.
- L. Make all joints, splices, and connections only at accessible junction or outlet boxes, never inside conduit or fitting. Make splices in No. 10 AWG and smaller wire with insulated spiral mechanical connectors.
- M. Make splices in No. 6 AWG and larger copper wire with compression type connectors.
- N. All splices located in handholes and wet locations shall be rated for wet locations.
- O. Low voltage and signal cable splices located in handholes and wet locations shall be sealed in 2-part epoxy sealing pack, 3M Scotchcast connector sealing pack 3570G.
- P. Insulate all joints at splices with "Scotch" brand electrical pressure sensitive tape to 150% of conductor insulation value.
- Q. Support conductors in vertical raceways in accordance to Division 26 Section "Hangers and Supports for Electrical Systems"
- R. Outlets:



1. Free ends and loops at boxes and enclosures shall be pushed back into boxes and protected by blank cover plates or other means until interior painting and decorating work is completed.
- S. Lights and outlets shall be grouped on circuits as indicated on the Drawings. Different types of circuits such as feeders, branch circuits, control circuits, and signal circuits, shall not be mixed in common conduit runs, but shall be run separately, although more than 1 circuit of the same system may be run in common conduit runs.
- T. Conductor ampacity derating shall be adhered to for all conductors in accordance with the National Electrical Code.
- U. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with tightening torque's specified in UL 486A and UL 486B.
- V. Motor control circuits may be No. 14 AWG.
- W. Do not fill raceways so that conductor derating will exceed 50 percent. Harmonic loading shall be considered for circuits serving office and or classroom spaces.
- X. Power branch circuits for receptacles in mechanical spaces, rooftop, outside convenience outlets and other similar locations may use shared grounded conductors.
- Y. Where 120 volt, 20 amp, branch circuit wiring from panelboard to first outlet exceeds 100 feet in length, increase home-run wire size to #10 AWG.
- Z. Where 277 volt, 20 amp, branch circuit wiring from panelboard to first light fixture exceeds 200 feet in length, increase home-run wire size to #10 AWG.
- AA. Common neutral conductors **shall not** be used for convenience outlet or lighting branch circuits.
- BB. Neutral conductors shall be clearly labeled at the panelboard with the circuit number of associated phase conductors.
- CC. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- DD. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- EE. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- FF. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- GG. Support cables according to Division 26 Section "Common Work Results for Electrical."



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- HH. Seal around cables penetrating fire-rated elements according to Division 07 Section "Penetration Firestopping."
- II. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems." Identify cable phasing left to right or front to back, facing front of equipment.
 - 1. Color coding bands should only be used when conductor colors are not available.
 - 2. Conductors are to have continuous color-coded insulation factory colored.
- JJ. Neatly train and tie wrap wiring inside boxes, equipment, and panelboards.
- KK. Clean conductor surfaces before installing lugs and connectors.
- LL. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.
- MM. Use solderless pressure irreversible connectors with insulating covers for copper conductor splices and taps, 8 AWG and larger.
- NN. Use insulated spring wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller.
- OO. Branch circuits may be combined up to 3 circuits in a homerun conduit.
- PP. Provide separate neutral for each circuit.
- QQ. Electrical Contractor shall be responsible for derating of conductors as required by N.E.C.
- RR. Type MC cable shall be supported and secured at intervals not exceeding 4'-0".
- SS. Fittings used for MC cable shall be identified for such use.
- TT. Between support, hangers and termination no more than 3" deflection from the bottom of the cable to a horizontal line between the support/hanger or termination.
- UU. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."
- VV. Each feeder shall be of the same conductor and insulation material (phase, neutral, and parallel).
- WW. All wiring shall be installed in conduit or approved raceway. All raceways shall be provided with a ground conductor unless noted otherwise on the Contract Documents.
- XX. Support communication cables above accessible ceiling using spring metal clips or plastic cable ties to support cables from structure. Do not rest cable on ceiling panels.
- YY. Clean conductor surfaces before installing lugs and connectors.
- ZZ. Use suitable cable fittings and connectors.



3.3 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 26 0553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
 - 1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
 - 2. Use compression type terminations for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.7 DUCT SEAL INSTALLATION

- A. Where conduits penetrate into the building, seal duct openings at conduit termination points with duct seal for all conduits entering the building to prevent migration of water and gases into the building and to prevent the condensation of water vapor inside the enclosures where the conduits terminate.
- B. Duct seal shall be applied after all cables have been installed.
- C. Install sealing material in strict accordance with the sealant Manufacturer's printed instructions.
- D. Where conduit will be simultaneously exposed to different temperatures, such as where it passes through the outside wall of a heated building or between two different rooms, the inside



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of the conduit shall be sealed with duct seal. Silicon or similar caulking shall not be used as a substitute for duct seal.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 3. Test insulation resistance on each conductor with respect to ground and adjacent conductors. Applied potential to be 1000 volts dc for 1 minute.
 - 4. Perform continuity test to insure proper cable connection.
 - 5. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
 - a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - b. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
 - 6. Test Values.
 - a. Minimum insulation resistance values shall be not less than fifty mega-ohms.
- C. Test Reports: Prepare a written report 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 action taken to achieve compliance with requirements.
- D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 0519



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

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. Section Includes: Grounding systems and equipment.
- B. Section includes grounding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Ground bonding common with lightning protection system.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated to be used on project.
- B. Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
 - 1. Ground rods.
 - 2. Ground rings.
 - 3. Grounding arrangements and connections for separately derived systems.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports. Submit written test reports to include the following:
 - 1. Test results that comply with requirements.
 - 2. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
 - 3. Indicate overall system resistance to ground.
 - 4. Indicate overall Telecommunications system resistance to ground.



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1.5 CLOSEOUT SUBMITTALS

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

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Refer to Specification Section “Electrical Testing.”
- B. 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.
- C. Comply with UL 467 for grounding and bonding materials and equipment.
- D. Comply with NFPA 70: for overhead-line construction and medium-voltage underground construction, comply with IEEE C2.
- E. Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system.
- F. Comply with ANSI/TIA/EIA-607 “Standard for Commercial Building Grounding and Bonding Requirements for Telecommunications”.
- G. Comply with ANSI/IEEE 1100 -1992 “Powering and Grounding Sensitive Electronic Equipment”.

1.7 REFERENCES

- A. ASTM B 8: Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft.
- B. ASTM B 33: Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.
- C. ASTM B 187: Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar and Shapes.
- D. IEEE 81: Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
- E. IEEE 142: Grounding of Industrial and Commercial Power Systems
- F. IEEE 837: Qualifying Permanent Connections Used in Substation Grounding.
- G. IEEE 1100 - 1992: Recommended Practice for Powering and Grounding Sensitive Electronic Equipment.
- H. IEEE C2: National Electrical Safety Code.
- I. IEEE NETA MTS – 2001: Maintenance Testing Specification
- J. NFPA 70: National Electrical Code



- K. NFPA 70B: Recommended Practice for Electrical Equipment Maintenance
- L. NFPA 780: Lightning Protection Code
- M. TIA/EIA 607: Commercial Building Grounding and Bonding Requirements Standard.
- N. UL 96: Lightning Protection Components.
- O. UL 467: Grounding and Bonding Equipment.
- P. UL 486A: Wire Connectors and Soldering Lugs for Use with Copper Conductors.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Grounding Conductors, Cables, Connectors, and Rods:
 - a. Erico Inc.; Electrical Products Corporation.
 - b. FCI Burndy Products.
 - c. ILSCO.
 - d. Kearney/Cooper Power Systems.
 - e. O-Z/Gedney Co.; a business of the EGS Electrical Group.

2.2 GROUND BUS

- A. Grounding Bus: Predrilled (as indicated rectangular bars of annealed copper, ¼" by 2" by length as indicated, with 9/32" holes spaced 1-1/8" apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600V. Lexan or PVC, impulse tested at 5000 V.

2.3 GROUNDING CONDUCTORS

- A. For insulated conductors, comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Material: Copper.
- C. Equipment Grounding Conductors: Insulated with green-colored insulation.
- D. Grounding Electrode Conductors: Hard drawn / Stranded cable.
- E. Underground Conductors: Hard drawn / Stranded copper.
- F. Bare Copper Conductors:



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1. Solid Conductors: ASTM B 3.
 2. Stranded Conductors: ASTM B 8.
 3. Tinned Conductors: ASTM B 33.
 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- G. Grounding Bus: Bare, annealed copper bars of rectangular cross section, with insulators.
- H. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connections to ground bus bar.
- I. Irreversible Connectors (Above Grade Only.)
1. Compression connectors of pure, wrought copper, per ASTM B187.
 2. Cast connectors of copper base alloy per ASTM B30.
 3. Clearly and permanently mark connectors with the following information:
 - a. Catalog number.
 - b. Conductors accommodated.
 - c. Installation die index or die catalog number is required.
 - d. Underwriters Laboratories "Listing Mark".
 - e. The words "Direct Burial" or "Burial" per UL 467.
 4. Pre-fill connectors with a corrosion inhibiting compound which is compatible with the conductors being joined.
 5. Provide connectors equivalent in current carrying capacity to the maximum size copper conductors being joined.
 6. Manufacturers
 - a. Burndy Electrical.

2.4 CONNECTOR PRODUCTS

- A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes and combinations of conductors and connected items.
- B. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- C. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
1. Pipe Connectors: Clamp type, sized for pipe.
- D. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.



- E. Compression type Connectors: Pure, wrought copper, per ASTM B187.

2.5 GROUNDING ELECTRODES

- A. Ground Rods: Sectional type; copper-clad steel.
 - 1. Size: $\frac{3}{4}$ inch in diameter by 120 inches long. Solid 98% conductivity, electrical grade copper.
- B. Chemical Electrodes: Copper tube, straight or L-shaped, filled with nonhazardous chemical salts, terminated with a 4/0 bare conductor. Provide backfill material recommended by manufacturer.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.
- B. In raceways, use insulated equipment grounding conductors.
- C. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections.
- D. Equipment Grounding Conductor Terminations:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Structural Steel: Welded connectors.
- E. Use bolted pressure clamps with at least two bolts.
- F. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- G. Ground Rod Clamps at Test Wells: Use bolted pressure clamps with at least two bolts.
- H. Grounding Bus: Install in electrical service equipment rooms.
 - 1. Size: $\frac{1}{4}$ inch by 2 inches bare, annealed copper.
 - 2. Use insulated spacer; space 1 inch from wall and support from wall 6 inches above finished floor, unless otherwise indicated.
 - 3. At doors, route the bus up to the top of the door frame, across the top of the doorway, and down to the specified height above the floor or route around door.



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4. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway and down to specified height above floor; connect to horizontal bus.

- I. Underground Grounding Conductors: Use hard drawn copper conductor, No. 4/0 AWG minimum unless noted otherwise. Bury at least 24 inches below grade.

3.2 POWER SYSTEM GROUND

- A. Ground the electric service system neutral at service entrance equipment to grounding electrodes per NFPA 70.
- B. Ground separately-derived ac power system neutrals, including distribution transformers to grounding electrodes, per NFPA 70.
- C. Separately ground the emergency generator neutral to grounding electrodes, per NFPA 70.

3.3 EQUIPMENT GROUNDING CONDUCTORS

- A. Install insulated equipment grounding conductor in all raceways with circuit conductors. Terminate each end on suitable lugs, bus or bushing.
- B. Busway Supply Circuits: Install insulated equipment grounding conductor from the grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
- C. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.
- D. Metal Poles supporting outdoor lighting fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.4 COUNTERPOISE (PERIMETER GROUND LOOP)

- A. Common Ground Bonding with Lightning protection system: Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.
 1. Install tinned-copper conductor not less than No. 4/0AWG for ground ring and for taps to building steel.
 2. Bury ground ring not less than 24 inches from building's foundation.
 - a. Provide underground – line warning tape 12" above cable.
- B. Common Ground Bonding with Lightning Protection System: Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.



3.5 COUNTERPOISE (PERIMETER GROUNDING LOOP)

- A. Ground the steel framework of the building with a driven ground rod at the base of every corner column and at intermediate exterior columns at distances not more than 60 feet apart. Provide a grounding conductor (counterpoise), electrically connected to each ground rod and to each steel column, extending around the perimeter of the building. Use tinned-copper conductor not less than No. 2/0 AWG for counterpoise and for tap to building steel. Bury counterpoise not less than 18 inches below grade and 24 inches from building foundation. Do not install in concrete floor.

3.6 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Equipotential Ground: Interconnect grounding electrodes to form one, electrically continuous, equipotential grounding electrode system. Grounding electrodes to be interconnected include:
 - 1. Ufer ground.
 - 2. Lightning protection system.
 - 3. Metal water service pipe.
 - 4. Building steel.
- C. Ground Rods: Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes.
 - 1. Drive ground rods until tops are 6 inches below finished floor or final grade, unless otherwise indicated.
 - 2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except as otherwise indicated. Make connections without exposing steel or damaging copper coating.
 - 3. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, Paragraph 250-81(c):
 - 1. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts.
 - 2. Extend grounding conductor below grade and connect to building grounding grid or to a grounding electrode external to concrete.
- E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.



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3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
 4. Bond cable tray to grounding bus with #6 AWG.
- F. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
 4. Bond steam and condensate piping.
- G. Concrete-Encased Electrodes: Connect grounding conductor to the foundation reinforcing bars or rods and bond the bars together with steel tie wires.
- H. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.
- I. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- J. Grounding Variable-Frequency Motors: Provide copper braided grounding strap between motor and metallic conduit (EMT or IMC) in addition of the equipment grounding conductor on motors controlled with a variable-frequency controller.
- K. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.
- L. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.
- M. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.
- N. Bond all steam and condensate piping upstream from equipment shutoff valve.
- O. Packaged Engine Generator: Separately ground the packaged engine generator neutral to grounding electrodes per NFPA 70.



P. Grounding Bus:

1. Electrical equipment rooms.
2. Telephone equipment rooms.
3. Rooms housing service equipment.

3.7 CONNECTIONS

- A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
 2. Make connections with clean, bare metal at points of contact.
 3. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
 4. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
- C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.
- D. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.
- E. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.
- F. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.
- G. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.8 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING

- A. Comply with IEEE C2 grounding requirements.



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- B. Duct Banks: Install an equipment grounding conductor with phase conductors with at least 50 percent ampacity of the largest phase conductor in the duct bank.
- C. Manholes and Handholes: Install a driven ground rod close to wall and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide a No. 1/0 AWG bare tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout. Extend #8 bare copper conductor to the manhole cover ring.
- D. Manholes and Handholes: Install a driven ground rod close to wall and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide a No. 1/0 AWG bare tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
- E. Connections to Manhole Components: Connect exposed-metal parts, such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.
- F. Generator Pad: Install two ground rods and counterpoise circling pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Use tinned-copper conductor not less than No. 2 AWG for counterpoise and for taps to equipment ground pad. Bury counterpoise not less than 18 inches below grade and 6 inches from the foundation.

3.9 TRANSFORMER VAULTS AND MAIN ELECTRICAL ROOMS

- A. Ground Rods
 - 1. At each location the rods shall be tied together by means of no. 4/0 AWG THW, stranded copper cables welded to each rod. Welded connections shall be Cadweld or Burndy Hyground.
 - 2. The tops of the ground rods shall be below the finished floor slab with the 4/0 AWG THW ground wire brought up close to the wall.
- B. Ground Bus
 - 1. Ground bus shall be installed approximately 12 inches above the floor. All joints shall be thoroughly cleaned and trimmed on both sides and edges, wiped smooth and bright, and bolted in approved manner.
- C. Ground Connections
 - 1. From the ground bus in the electrical room, run two ground cables to the ground rods located on the drawing and one ground cable to cold water main. Provide jumpers at all



water meters. Provide ground cable from ground bus to underground duct system ground. All ground cable shall be 4/0 AWG THW, stranded copper.

2. All conduit, pipe racks, switches, supports, wiring troughs, cable sheaths, cabinets, transformers, special equipment and non-current carrying parts shall be permanently and effectively grounded to one of these ground systems.
3. Make ground connections at equipment with grounding devices manufactured for this purpose equal to Burndy Engineering Co. fittings. No soldered ground connections shall be used on grounding circuits at any point, except where ground conductor is attached to the lead sheathed cables. Primary grounds and secondary neutral shall be connected to ground bus with approved mechanical connectors.
4. Primary and secondary neutrals of transformers shall be connected to the ground bus with approved mechanical connectors.
5. An equipment grounding conductor shall be installed with feeders and branch circuits and connected to all devices and equipment.
6. Conductors used for grounding that are installed separately in electrical rooms or other locations shall be installed in conduit in areas where they are subject to physical damage. The conduit shall be bonded to the conductor.

3.10 COMMUNICATION ROOMS

- A. Install a 1/4" x 4" x 30" copper ground bus with predrilled holes in all communication rooms.
 1. Connect each cable tray and equipment cabinet/rack to the ground bus each with a #6 AWG green insulated conductor.
- B. BEF Room
 1. Bond each ground bus of the BEF and CDR Room, together with a No. 4 AWG THWN/THHN bonding conductor in conduit.
 2. Install a No. 4 AWG THWN/THHN grounding conductor in conduit from the ground bus BDF Room to the ground grid in the substation.
- C. CDR Rooms
 1. Connect each ground bus of CDR Rooms with a No. 4 AWG THWN/THHN grounding conductor in conduit to the ground grid in the substation room.
- D. Telecommunications Grounding System: The telecommunications grounding system shall consist of:
 1. A Telecommunications Grounding Busbar (TGB) in each telecommunications room, cabinets, etc.
 2. A Telecommunications Bonding Backbone (TBB) tying together the TMGB and each TGB.
 3. Bonding of all equipment racks, raceways, non-current carrying metallic equipment and surge protection devices within the telecommunications room to the TGB's or TMGB using approved bonding conductors. Each piece of equipment shall be bonded individually directly to the ground bus.
- E. All bonding connections shall be installed at an accessible location for inspection and maintenance.



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- F. All telecommunications bonding connections shall be of an approved mechanical type connection. Do not use exothermic welds unless specifically indicated on the Drawings.
- G. The physical routing shall, in general, follow the same path as the backbone cable system.
- H. Bond each TGB directly to the electrical grounding electrode system with a 4/0 conductor.
- I. Do not use TGB's as a power system ground connection unless specifically noted on the Drawings.
- J. All bonding connectors and conductors shall be UL listed for the purpose intended.
- K. Mount TMGB and TGB bus to backboard or wall using 2" standoff insulators.
- L. Individually bond each piece of non-current carrying metallic equipment in the Telecommunications Room to the TGB.
- M. Install continuous cable from the TMGB to the furthest TGB. Bond all TGB's to TBB with bare No. 3/0 AWG copper ground conductor and T-tap grounding hardware.

3.11 OTHER BUILDING SPACES

- A. Install a 1/4" x 2" solid copper ground bus with predrilled holes where shown on the drawing. Length shall be 12" or longer as noted on the drawings. Connect each ground bus with a No. 4 AWG THWN/THHN grounding conductor in conduit to the ground grid in the main electrical room.

3.12 LABELING

- A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.
- B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
 - 1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."
- C. Pad-Mounted Transformers and Switches: Install two ground rods and counterpoise circling pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Use tinned-copper conductor not less than No. 2 AWG for counterpoise and for taps to equipment ground pad. Bury counterpoise not less than 18 inches below grade and 6 inches from the foundation.

3.13 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING

- A. Duct Banks: Install a grounding conductor with at least 50 percent ampacity of the largest phase conductor in the duct bank.



- B. **Manholes and Handholes:** Install a driven ground rod close to wall and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide a No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
- C. **Connections to Manhole Components:** Connect exposed-metal parts, such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.
- D. **Pad-Mounted Transformers and Switches:** Install two ground rods and counterpoise circling pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Use tinned-copper conductor not less than No. 2 AWG for counterpoise and for taps to equipment ground pad. Bury counterpoise not less than 18 inches below grade and 6 inches from the foundation.

3.14 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Make tests at ground rods before any conductors are connected.
 - 4. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - 5. Perform tests by fall-of-potential method according to IEEE 81.
 - 6. Equipment Grounds: Utilize two-point method of IEEE 81. Measure between equipment ground being testing and known low-impedance grounding electrode or system.
- B. **Excessive Ground Resistance:** If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.



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3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Substations and Pad-Mounted Switching Equipment: 5 ohms.
5. Manhole Ground: 10 ohms.
6. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohms.
7. The telecommunications grounding system shall have a maximum resistance of 1 ohm as measured from the TMGB ground to earth ground.

END OF SECTION 26 0526



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.2 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents. Provide capacity for expansion of 25%.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit

1.4 INFORMATION SUBMITTALS

- A. Welding certificates



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1.5 ACTION SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:
- B. Product Data for the following:
 - 1. Steel slotted support systems.
 - 2. Pipe Hanger
 - 3. Sleeves
 - 4. Fastener
- C. Hanger and support schedule showing manufacturer's figure number, size, spacing, features, and applications for each required type of support, hanger, sleeve, seal, and fastener to be used.
- D. Shop drawings indicating details of fabricated products and materials.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver all materials in original, unbroken, brand marked containers or wrapping as applicable.
- B. Handle and store materials in a manner which will prevent deterioration or damage, contamination with foreign matter, damage by weather or elements, and in accordance with Manufacturer's directions.
- C. Store materials indoors and protect from weather. When necessary to store outdoors, elevate materials above grade and enclose with durable, watertight wrapping.
- D. Reject damaged, deteriorated, or contaminated material and immediately remove from the Site. Replace rejected materials with new materials at no additional cost to Owner.

1.8 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement and formwork requirements are specified in Division 03.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."



PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation. (except "Caddy B18" combination devices)
 - d. Thomas & Betts Corporation.
 - e. Unistrut; Tyco International, Ltd.
 - 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 5. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened Portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Hilti Inc.
 - 3) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 4) MKT Fastening, LLC.



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2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle Bolts: All-steel springhead type.
6. Hanger Rods: Threaded steel.

- G. Fittings and boxes: Do not use die cast zinc fittings or combination box/conduit hanger. Do not use Erico Caddy Series B18 Combination Box/Conduit hanger or anything similar by other approved manufacturers.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.
- C. Pipe Sleeves: Provide pipe sleeves of one of the following:
 1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from the following gage metal for sleeve diameter noted:
 - a. 3" and smaller: 20-gage.
 - b. 4" to 6": 16-gage.
 - c. Over 6": 14-gage.
 2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.
 3. Plastic Pipe: Fabricate from Schedule 80 PVC plastic pipe.

2.3 ROOF MOUNTED CONDUIT AND EQUIPMENT SUPPORTS

- A. General: Shop or field fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted conduit and equipment.
- B. Adjustable Compact Stand: Recycled rubber base unit with integral threaded coupling capable of accepting 3/8-16 threaded rod, or 1 5/8" by 1 5/8" metal strut and various supporting elements.
 1. Manufacturers: Subject to compliance with the requirements, provide products by one of the following:
 - a. B-Line Systems, Inc.; a division of Cooper Industries; Dura-Blok.
 - b. ERICO International Corp.; Caddy Pyramid.
 - c. Tolco; a brand of Nibco; Pipe Piers
- C. Low-Type, Single-Conduit Stand: Assembly of base and horizontal members, and support, for roof installation without membrane penetration.



1. Manufacturers: Subject to compliance with requirements, provide products by one for the following:
 - a. B-Line Systems, Inc.; a division of Cooper Industries; Dura-Blok.
 - b. ERICO International Corp.; Caddy Pyramid.
 - c. Tolco; a brand of Nibco; Pipe Piers
2. Base: Plastic, Recycled rubber.
3. Horizontal Member: Cadmium-plated-steel or galvanized-steel strut designed for use with standard strut clamps and accessories.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems, except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where Table 1 lists maximum spacing less than stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 1. Secure raceways and cables to trapeze member with clamps approved for application.
 2. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.
- D. Support all electrical items independently of supports provided by the other trades.
- E. Support single runs of MC cable using spring-steel clamps from suspended ceiling hangers, hanger wire or building structure at intervals not to exceed three feet. Do not support MC cable from ceiling grid.
- F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1 1/4" and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements, except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, as permitted in NFPA 70.



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- C. Install seismic-restraint components using methods approved by the evaluation service providing required submittals for component.
- D. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- E. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners, lead anchors.
 - 5. To Steel:
 - a. Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts
 - b. Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69
 - c. Spring-tension clamps.
 - 6. To Light Steel: Sheet metal screws.
 - 7. Plastic anchors may be used for mounting 4 inch square boxes.
 - 8. Power actuated anchors may not be used.
 - 9. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
 - 10. Enclosures for panelboards, motor starters, motor control centers, enclosed switches and circuit breakers, enclosed controllers and transfer switches and other similar equipment shall be mounted on ½" spacers when mounted in a room on a below grade exterior wall and in wet or damp locations.
- F. Slotted support systems applications:
 - 1. Indoor dry and damp Locations: Painted Steel
 - 2. Outdoors and interior wet locations: Galvanized Steel
- G. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.
- H. Do not fasten supports to pipes, ducts, mechanical equipment, or other conduit.
- I. Do not use E-Z type anchors.
- J. Obtain permission from Architect/Engineer before drilling or cutting structural members.
- K. Fabricate supports from structural steel or steel channel. Rigidly weld members or use hexagon head bolts to present neat appearance with adequate strength and rigidity. Use spring lock washers under all nuts.



- L. The Contractor shall replace all supports and channels that sag, twist, and/or show signs of not providing proper structural support to the equipment it is intended for, as determined by the Owner and Architect/Engineer. All costs associated with replacing supports and steel channels shall be incurred by the Contractor.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field welding: comply with AWS D1.1/D1.1M.

3.4 INSTALLATION OF ROOF MOUNTED SUPPORTS

- A. Install in accordance with manufacturer's instructions.
- B. If gravel top roof, gravel must be removed around and under support.
- C. Consult roofing manufacturer for roof membrane compression capacities. If required, a compatible sheet of roofing material (rubber pad) may be required under rooftop support to disperse concentrated loads and add further membrane protection.
- D. Utilize properly sized clamps and accessories to suit conduit sizes.
- E. Field Welding: Comply with AWS D1.1/D1.1M.

3.5 CONCRETE BASES

- A. Provide concrete bases for all floor mounted electrical equipment.
- B. Provide concrete bases for all exterior, grade level electrical equipment, and where indicated.
- C. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and seismic criteria at Project.
- D. Construct concrete bases of dimensions indicated but not more than 4 inches larger in both directions than supported unit, and so expansion anchors will be a minimum of 10 bolt diameters from edge of the base.
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of the base.
 - 2. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor for equipment over 500 pounds.



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3. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
6. Use 3000-psi, 28-day compressive-strength concrete or as specified in section 03 3000.

3.6 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils .
- B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 0529



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 0533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

1.2 DEFINITIONS

- A. GRC: Galvanized rigid steel conduit
- B. IMC: Intermediate metal conduit

1.3 RELATED REQUIREMENTS

1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior duct banks, manholes, and underground utility construction.

1.4 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures and cabinets. For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.
- B. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 1. Structural members in paths of conduit groups with common supports.
 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.



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- C. Source quality-control test reports

1.5 QUALITY ASSURANCE

- A. 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.
- B. Comply with NFPA 70.

1.6 COORDINATION

- A. Coordinate layout and installation of raceways, boxes, enclosures, cabinets, and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 2. AlfLEX
 - 3. Grinnell Co./Tyco International; Allied Tube and Conduit Div.
 - 4. O-Z Gedney; Unit of General Signal.
 - 5. Wheatland Tube Co.
 - 6. Shamrock Conduit Products/Thomas and Betts.
- B. Manufacturers for Fire Alarm System EMT: Subject to compliance with requirements, provide products by one of the following:
 - 1. Grinnell Co./Tyco International; Allied Tube and Conduit Div.
 - 2. Republic Conduit
 - 3. Wheatland Tube Co.
- C. General construction:
 - 1. All boxes, brackets, bolts, clamps, etc., shall be galvanized, electro-galvanized, metalized, or sherardized.
 - 2. All hardware used outdoors shall be hot dipped galvanized.
 - 3. Pull boxes, junction boxes, and outlet boxes installed outdoors shall be heavy duty die cast aluminum construction powder coat finished with gasketed cover plate.
- D. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.



- E. GRC: ANSI C80.1 and UL 6.
- F. GRC – PVC Coated: ANSI C80.1 and UL 6.
- G. IMC: ANSI C80.6 and UL 1242.
- H. EMT and Fittings: ANSI C80.3 and UL 797.
 - 1. Fittings: Compression type.
- I. FMC: Zinc-coated steel, comply with UL.
- J. LFMC: Flexible steel conduit with PVC jacket, comply with UL 360.
- K. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
 - 2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: steel compression
 - c. Do not use die cast zinc fittings.
 - 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
- L. Threaded Conduit Joints, exposed to wet, damp, corrosive, or outdoor conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- M. Joint Compound for IMC or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.
- N. All conduits penetrating underground walls into basements, crawlspaces, vaults, etc. shall be sealed between the conduits and walls with Link-Seal Model "C" modular sealing systems.
- O. Terminations: All conduits.
 - 1. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.
 - 2. Threaded couplings, connectors and conduit bodies shall be used on rigid galvanized conduit and intermediate metal conduit; set screw or threadless types are not acceptable.
- P. Raceways for Communications Cable: Install metallic raceways as follows:
 - 1. One Inch Trade Size: Install raceways in maximum lengths of 100 feet, without a box.



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2. When conduits are needed to bypass a large interference in a cable tray run, the cross-sectional area of the conduits shall equal or exceed the cross-sectional area of the cable tray.
3. Conduit bends and offsets shall be made with sweeps or manufactured elbows. Conduits shall not have more than the equivalent of two ninety-degree bends between pull points. Pull boxes shall be provided as required to meet this requirement.
4. Provide nylon pull string in all conduits.
5. Bond the entire raceway system together and connect it to the ground system.
6. Extend telecommunication conduits from outlet boxes to cable tray and fasten by ground mechanical fasteners.
7. All conduit ends shall have an insulated bushing.

Q. All home run branch circuit conduit shall be sized for additional 25% conductor fill capacity.

R. All surface mounted device boxes mounted on columns shall be cast FS type.

2.2 NONMETALLIC CONDUIT AND TUBING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cantex
 2. Lamson & Sessions; Carlon Electrical Products.
 3. RACO; Division of Hubbell, Inc.
 4. Thomas & Betts Corporation.
- B. RNC: NEMA TC 2, Schedule 40 and Schedule 80 PVC.
- C. RNC Fittings: NEMA TC 3; match to conduit or tubing type and material.
- D. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 METAL WIREWAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper B-Line, Inc.
 2. Hoffman.
 3. Schneider Electric.
- B. Material and Construction: Sheet metal sized and shaped as indicated, NEMA 1 or 3R as required.
- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.



- D. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.
- E. Wireway Covers: Hinged type, Screw-cover type, Flanged-and-gasketed type, as indicated.
- F. Finish: Manufacturer's standard enamel finish.

2.4 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

- A. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.
- B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- C. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.
- D. Provide in Wet Locations.

2.5 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with snap-on covers. Finish with manufacturer's standard prime coating and ivory finish coat.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell, Inc.
 - b. Wiremold Company; Electrical Sales Division
- C. Surface Metal Raceways: Satin anodized extruded aluminum with snap-on covers.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Panduit
 - b. Hubbell, Inc.
 - c. Wiremold Company; Electrical Sales Division
- D. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC compound with matte texture ivory color.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hellermann Tyton



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- b. Hubbell, Inc.; Wiring Device Division.
 - c. Panduit Corp.
 - d. Wiremold Company; Electrical Sales Division
- E. Types, sizes, and channels as indicated and required for each application, with fittings that match and mate with raceways. Provide concealed support clips or fasten raceway internally. Do not use external mounting straps.

2.6 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
 - 2. Emerson/General Signal; Appleton Electric Company.
 - 3. Erickson Electrical Equipment Co.
 - 4. Hoffman.
 - 5. Hubbell, Inc.; Killark Electric Manufacturing Co.
 - 6. O-Z/Gedney; Unit of General Signal.
 - 7. RACO; Division of Hubbell, Inc.
 - 8. Thomas & Betts Corporation.
 - 9. Walker Systems, Inc.; Wiremold Company (The).
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet Metal Outlet and Device Boxes: NEMA OS 1 and UL514A. Minimum 2 1/8" deep within walls or ceilings.
- D. Cast Metal Outlet and Device Boxes: NEMA FB 1 ferrous alloy, Type FD, with gasketed cover for exposed, non-recessed locations.
- E. Cast Metal Pull and Junction Boxes: NEMA FB 1 cast aluminum with gasketed cover. Shall be used in areas exposed to water.
- F. Nonmetallic Outlet and Device Boxes: NEMA OS 2 and UL514C. Shall be used in corrosive areas.
- G. Metal Floor Boxes:
 - 1. Material: Sheet-metal.
 - 2. Type: Fully adjustable.
 - 3. Shape: Rectangular.
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application. Floor box cover shall be brass.
 - 5. See Editing Instruction No. 2 in the Evaluations for discussion of floor boxes.
 - 6. Metal Floor Boxes:
 - 7. Material: **[Cast metal] [or] [sheet metal]**.
 - 8. Type: **[Fully adjustable] [Semi-adjustable]**.
 - 9. Shape: Rectangular.



10. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 11. Nonmetallic Floor Boxes: Nonadjustable, **[round]** **[rectangular]**.
 12. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- I. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch to match panelboards.
1. Metal Enclosures: Galvanized Steel, finished inside and out with manufacturer's standard enamel.
 2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.
 3. Removable interior panel and removable front.
 4. Include metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.
 5. Finish: Floor box cover finish shall be brass.
- J. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- K. Telephone/Data Backboxes: Provide 2-gang, 3 ½" deep backboxes with single gang raised cover unless noted otherwise on plans.
1. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.
 2. Telephone/Data Backboxes: Provide 2-gang, 3 ½ inch deep backboxes with single gang raised cover unless noted otherwise on plans.

2.7 FACTORY FINISHES

- A. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard gray paint applied to factory-assembled surface raceways, enclosures, and cabinets before shipping.

2.8 CABLE PATHWAY AND FIRESTOP DEVICE

- A. Manufacturer:
1. Specified Technologies, Inc., EZ-Path fire rated pathway.
 2. Wiremold, FlameStopper FS Series thru-wall fitting for fire walls.
- B. Description: Through-the-wall 3"x3" steel wiring channel or 4" EMT equipped with heat expanding intumescent fire stopping material.



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2.9 SLEEVES FOR RACEWAYS

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated “wall pipe,” equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052” or 0.138” thickness as indicated and of length to suit application.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 7 Section “Through-Penetration Firestop Systems”.

2.10 SLEEVE SEALS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. Calpico, Inc.
 - 3. Metraflex Co.
 - 4. Pipeline Seal and Insulator, Inc.
- B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
 - 1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 2. Pressure Plates: Plastic. Include two for each sealing element.
 - 3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.11 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.12 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. General Requirements for Handholes and Boxes:
 - 1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
 - 2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.



- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
1. Standard: Comply with SCTE 77.
 2. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering, "ELECTRIC".
 6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate to entering ducts for secure, fixed installation in enclosure wall.
 7. Wall Style: Flared wall assembly.



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2.13 CABLE PATHWAY AND FIRESTOP DEVICE

2.14 Manufacturer:

2.15 Specified Technologies, Inc., EZ-Path fire rated pathway.

2.16 Wiremold, FlameStopper FS Series thru-wall fitting for fire walls.

2.17 Description: Through-the-wall 3" x 3" steel wiring channel or 4" EMT equipped with heat expanding intumescent fire stopping material.

2.18 Wiring channel shall be provided with steel wall plates allowing for single or multiple channels to be ganged together.

2.19 Wiring channel shall have an F rating equal to the rating of the barrier in which it is installed.

2.20 Wiring channel shall be capable of allowing a 0 to 100 percent visual fill of cable.

2.21 Wiring channel shall be tested in accordance with ASTM E 814 (ANSI/UL1479). Channel shall bear the UL classification marking.

2.22 Provide the quantity of devices needed to allow a cable pass cross section capacity of 50 percent of the adjacent cable tray cross section.

2.23 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

2.24 See Editing Instruction No. 3 in the Evaluations. Verify with manufacturers that units of types specified are available in sizes required. Indicate the size of each enclosure on Drawings, and use a symbol or other notation to differentiate between handholes and pull boxes.

2.25 General Requirements for Handholes and Boxes:

2.26 Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.

2.27 Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.



- 2.28 Retain one or more of three paragraphs below to select enclosure type(s) for areas not subject to traffic by vehicles. Indicate location of each type in "Raceway Application" Article. For enclosures with cover options, verify that selected cover is available with load rating specified in "Raceway Application" Article. If retaining more than one type of box and cover combination, indicate location of each type on Drawings.
- 2.29 Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
- 2.30 Standard: Comply with SCTE 77.
- 2.31 First option in "Configuration" Subparagraph below facilitates bottom conduit entry. Second option may be provided by a separate slab placed in the excavation under an open-bottom enclosure; third option is obtained by molding or fabricating the bottom integrally with the body of unit.
- 2.32 Configuration: Designed for flush burial with open bottom unless otherwise indicated.
- 2.33 Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
- 2.34 Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- 2.35 Cover Legend: Molded lettering, "ELECTRIC."
- 2.36 Retain "Conduit Entrance Provisions" Subparagraph below if conduit enters enclosure through the side. Otherwise, entry is made through an open bottom or through side openings cut in the field, as specified in "Installation of Underground Handholes and Boxes" Article. Coordinate with Drawings.
- 2.37 Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
- 2.38 Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete.
- 2.39 Standard: Comply with SCTE 77.



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- 2.40 First option in "Configuration" Subparagraph below facilitates bottom conduit entry. Second option may be provided by a separate slab placed in the excavation under an open-bottom enclosure; third option is obtained by molding or fabricating the bottom integrally with the body of unit.
- 2.41 Configuration: Designed for flush burial with open bottom unless otherwise indicated.
- 2.42 Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
- 2.43 Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- 2.44 Cover Legend: Molded lettering, "ELECTRIC."
- 2.45 Retain "Conduit Entrance Provisions" Subparagraph below if conduit enters enclosure through the side. Otherwise, entry is made through an open bottom or through side openings cut in the field, as specified in "Installation of Underground Handholes and Boxes" Article. Coordinate with Drawings.
- 2.46 Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors:

- 1. Exposed: Rigid steel.
- 2. Concealed, Aboveground: Rigid steel or IMC.
- 3. Underground: RNC Schedule 80.
- 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
- 5. Boxes and Enclosures: NEMA 250, Type 4X Stainless Steel.

B. Indoors:

- 1. Exposed in Unfinished Utility Spaces: EMT.
- 2. Exposed in Finished Spaces: All conduit shall be concealed unless specifically indicated on plans.
- 3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit or IMC.
- 4. Exposed below 10' in the following locations to be Rigid steel conduit or IMC, above shall be EMT:



- a. Loading dock
 - b. Electrical substation rooms and electrical rooms
 - c. Mechanical Room
- 5. Concrete Floors: RNC.
- 6. Concealed in Ceilings and Interior Walls and Partitions: EMT
- 7. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
- 8. Damp or Wet Locations: Rigid steel conduit or IMC.
- 9. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
 - a. Damp or Wet Locations: NEMA 250, Type 4, stainless steel.
- C. Provide separate raceway systems for:
 - 1. Normal power wiring.
 - 2. Emergency power wiring.
 - 3. Data/Communication wiring.
 - 4. Fire alarm system wiring.
 - 5. A.C. signal and control wiring.
 - 6. Low voltage signal and control wiring.
 - 7. Special systems wiring.
- D. Do not utilize panelboards, motor control centers, distribution equipment or like devices as raceways.
- E. Provide innerduct in each conduit run that contains fiber optic cable.
- F. Minimum Raceway Size: 3/4-inch trade size (21mm).
 - 1. 1/2" minimum for flexible conduits.
- G. Raceway Fittings: Compatible with raceways and suitable for use and location.
 - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
 - 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.
 - 3. Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
- H. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.
- I. Do not install aluminum conduits in contact with concrete, soil, or within 10' of corrosive locations.
- J. Metal Clad (MC) and Armored (AC) cable.
 - 1. Shall include a grounding conductor.
 - 2. May be used for light fixture whips not to exceed 6'-0".



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3. Not to be used for connecting items other than light fixtures.

3.2 INSTALLATION

- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- B. Steel conduit for Type RHW 2-hour fire rated cable serving emergency power system equipment shall be supported on 5 foot centers. Since cable splices are not permitted, use pull boxes and planning to achieve continuous cable installation.
- C. Provide separate raceways for lighting, receptacle, and motor loads. Do not mix branch circuit wiring for these different loads in the same raceway.
- D. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- E. Complete raceway installation before starting conductor installation.
- F. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- G. Support raceways as specified in Division 26 Section "Common Work Results for Electrical."
- H. Install temporary closures to prevent foreign matter from entering raceways.
- I. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above finished slab.
- J. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- K. Make bends and offsets so ID is not reduced. Keep legs of bends in same plane and keep straight legs of offsets parallel, unless otherwise indicated.
- L. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
 1. Install concealed raceways with a minimum of bends in shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.
 2. Conduit and EMT may be surface mounted in Mechanical and Electrical Rooms.
 3. Surface mounted conduit or EMT may be used where specifically approved by Architect/Engineer. In such situations, the conduit, fastening devices, and junction boxes shall be painted to match the adjacent surface.
- M. Raceways Embedded in Slabs: Install in middle 1/3 of slab thickness where practical and leave at least 2 inches of concrete cover.
 1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
 2. Space raceways laterally to prevent voids in concrete.



3. Run conduit larger than 1-inch trade size parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 4. Change from nonmetallic tubing to rigid steel conduit before rising above floor.
 5. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 6. Conduits shall run flat. Do not allow conduits to cross.
- N. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.
1. Run parallel or banked raceways together on common supports.
 2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
- O. Stub-ups to Above Recessed Ceilings:
1. Use EMT, IMC, or RMC for raceways.
 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- P. Join raceways with fittings designed and approved for that purpose and make joints tight.
1. Use insulating bushings to protect conductors.
- Q. Tighten set screws of threadless fittings with suitable tools.
- R. Terminations:
1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.
 2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.
 3. Telephone, data and fiber optic cable conduits shall be provided with bushings on conduit ends.
- S. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- T. Color-Coding: Paint fire alarm system junction boxes and covers red.
- U. Raceways for Optical Fiber and Communications Cable: Install as follows:
1. $\frac{3}{4}$ " trade size and smaller: Install raceways in maximum lengths of 50 feet.
 2. 1" trade size and larger: Install raceways in maximum lengths of 75 feet.
 3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.



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- V. Telephone, data, and fiber optic cable system conduit shall be provided with wide sweep bends. No condulets.
- W. Telephone, data, and fiber optic cable outlets shall be provided with a 1 inch conduit stubbed into accessible ceiling space unless noted otherwise on the drawings. Provide bushings on the ends of the conduit.
 - 1. Raceways for Optical Fiber and Communications Cable: Install as follows:
 - 2. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
 - 3. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
 - 4. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
 - 5. Telephone, data and fiber optic cable system conduit shall be provided with wide sweep bends.
 - 6. Telephone, data and fiber optic cable outlets shall be provided with a 1 inch conduit stubbed into accessible ceiling space unless noted otherwise on the drawings. Provide bushings on the ends of the conduit.
- X. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where otherwise required by NFPA 70.
- Y. Expansion fittings shall be used in all conduits crossing building expansion joints. Fittings shall be equipped with an external bonding jumper.
- Z. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.
- AA. Flexible Connections: Use maximum of 72 inches of flexible conduit for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in damp or wet locations. Install separate ground conductor across flexible connections. Provide adequate length of flexible conduit to allow relocation of fixture on grid space in any lateral direction.
 - 1. Flexible Connections to Lighting Fixtures: Provide flexible conduit to all recessed lighting fixtures. For fixtures mounted on grid ceilings, provide adequate length of flexible conduit to allow relocation of fixture on grid space in any lateral direction.
- BB. Equipment Grounding Conductor: Install a green equipment grounding conductor in all flexible conduit and non-metallic (PVC) conduit.
- CC. Surface Raceways: Install a separate, green, ground conductor in raceways from junction box supplying raceways to receptacle or fixture ground terminals.



- DD. Recessed back-to-back boxes are not permitted in the same wall. Arrange boxes with at least 12 inches of horizontal spacing.
- EE. Recessed Boxes in Masonry Walls: Saw-cut opening for box in masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between the box and cover plate or the supported equipment and box.
- FF. Locate boxes so that cover or plate will not span different building finishes.
- GG. Set floor boxes level and flush with finished floor surface.
- HH. Install hinged-cover enclosures and cabinets plumb. Support at each corner.
- II. Provide stainless steel cover plates on all abandoned boxes that remain from selective demolition.
- JJ. Cable pathway and firestop device: Install in locations where indicated on the plans. Arrange singly or in gangs and mounted above accessible ceilings. Install the devices in strict accordance with the manufacturer's recommendations.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6" in nominal diameter.
2. Install backfill as specified in Division 31 Section "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12" of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout length elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3" of concrete.
 - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60" from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
6. Underground Metallic Warning Tape: Comply with requirements in Section 26 0553 "Identification for Electrical Systems."



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3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from $\frac{1}{2}$ " sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures flush with finished grade.
- D. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used and seal sound penetrations after fittings are installed. Coordinate with Roofing Contractor.



3.5 INSTALLATION OF UNDERGROUND CONDUIT

3.6 Retain this Article if Project includes small amounts of exterior underground wiring, 600 V and less. Delete if Division 26 Section "Underground Ducts and Raceways for Electrical Systems" is included in the Project Manual. See Editing Instruction No. 3 in the Evaluations.

3.7 Direct-Buried Conduit:

3.8 Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches in nominal diameter.

3.9 Install backfill as specified in Division 31 Section "Earth Moving."

3.10 After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."

3.11 Retain one of two subparagraphs below to specify type of stub-ups for direct-buried conduits in Project.

3.12 Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.

3.13 Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

3.14 Retain first two subparagraphs below with either subparagraph above.

3.15 Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.

3.16 For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.



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- 3.17 Warning Tape: Install continuous underground plastic line marker located directly above line at 6 to 8 inches below finished grade. Where width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches overall, use a single line marker.
- 3.18 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES
- 3.19 Retain this article if Project includes small amounts of exterior underground wiring 600 V and less. Delete if Division 26 Section "Underground Ducts and Raceways for Electrical Systems" is included in the Project Manual. See Editing Instruction No. 3 in the Evaluations.
- 3.20 Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- 3.21 Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- 3.22 Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- 3.23 Install handholes with bottom below frost line, below grade.
- 3.24 Delete paragraph below if conduits enter enclosure through open bottom.
- 3.25 Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- 3.26 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS
- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
 - B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
 - C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - D. Rectangular Sleeve Minimum Metal Thickness:
 - 1. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.



2. For sleeve cross-section rectangle perimeter equal to or greater than 50 inches and 1 or more sides equal to or greater than 16 inches thickness shall be 0.138 inch.
- E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- F. Cut sleeves to length for mounting flush with both surfaces of walls.
- G. Extend sleeves installed in floors 2 inches above finished floor level.
- H. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
- I. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- J. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.27 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.28 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.29 CLEANING

- A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.

END OF SECTION 26 0533



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 0536 – CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes cable trays and accessories.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 7 Section "Firestopping."
 - 2. Division 26 Section "Hangers and Supports For Electrical Systems" for cable tray supports not specified in this Section.

1.3 Submittals

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for each product specified. Provide manufacturers catalog cuts for each type of tray provided, including dimensions and, finish.
- C. Shop Drawings: For each type of cable tray.



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1. Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
- D. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements. Show the following:
 1. Vertical and horizontal offsets and transitions.
 2. Clearances for access above and to side of cable trays.
 3. Vertical elevation of cable trays above the floor or bottom of ceiling structure
- E. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include list of completed projects with project names, addresses, names of Architects and Owners, and other information specified.
- F. Factory certified test reports of specified products, conforming to NEMA VE 1.
- G. Field test reports indicating and interpreting test results relative to compliance with performance requirements specified in "Field Quality Control" Article of this Section.
- H. Maintenance data for cable tray, for inclusion in "Operating and Maintenance Manual" specified in Division 1. Include detailed manufacturer's instructions on tightening connections.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Select a firm experienced in manufacturing cable trays similar to those indicated for this Project and which has a record of successful in-service performance
- B. Comply with NFPA 70 "National Electrical Code" for devices and installation.
- C. Listing and Labeling: Provide products that are listed and labeled for their applications and installation conditions and for the environments in which installed.
 1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.
- D. Single-Source Responsibility: All cable tray components shall be the product of a single manufacturer.



1.5 Sequencing and scheduling

- A. Coordination: Coordinate layout and installation of cable tray with other installations.
 - 1. Revise locations and elevations from those indicated as required to suit field conditions and as approved by the Architect.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store indoors to prevent water or other foreign materials from staining or adhering to cable tray. Unpack and dry wet materials before storage.

PART 2 - PRODUCTS

2.1 Manufacturers

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
 - 1. Ceiling Mounted
 - a. B-Line Systems, Inc.
 - b. Mono-Systems, Inc.
 - c. Thomas & Betts
 - 2. Wall Mounted
 - a. B-Line Systems, Inc.
 - b. Mono-Systems, Inc.
 - c. Thomas & Betts

2.2 MATERIALS AND FINISHES



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- A. Cable Trays, Fittings, and Accessories: Aluminum, complying with NEMA VE 1, Aluminum Association's Alloy 6063-T6 for rails, rungs, and cable trays, and Alloy 5052-H32 or Alloy 6061-T6 for fabricated parts.
- B. Ladder Cable Tray – Type CT-1
 - 1. Provide tray with side rails and rungs, tested and manufactured per NEMA VE 1. Provide rungs which do not protrude below bottom edge of side rails.
 - 2. Provide side rails, rungs, splice plates and splice bolts which are smooth and free from rough edges or burrs which might damage cable insulation during installation.
 - 3. Provide side rail configuration for elbows, risers, tees, and related items which matches side rails for straight tray sections.
 - 4. Provide curve and bend fittings with a minimum radius of 600 mm (24 inches). Provide a 75-mm (three-inch), rigid and square, extension fitting at each end of a curve or bend tray section, and at each tray termination point, unless otherwise noted.
 - 5. Provide fittings with 3-inch tangent on the ends for a straight connection point to straight tray sections.
 - 6. Provide cable tray dimensions of width as indicated and load depth of 100 mm (4 inches).
 - 7. Provide rungs with a minimum flat, cable-supporting surface of 16 mm (5/8 inch), not including a 3- mm (1/8-inch) minimum edge radius. Provide maximum rung spacing of 150 mm (6 inches) on center for straight lengths and 225 mm (9 inches) on center for fittings. Provide rung configuration which is the same for the full inside width of the tray or fittings.
 - 8. Provide ladder cable tray per NEMA VE 1 and constructed of aluminum 6063, natural finish.
 - 9. Provide cable tray capable of carrying a minimum, uniformly distributed, allowable working load of 112 kg/m (75 lb/ft) with a safety factor of 2.0, when supported as a simple beam span and tested per NEMA VE 1.
 - 10. Provide cable tray capable of supporting a minimum of 90 kg (200 pounds) of concentrated load at mid-point of span in addition to allowable working load without permanent distortion to the cable tray.
 - 11. Limit cable tray deflection to not more than 1/75 of the clear span length between supports.
 - 12. Provide rungs capable of supporting 90 kg (200 pounds).
- C. Fabricate cable tray products with rounded edges and smooth surfaces.
- D. Cable Tray shall meet the loading requirements of NEMA 12C.

2.3 SIZES AND CONFIGURATIONS

- A. Conform to NEMA VE 1.
- B. Ceiling Mounted Type Trays.
 - 1. Width: As indicated on the drawings.
 - 2. Inside Depth: 4 inches (102 mm).



3. Cross-Rung Spacing: 6 inches [152 mm) o.c.
4. Minimum Fitting Radius: As shown of the drawings.

C. Wall Mounted Type Trays.

1. Width: As indicated on the drawings.
2. Inside Depth: 4 inches (102 mm).
3. Cross-Rung Spacing: 4 inches C 102mm).
4. Minimum Fitting Radius: As shown on the drawings.
5. Multi-Tier where indicated on the drawings.

2.4 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, manufactured with the same materials and finishes as the cable trays.
- B. Cable tray supports and 'connectors, including bonding jumpers, as recommended by Cable tray manufacturer.

2.5 SOURCE QUALITY CONTROL

- A. Perform design and production tests according to NEMA VE 1.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces to receive cable tray for compliance with installation tolerances and other required conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 WIRING METHODS



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- A. Use cable tray of indicated types and sizes, complete with manufacturer's recommended covers, barrier strips, dropouts, fittings, conduit adapters, hold-down devices, grommets, and blind ends.

3.3 CABLE TRAY INSTALLATION

- A. Remove burrs and sharp edges of cable trays.
- B. Fasten cable tray supports securely to the building structure as specified in Division 26 Section "Hanger and Supports for Electrical Systems" unless otherwise indicated.
 - 1. Locate and install supports according to recommendations of NEMA VE 1.
 - 2. Design supports, including fastenings to the structure, to carry the greater of the calculated load multiplied by a safety factor of 4. or the calculated load plus 200 lbs (90 kg).
 - 3. Place supports so that spans do not exceed maximum spans on schedules.
 - 4. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
 - 5. Support bus assembly to prevent twisting from eccentric loading.
 - 6. Manufacture center-hung support, designed for 60 percent versus 40 percent eccentric loading condition, with a safety factor of 3.
- C. Make connections to equipment with flanged fittings fastened to the tray and to the equipment. Support the tray independently of fittings. Do not carry the weight of the tray on the equipment enclosure.
- D. Install expansion connectors in cable tray where specified by NEMA VE 1. Space connectors and set gaps according to NEMA VE 1.
- E. Make changes in direction and elevation using standard fittings.
- F. Make cable tray connections using standard fittings.
- G. Firestop penetrations through fire and smoke barriers according to Division 7 Section "Firestopping."
- H. Seal penetrations through fire and smoke barriers according to Division 7.



- I. Workspace: Install cable trays with minimum 6 inches of clear space above and to each side to permit access to installing cables.
- J. Support cable tray independently of other systems and do not use cable tray or its supports for supporting other systems.
- K. Balance cable load for center spline supported cable tray evenly on each side to prevent twisting of tray.
- L. Provide miscellaneous U-channel to support wall rail cable tray when not mounted to wall.

3.4 GROUNDING

- A. Connect cable trays to ground as instructed by manufacturer.
- B. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A.

3.5 FIELD QUALITY CONTROL

- A. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements. Perform the following field quality-control survey:
 - 1. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.



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2. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.
 3. Remove deposits of dust, industrial process materials, trash of any description, and any blockage of tray ventilation.
 4. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
 5. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
 6. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable tray.
- B. Grounding: Test cable trays to ensure electrical continuity of bonding and grounding connections.
- C. Replace damaged or defective components.
- D. Report results in writing.

3.6 CLEANING

- A. Upon completion of installation of system, including fittings, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes, including chips, scratches, and abrasions.

3.7 PROTECTION

- A. Provide final protection and maintain conditions in a manner acceptable to manufacturer and Installer to ensure that the cable tray is without damage or deterioration at Substantial Completion.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by the tray manufacturer.
 2. Repair damage to PVC or paint finishes with matching touch-up coating recommended by the tray manufacturer.
 3. Install temporary protection for cables in open trays to protect exposed cables from falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials until the risk of damage is over.



END OF SECTION 26 0536



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 0539 – UNDERFLOOR RACEWAYS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

1. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
2. Requirements of the following Division 26 Sections apply to this section:
 - a. "Basic Electrical Requirements."
 - b. "Basic Electrical Materials and Methods."

1.2 SUMMARY

- A. This section includes underfloor duct systems, including the following:
 1. Underfloor ducts, junction boxes, and fittings.
 2. Trench header ducts and fittings.

1.3 DEFINITIONS

- A. Trench Duct: A duct installed with its top flush with the floor and equipped with removable covers, and its bottom connecting with distribution ducts or floor cells, arranged to provide paths for wiring from sources to the distribution ducts or cells.

1.4 SYSTEM DESCRIPTION



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- A. The underfloor duct system for this project is a single compartment system using individual, rectangular cross section, steel ducts for casting in concrete. Trench ducts are equipped with relocatable 1/4" coverplates, aluminum trim, and 3/4" pre-pour height adjustment.

1.5 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:

- 1. Product data for underfloor duct, including components, fittings, and accessories

1.6 QUALITY ASSURANCE

- A. UL Compliance: Underfloor duct systems and components shall be UL listed and labeled.
- B. National Electrical Code Compliance: Components and installation shall comply with NFPA 70.
- C. Single-Source Responsibility: All floor electrification components shall be the product of a single manufacturer.
- D. Coordination of the Work: Coordinate layout and installation of underfloor wiring products with structural work including slab reinforcing and with floor finish work. Coordinate height of trench ducts with depth of concrete slab and floor fill. Arrange for thickening of slabs where required for adequate encasement of system components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
 - 1. Underfloor Duct:
 - a. Wiremold (Walker Div.)



2.2 TRENCH DUCT

- A. Trench Duct: Constructed of welded, 16-gage steel with corrosion resistant finish applied after fabrication. Types and sizes as indicated, with coupling, including grounding screws, supports, hold downs, adapters, end-caps, and fittings to form complete installation. Include the following features:
1. Adjustable to configuration of slab with minimum adjustment of minus 1/8-inch to plus 5/8-inch before and during concrete placement. Provide leveling screws that rigidly support cover assembly and screed strips at proper elevation without addition of extra shim material.
 2. Cover Plate: Removable steel plates 1/4-inch thick with full gasket and weighing 60 pounds or less. Securely adhere gasket to trench header side adjustable units. Provide support for cover to limit unsupported spans to 15 inches or less.
 3. Screed Strip: Extruded aluminum, along both edges.
 4. Trim Strip: Aluminum trim.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install underfloor duct systems as indicated.
- B. Duct Supports: Adjust to maintain elevation of ducts so coverplate is flush with the finished floor. Install supports secure at ends and at intervals not to exceed 5-feet so they maintain proper elevation and alignment of ducts securely in slab or form.
- C. Seals: Seal trenches to prevent entrance of water, concrete, or foreign matter into raceway system, before and during pouring of slab or placing of fill. Provide tape or sealing compound at joints, as recommended by duct manufacturer.

3.2 GROUNDING

- A. Electrically ground underfloor duct system components and ensure continuous electrical conductivity of system.

3.3 FIELD TESTING



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- A. Grounding: Test underfloor raceway system to ensure electrical continuity of bonding and grounding connections.

3.4 CLEANING AND FINISH REPAIR

- A. Upon completion of installation of system, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, and abrasions.

END OF SECTION 26 0539



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 0543 – UNDERGROUND DUCTS AND UTILITY STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Conduit, ducts, and duct accessories for concrete-encased duct banks.
 - 2. Direct-buried conduct, ducts and duct accessories.
 - 3. Handholes and boxes.
 - 4. Manholes.

1.3 DEFINITION

- A. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Duct-bank materials, including separators and miscellaneous components.
 - 2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
 - 3. Accessories for manholes, handholes and boxes.
 - 4. Warning tape.



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- B. Shop Drawings for Factory-Fabricated Manholes, Handholes and Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
 - 1. Duct entry provisions, including locations and duct sizes.
 - 2. Support rings.
 - 3. Grounding details.
 - 4. Layout Drawings: For manholes, vaults, handholes, underground conduits and duct bank. Plans shall be to scale and identify invert elevations where conduits enter handholes and buildings.
- C. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
 - 1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
 - 2. Drawings shall be signed and sealed by a qualified professional engineer.
- D. A post construction survey will be required to create actual as-built conditions including duct bank routing and elevations of duct bank and manholes before backfill.
- E. Source quality-control test reports.
- F. Field quality-control test reports.
 - 1. Photos of finished install in vaults including all sides, grounding, supports, and ladder.

1.5 QUALITY ASSURANCE

- A. Comply with ANSI C2.
- B. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
- B. Store other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.
- C. Lift and support precast concrete units only at designated lifting or supporting points.



1.7 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Construction Manager no fewer than two weeks in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

1.8 COORDINATION

- A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.
- B. Coordinate elevations of ducts and duct-bank entrances into, manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Engineer.

PART 2 - PRODUCTS

2.1 CONDUIT

- A. Rigid Non-metallic (RNC): NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AFC Cable Systems, Inc.
 - b. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - c. CANTEX Inc.
 - d. RACO; a Hubbell Company.
 - e. Thomas & Betts Corporation.
 - f. Carlon

2.2 ELECTRICAL/TELECOMMUNICATIONS MANHOLES

- A. Manufacturers
 - 1. Advance Concrete Products Co.



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2. Hartford concrete products Inc.
3. Or as approved.

B. Manholes

1. Manholes shall be either reinforced precast concrete or cast-in-place concrete.
2. Manhole walls, base and roof shall all have a minimum thickness of 6".
 - a. Reinforcement will be Grade 60 rebar conforming to ASTM A706
 - b. Rebar cage shall be designed to meet AASHTO HS-20 loading conditions.
3. Reinforced precast concrete manholes shall be in accordance with the standard manhole details as shown. Concrete shall be mixed to produce a 28-day minimum compressive strength of 4500 psi. Manholes shall be transported in such a manner so as to prevent cracking, chipping, or other damage. Manholes shall be installed under the manufacturer's supervision or by installers having a minimum of five years of experience installing this manufacturer's manholes. They shall be assembled in accordance with manufacturer's recommendations.
4. Reinforced precast concrete manholes shall have integral floor-to-wall construction and integral roof-to-wall construction. The two-piece precast concrete manholes joints shall be sealed with two rows of 1" butyl rope mastic per manufacturer's instructions.
5. Cast-in-place manholes shall be constructed in accordance with the standard manhole detail as shown. Concrete shall be ready-mixed conforming to the standard specifications for ready-mixed concrete ASTM C-94 and mixed to produce a 28-day minimum compressive strength of 3000 psi.
6. Manhole interior dimensions shall be indicated on the drawings. Openings for duct shall be beveled.
7. Manholes shall have a minimum 30" diameter clear opening.
 - a. Manhole covers shall be heavy duty type with machined bearing surfaces and shall be lettered with words "ELECTRIC"/"TELECOMMUNICATIONS".
 - b. Ring and cover shall be Neenah or East Jordan Iron Works heavy-duty cast-iron frame and cover, with WMU seal. (Refer to drawings for detail.)
 - c. Provide two hatches.
8. Manhole ring will set on two courses of brick or equivalent in precast concrete rings to allow for future grade adjustments.
9. Covers on electric manholes will be secured by the Owner, only as required.
10. Beveled duct terminators shall be cast in the walls for conduit. Knockout windows or clear windows shall be provided as specified or shown on drawings for future conduit.

C. Cable Racks

1. Cable racks shall be installed in all manholes to properly support cables.
2. 1/2 inch threaded inserts shall be cast-in walls for cable rack connections with a horizontal spacing no greater than 24 inches on-center.
3. Provide porcelain cable supports or nonmetallic supports.
4. Concrete inserts for cable rack bolts will be hot-dipped galvanized.
5. In existing manholes plated steel expansion shield equal to "Phillips," or "A & J" may be used in lieu of inserts.



6. Manhole hardware shall be stainless steel manufactured by Inwesco or approved equal. Cable racks shall #10A22, corner brackets shall be #10A50, sidewall brackets shall be #10A37 (10 inch long).

D. Pull-in Irons

1. Each wall of each manhole will have at least one 1" hot-dipped galvanized pull-in iron.
 - a. A pull-in irons shall be installed directly across from each set of duct bank terminators, and new and future duct bank openings.
 - b. Pull-in irons will be by Advance Concrete or approved equal.

E. Ground Rods

1. All electric manholes shall have two (2) 5/8" x 10'0" copper-clad steel ground rods driven in diagonally opposite corners of the manhole exterior. A #4/0 hard drawn bare ground cable shall connect each ground rod together.

F. Waterproofing

1. All cast-in-place manholes will be waterproofed with a modified asphalt membrane waterproofing or Bituthene waterproofing.
 - a. Acceptable Products and Manufacturers: Bituthene by Grace Construction Products Division, Polyguard No. 650 by Polyguard Products, Inc.
2. All precast manholes shall be waterproofed with factory applied exterior damp-proofing on the top, bottom, and all four sides.
3. All cast-in-place and precast manholes shall have fanhold DOW Protection Board III applied over the waterproofing to protect the waterproof membrane during backfill.
4. All joints where the duct enters manholes shall have Durajoint PVC, Type 4 waterstop or equal. Waterstop shall be continuous, all joints shall be welded together as recommended by the manufacturer.

G. Ladder

1. Provide a 3I-3600 series 8 foot (or as required for safe access) hooked ladder for each manhole.

H. Sump

1. Locate near center of hatch.
2. Slope floor to sump.

2.3 ELECTRICAL DUCT BANK

A. Duct Banks

1. All underground duct banks, including conduit, couplings, bends, and bells, and any special fillings shall have plastic duct.



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2. Plastic duct and fittings shall be corrosion-resistant and not adversely affected by acids, alkalis, salts or organic matter. Fittings shall be of a type especially made for use with plastic duct for electrical service. All plastic conduit and fittings shall be joined by a solvent welding cement.
3. Duct end bells shall have a minimum opening diameter of 5".
4. All joints in the ducts will be made water tight.
5. Factory bends and sharp sweeps in new duct banks shall not be allowed; unless specifically noted otherwise. If factory bends are installed, the minimum bend radius shall be 60".
6. Tracer Wire: Tracer wire shall be installed to enable the detection of plastic pipes, fiber optics, and non-conducting utilities. Tracer wire shall be 12 AWG (min.), THWN or RHW conductor embedded in the concrete envelope.

2.4 DUCT ACCESSORIES

A. Manufacturers

1. Underground Devices, Inc Wunpeece

B. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.

2.5 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE, of TELECOMMUNICATIONS as appropriate.

2.6 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Description: Comply with SCTE 77.

1. Color: Gray.



2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure. Tier 8
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering, "ELECTRIC," "EMERGENCY," "CONTROLS," or "TELECOMMUNICATIONS" as appropriate.
 6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
 7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 8. Handholes 18 inches wide by 30 inches long (450 mm wide by 750 mm long).
 9. Bottom shall have 2" minimum of pea stone and adequate drainage.
 10. Do not install where subject to vehicle traffic.
- B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. CDR Systems Corporation.
 - d. NewBasis.
 - e. Quazite.

PART 3 - EXECUTION

3.1 GENERAL

- A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.
- B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.



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- C. The Contractor shall locate existing utilities and confirm elevations prior to construction, as determined necessary by the Engineer to insure the continued service of these utilities. When locating such utilities, the Contractor shall proceed with caution, using hand instead of machine excavation.
- D. Where exterior building walls are cored for conduit penetrations, follow the waterproofing guidelines described in this specification for manholes. Mechanical seals shall be installed as to allow future tightening or replacement of devices. Seals shall be sized, selected, and installed in accordance with Manufacturer's recommendations.

3.2 UNDERGROUND DUCT AND RACEWAY APPLICATION

- A. Electrical Cables Over 600 V: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank, unless otherwise indicated.
- B. Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80-PVC, in direct-buried duct bank, unless otherwise indicated.
- C. Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, direct-buried duct bank unless otherwise indicated.
- D. Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank, unless otherwise indicated.
- E. Telephone, Communications, or Data Circuits: RNC, NEMA Type EPC-80-PVC, in direct-buried, duct bank unless otherwise indicated.
- F. Underground Duct Banks Crossing Under Walks, Driveways, Roadways: Rigid steel conduit, extending 10 feet (3 meters) beyond walks, driveways and roadways and encased in reinforced concrete.

3.3 ELECTRICAL MANHOLES

- A. General
 - 1. Whenever a contractor has work to perform in an existing manhole and it is partially or entirely filled with water, it shall be the Contractor's responsibility to pump it out at his expense.
 - a. Water must be pumped to sanitary sewer.
 - 2. The Contractor shall be responsible for the removal and proper disposal of any and all asbestos fire proofing tape on any cables in existing electrical manholes involved in this



project. The asbestos removal shall take place prior to performing any work in the manholes.

B. Waterproofing

1. Manhole waterproofing membrane will cover the cove, the top, and sides, down to 8" below the joint between the wall and floor. Membrane will be flashed tight to conduits and reinforcing dowels at duct entrance.
2. Membrane waterproofing shall be installed in the following manner:
 - a. All surfaces shall be primed with a manufacturers approved primer. Roll on membrane overlapped 2-1/2" min. at seams with primer. Apply elastomeric mastic to all seams and edges.
 - b. At all corners, cracks, and construction joints, two layers of membrane shall be applied.
3. All construction joints will have cast-in waterstops.
4. Waterproofing must be completed at the factory. All joints, grade rings and conduit penetrations will be completed on site by the contractor.
5. Install protection board on all four sides, top and bottom before backfilling.
6. Any membrane damaged during shipping or installation will be repaired by the contractor.

C. Drainage

1. Foundation tile will be 4" corrugated polyethylene with drainage slits, ADS, Inc. or equal. Drain pipe from any extra floor drains and from sump to catch basins, shall be as indicated on the Civil Plans and Specifications. (See Section 33 4000 Storm Drainage).
2. Electric/communication manholes shall be provided with floor drains as shown. Manholes and drains shall be provided with Smith no. 2515-S floor drain to be furnished with cleanout, connected to ductile iron pipe when under manhole floor, then connected to storm piping as indicated on the Civil plans when outside of manhole perimeter. Use 4 inch to 6 inch adapter between floor drain and drain pipe. Lay drain pipe to sewer as indicated on the Civil plans and profiles and install in accordance with Section 33 4000 Storm Drainage.

3.4 ELECTRICAL DUCT BANK

A. General

1. Primary distribution will be run in plastic duct with reinforced concrete encasement. Size, location, and elevation will be shown on drawings. The duct bank will be pitched to drain any seepage to a manhole. Duct banks entering buildings will pitch away from the building. Slope will not be less than 4 in./100 ft. of duct. Grade shots will be taken at least every 25 ft. to assure uniform pitch.
2. Duct banks shall have no pull boxes or short radius bends. Long radius sweeps are allowed as shown on the drawings. Any change in direction (greater than 75°) should take place at a manhole, for electric and communications.
3. Duct banks shall be marked with a marker tape buried in the trench above the duct.



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B. Duct Bank Encasement

1. Lay concrete blocks at 4 ft. on center to establish grade and tie ducts to blocks to make secure. Plastic separators shall be used to maintain space between ducts, 3 inches between electric ducts. Install separators approximately five feet on center. Install plastic separator on top of each row of the highest level of conduits.
2. In lieu of the blocks a 3 inch concrete pad may be poured and leveled to the grade established, with the wires inserted every four feet to secure ducts.
3. A concrete envelope of 3000 PSI test, using 6-AA limestone, shall be poured around ducts with low enough slump to be worked into all openings. When concrete is poured, some method of deflecting the concrete shall be employed to minimize force on the ducts.
4. The concrete shall cover the fiber or plastic duct a minimum of 3 inches on both sides and top, except as follows:
 - a. Under roadways, the concrete shall cover the ducts a minimum of 6 inches on top and the duct bank shall be reinforced with two 5/8 inch steel rods laid parallel to and below the duct.
 - b. Where duct enters manholes or buildings, or where duct is to cross new utilities installed, or indicated as proposed, or where duct is to be installed in fresh fill, the duct shall have minimum of 4 inches of concrete top and bottom and shall be reinforced with four 5/8 inch steel bars laid parallel to the duct. Two reinforcing steel rods shall be laid in the concrete envelope below the duct and two above, each with one end resting on the building or manhole wall and the other extending back to undisturbed soil. Where a duct bank crosses a steam line, there shall be a minimum of 6 inches of sand fill between the outside of the concrete envelope and the insulation around the steam line.
 - 1) The steel bars shall be extended into the manhole or building wall. Epoxy shall be applied at all steel bar penetrations.
5. There shall be a minimum separation of 12 inches between the concrete envelope of the duct bank and any existing or new gas main or line.
6. The concrete envelope of the duct bank shall not come in contact with any water or sewer line.
7. The minimum distance between the top of the concrete envelope of the duct bank and final grade shall be 30 inches, unless otherwise specified or special permission is obtained from the Owner.
8. Excessive amounts of concrete shall not be poured around duct. Concrete covering the top and sides of the duct shall not exceed 6", unless special permission is obtained from the Owner.
9. Pour the concrete in several lifts and vibrate the concrete between lifts to remove air pockets.
10. All new duct bank conduits shall be tested by pulling a nominal 4" mandrel through each 4" duct.

C. Pull String

1. Install a heavy-duty nylon pull string in each conduit in the duct bank that is not receiving new cable on this project.

D. Utility Marker Tape



1. Underground duct banks shall be marked with a plastic identifying tape buried in the trench directly above the duct bank of 8 to 12 inches below finished grade. The tape will be vivid opaque red in color with "Caution Electric Line Buried Below" or "Telecommunications" continuously printed in black letters over the entire length of the tape. The tape will also be magnetic. Tape will be as manufactured by Allen Systems, Inc. or Terra Tape.
2. If the duct bank is 18 inches or less in width the tape shall be 3 inches wide. If the duct bank is over 18 inches in width the tape shall be 6 inches wide.

E. Tracer Wire

1. All new duct banks shall be installed with tracer wire. The tracer wire shall be installed continuously along the new duct banks with access points at each manhole. The tracer wire shall be accessible at the ground surface without entering the manhole. Splices in the tracer wire shall be connected by means of a split bolt or compression type connector to ensure continuity. Wire nuts shall not be used. A waterproof or corrosion-proof connector for direct bury applications shall be used. After installation, the tracer wire shall be tested to verify continuity of the tracer wire system and a report indicating continuity shall be submitted to the Owner as part of the construction record documents.

F. Grounding Cable

1. The Contractor shall furnish and install two new 4/0 hard drawn, stranded copper cable in the entire concrete envelope of all new electric duct banks. All joints in the grounding cable shall be brazed or cadwelded.
2. In manholes, neatly clamp cable to the walls.
3. All ground cables shall be connected by exothermic weld or Burndy Hyground.

3.5 DIRECT-BURIED DUCT BANKS

- A. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than 6 inches (150 mm) in nominal diameter.
- B. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
- C. Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
- D. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts



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to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with Division 31 Section "Earth Moving" for installation of backfill materials.

1. Place minimum 3 inches (75 mm) of sand as a bed for duct bank. Place sand to a minimum of 6 inches (150 mm) above top level of duct bank.
- E. Install ducts with a minimum 3 inches (75 mm) of sand as a bed for duct bank. Place sand to a minimum of 6 inches (150 mm) above top level of duct bank.
- F. Depth: Install top of duct bank at least 36 inches below finished grade, unless otherwise indicated.
- G. Set elevation of bottom of duct bank below the frost line.
- H. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
1. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches of concrete.
 2. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

3.6 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for 600 V and Less, including Telephone, Communications, and Data Wiring:
1. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer concrete units, SCTE 77, Tier 8 structural load rating.

3.7 EARTHWORK

- A. Excavation and Backfill: Comply with Division 31, but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restore surface features at areas distributed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- C. Restored areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32.



- D. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 1.

3.8 DUCT INSTALLATION

- A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment.
- B. Curves and Bends: Minimum bend radius shall be 60 inches.
- C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- D. Duct Entrances to Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 8 inches (200 mm) o.c. for 4-inch (100-mm) ducts.
- E. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.
- F. Pulling Cord: Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.
- G. Floor Penetration: Use manufactured 60 inch rigid conduit sweeps for stub-up through floor.
 - 1. Stub sweeps for stub-up through floor.
 - a. Stub conduit 12 inches above finish floor.

3.9 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

- A. Cast-In-Place Manhole Installation:
 - 1. Finish interior surfaces with a smooth-troweled finish.
 - 2. Windows for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches (38 to 50 mm) thick, arranged as indicated.
 - 3. Cast-in-place concrete, formwork, and reinforcement are specified in Division 03.
- B. Precast Concrete Handhole and Manhole Installation:
 - 1. Comply with ASTM C 891, unless otherwise indicated.
 - 2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
 - 3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded with 1- inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.



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- D. Manhole Access: Circular opening in manhole roof; sized to match cover size.
 - 1. Manholes with Fixed Ladders: offset access opening from manhole centerlines to align with ladder.
 - 2. Install chimney, constructed of precast concrete collars and rings to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.
 - 3. Provide two openings – second for ventilation.
- E. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.
- F. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
- G. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (98 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.
- H. Warning Sign: Install “Confined Space Hazard” warning sign on the inside surface of each manhole cover.

3.10 INSTALLATION OF HANDHOLES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.7-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
- D. Install handholes and boxes with bottom below the frost line, below grade.
- E. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.11 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.



- B. Grounding Manholes and Handholes: Install a driven ground rod close to exterior manhole wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. Install ground rod before manhole is placed and provide No. 4/0 AWG hard drawn bare, tinned-copper conductor from ground rod into manhole through the concrete duct bank.
 - 1. Connect #4/0 ground cables from ground rods to ground cables with duct bank.
 - 2. All connection shall be exothermic weld method or Burndy Hyground.
- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

3.12 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
 - 2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
 - 3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections.
 - 4. Correct deficiencies and retest as specified above to demonstrate compliance.

3.13 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump. Remove foreign material.

3.14 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.



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2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
- B. Grounding system will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.
- D. Report measured ground resistances that exceed the following values:
1. Manhole Grounds: 10 ohms.
- E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 0543



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.2 ACTION SUBMITTALS

- A. Product Data: For each electrical identification product indicated.

1.3 QUALITY ASSURANCE

- A. Comply with ANSI A13.1.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.4 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.



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- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady USA Inc.; Industrial Products Div.
 - 2. Ideal Industries, Inc.
 - 3. Panduit Corp.
 - 4. 3M Company

2.2 RACEWAY AND CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at 600V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage.
- C. Colors for Raceways Carrying Circuits over 600V:
 - 1. Orange letters on a black field.
 - 2. Legend: Indicate voltage.
- D. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- E. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- F. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place with gripping action.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.



- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

- A. Conductors to have continuous color insulation per the identification schedule for THHN and others when available from the manufacturer.
- B. Medium Voltage cables to be identified with 3" of color marking tape at all accessible locations.

2.5 NAMEPLATES AND SIGNS

- A. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.
 - 1. Engraved legend with black letters on white face.
 - 2. Punched or drilled for mechanical fasteners.
- B. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 1/4-inch grommets in corners for mounting.
- C. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for the application. 1/4-inch grommets in corners for mounting.
- D. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.
- E. Do not use adhesive tape as sole means of nameplate attachment.
- F. Miscellaneous Identification Products
 - 1. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties with the following features:
 - a. Minimum Width: 3/16 inch
 - b. Tensile Strength: 50 pounds minimum.
 - c. Temperature Range: Minus 40 to 185 deg F.
 - d. Color: As indicated where used for color coding.
 - 2. Paint: Alkyd-urethane enamel over primer as recommended by enamel manufacturer.



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2.6 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
4. Not less than 6 inches wide by 4 mils thick.
5. Compounded for permanent direct-burial service.
6. Embedded continuous metallic strip or core.
7. Printed legend indicating type of underground line.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.



- 2.7 Common trenching and tape laying methods are hand, static plow, and vibratory plow. Revise options in this article if only specific trenching methods are allowed.
- 2.8 Tape:
- 2.9 Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
- 2.10 Printing on tape shall be permanent and shall not be damaged by burial operations.
- 2.11 Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
- 2.12 Not less than 6 inches wide by 4 mils thick.
- 2.13 Compounded for permanent direct-burial service.
- 2.14 Embedded continuous metallic strip or core.
- 2.15 Printed legend indicating type of underground line.
- 2.16 Color and Printing:
- 2.17 Comply with ANSI Z535.1 through ANSI Z535.5.
- 2.18 Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
- 2.19 Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.
- 2.20 WARNING LABELS AND SIGNS
 - A. Comply with NFPA 70 and 29 CFR 1910.145.
 - B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.



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C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 7 by 10 inches .

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 10 by 14 inches .

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR ## INCHES ." (Replace ## with "36" or "42" based on equipment voltage and NEC code required clearances in inches).
3. Arc Flash Notification Label in accordance with ANSI Standard Z535.4. Refer to section 26 0574 – OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY.

2.21 EQUIPMENT IDENTIFICATION LABELS

- A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch . Overlay shall provide a weatherproof and UV-resistant seal for label.
- B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a black background. Minimum letter height shall be 3/8 inch.
- C. Stenciled Legend: In non-fading, waterproof, black ink or paint. Minimum letter height shall be 1 inch .
- D. Required emergency equipment labels shall be white with red letters.
- E. Optional standby equipment labels shall be red with black letters.
- F. Fire alarm system equipment labels shall be red with white letters.
- G. Access control system equipment labels shall be green with white letters.
- H. Telecommunication system equipment labels shall be yellow with black letters.
- I. Equipment associated with uninterruptable power supply labels shall be brown with white letters.



2.22 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.
- C. Wiring device identification: Self-adhesive label with black upper-case letters on clear polyester label, font size 7.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Apply identification devices to surfaces that require finish after completing finish work.
- C. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- D. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- E. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.
- F. Circuits with More Than 600 V: Identify raceway and cable with "DANGER--HIGH VOLTAGE" in black letters 2 inches high, stenciled with paint at 10-foot intervals over a continuous, painted orange background. Identify the following:
 - 1. Entire floor area directly above conduits running beneath and within 12 inches of a basement or ground floor that is in contact with earth or is framed above unexcavated space.
 - 2. Wall surfaces directly external to conduits concealed within wall.
 - 3. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in the building, or concealed above suspended ceilings.
 - 4. Entire surface of exposed conduits.
 - 5. Primary Cable Identification: Locate at each termination and in each vault.
- G. Accessible raceways and Metal Clad Cables with circuits less than 600V, for Service and Feeders More than 400A, Identify with orange self-adhesive vinyl label.
- H. Branch Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use marker tape. Identify each ungrounded conductor according to source and circuit number as indicated on Drawings. Identify control circuits by control wire number as indicated on shop drawings.



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- I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
 - 1. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory installed connections.
 - 2. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.

- J. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
 - 1. Indoor Equipment: Engraved, laminated acrylic or melamine label mechanically secured.
 - 2. Outdoor Equipment: Stenciled.
 - 3. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from floor.
 - 4. Voice and data cable terminal equipment.
 - 5. Intercommunication and call system master and staff stations.
 - 6. Television/audio components, racks, and controls.
 - 7. Fire-alarm control panel and annunciators.
 - 8. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
 - 9. Monitoring and control equipment.
 - 10. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.
 - 11. Breakers or switches at distribution panels.
 - 12. Panelboards, electrical cabinets, and enclosures.
 - 13. Access doors and panels for concealed electrical items.
 - 14. Electrical switchgear and switchboards.
 - 15. Electrical substations.
 - 16. Emergency system boxes and enclosures.
 - 17. Motor-control centers.
 - 18. Variable Frequency Drives.
 - 19. Disconnect switches
 - 20. Enclosed circuit breakers.
 - 21. Motor starters.
 - 22. Push-button stations.
 - 23. Boiler shut-offs.
 - 24. Power transfer equipment.
 - 25. Contactors.
 - 26. Remote-controlled switches.
 - 27. Dimmers.
 - 28. Control devices.
 - 29. Transformers
 - 30. Power-generating units.
 - 31. Clock/program master equipment.

- K. Wiring Device Identification Labels: On each faceplate install circuit designation label that is consistent with panelboard directories, and as-built plan drawings. Apply labels to receptacle faceplates centered below bottom outlet. Apply labels to toggle switch faceplates on backside.

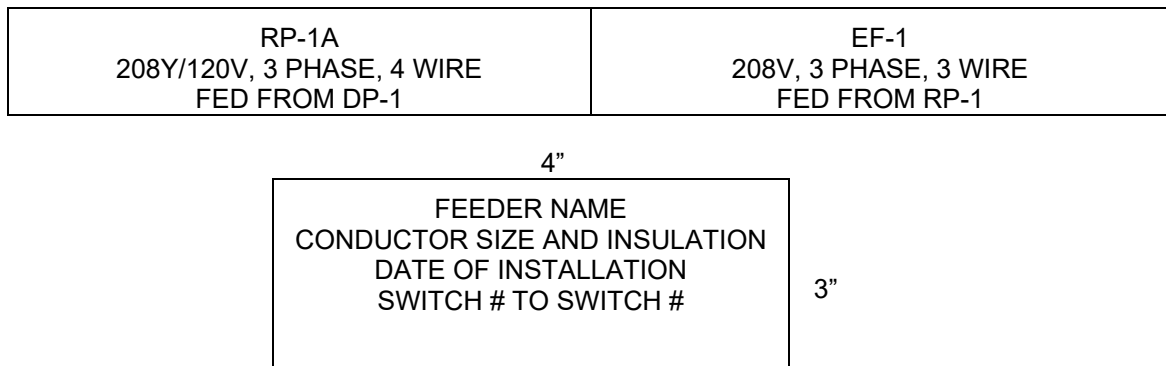


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L. Labels arrangement for labels with 3 lines of text

1. Line one shall have description of panel or equipment. Line one example: "DP-XX", "RP-XX", "T-XX", "EF-XX", etc.
2. Line two shall describe the voltage, phase and wires. Line two example: "208Y/120V, 3 phase, 4 wire".
3. Line three shall describe the first disconnecting means feeding this panel or equipment. Line three example: "FED FROM DP-XX", "FED FROM RP-XX", etc.

M. Label examples:



N. Install painted identification according to manufacturer's written instructions and as follows:

1. Clean surfaces of dust, loose material, and oily films before painting.
2. Prime surfaces using type of primer specified for surface.
3. Apply one intermediate and one finish coat of enamel.

O. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.

P. Circuit Identification on Device Plates.

1. Identify circuits feeding receptacles with the designation of the panelboard and the circuit number in permanent marker on the back of each device cover plate and inside box.
2. Identify on device plate for receptacles.

Q. Circuit Identification Labels on Boxes: Install labels externally.

1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
2. Concealed Boxes: Plasticized card-stock tags.
3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
4. Identify all circuits contained within a junction box.



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- R. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas. Bands shall be 6" width minimal.
- S. Underground-Line Warning Tape: During backfilling of trenches, install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
- T. Underground-Line Warning Tape: During backfilling of trenches, install continuous underground-line warning tape directly above line at 6 to 8 inches overall.

3.2 IDENTIFICATION SCHEDULE

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30A, and 120 V to ground: Install 12" wide labels at 20-foot maximum intervals and 5' from any box.
- B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels or by painting with the wiring system legend and system voltage. System legends shall be color coded as follows:
 - 1. General Power Systems: Black
 - 2. Emergency Power or life safety: Red.
 - 3. Fire Alarm: Red.
 - 4. UPS Power: Brown.
 - 5. Access Control/Security: Green.
 - 6. Telecommunications / BAS: Yellow.
- C. Color-Coding of Secondary Phase Conductors: Use the following colors for service feeder and branch-circuit phase conductors:
 - 1. 208/120-V Conductors:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White.
 - e. Ground: Green.
 - 2. 480/277-V Conductors:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - d. Neutral: Slate/Gray.
 - e. Ground: Green.



3. Factory apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire where continuous color is not available:
 - a. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 1-inch-wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.
 - b. Colored cable ties applied in groups of three ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length.
 4. Primary Power Circuit Identification: Use identification tags for cables, feeders, and power circuits in vaults, pull boxes, junction boxes, manholes, and switchboard rooms. The tags shall indicate:
 - a. Cable name or number.
 - b. Size of cable and single or three conductor.
 - c. Insulation class of cable (add GN if grounded neutral).
 - d. Primary cable identification shall be engraved laminate tags.
- D. Apply identification to conductors as follows:
1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.
 2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
 3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.
- E. Apply warning, caution, and instruction signs as follows:
1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
 2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch- high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.
 3. Arc Flash: Self Adhesive Film Label denoting Arc Flash warning and personal protection requirement meeting ANSI Z535.4.
- F. Fire Alarm System Conductor Identification: Refer to Specification Section 28 3100.
- G. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.



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2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.
- H. Distribution Equipment: For each of the following pieces of distribution equipment, provide label attached to enclosure cover. Label shall identify:
1. Disconnect Switches: Name of equipment served, number of poles, ampere rating/fuse size (where applicable), and load (example, "RTU-1, 3P30/25, 8 TON").
 2. Enclosed Circuit Breakers: Name of device as indicated on one line diagram, number of poles, and circuit breaker size (example, "MCB, 3P200").
 3. Switchboards:
 - a. Name of device as indicated on one line diagram and voltage-phase (example, "MSWBD, 480V/277V-3Ø").
 - b. Provide label near each feeder/branch breaker identifying name of equipment served, number of poles, and circuit breaker size (example, "EF-1, 3P20").
 4. Unit Substations
 - a. Incoming line section:
 - 1) Designation (e.g. "Primary Switch A-1")
 - 2) Incoming line designation (e.g. "Incoming line A102").
 - 3) Incoming line electrical characteristics (e.g., "13.8kW, 3PH, 3W")
 - b. Transformer Section:
 - 1) Designation (e.g. "Transformer TR-A1").
 - 2) Primary characteristics (e.g. "Primary: 13.8kV, 3PH, 3W").
 - 3) Secondary characteristics (e.g. "Secondary: 480Y/277V, 3PH, 4W").
 - 4) Power rating (e.g. "1500/2000 kVA AA/FA").
 - c. Secondary breakers:
 - 1) Designation (e.g. "Feeder Brkr. A-10").
 - 2) Load served (e.g. "Load served: PP-A2E").
 5. Panelboards:
 - a. Name of device as indicated on one-line diagram, voltage-phase, and area served (example, "LPA, 208Y/120V-3Ø, First Floor Lighting").
 - b. Equipment interior of enclosure door with a circuit directory frame, typewritten card, and clear plastic cover. Directory shall identify load description for each circuit, including spares. Hand lettering is not acceptable.
- I. Apply designation labels of engraved plastic laminate for disconnect switches, breakers, push buttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components where labeling is specified elsewhere. For panelboards, provide typed circuit schedules with explicit description



and identification of items controlled by each individual breaker. Provide editable file for each panel circuit index to owner.

- J. Provide electrical riser diagrams for lighting and power distribution and fire alarm system. Frame diagrams with lexan cover and mounted on the wall in the substation room. Prints shall be of the diffusion transfer process to eliminate fading.
- K. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- L. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer, load shedding and multiple services.
- M. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide a single line of text with 1/2-inch-(13-mm-) high lettering on 1-1/2-inch-(38-mm-) high label; where two lines of text are required, use labels 2 inches(50 mm) high. Apply labels for each unit of the following categories of equipment using mechanical fasteners:
 - 1. Panelboards, electrical cabinets, and enclosures.
 - 2. Access doors and panels for concealed electrical items.
 - 3. Electrical switchgear and switchboards
 - 4. Electrical substations.
 - 5. Emergency system boxes and enclosures.
 - 6. Motor-control centers.
 - 7. Variable Frequency Drives.
 - 8. Disconnect switches.
 - 9. Enclosed circuit breakers.
 - 10. Motor starters.
 - 11. Push-button stations.
 - 12. Boiler shut-offs.
 - 13. Power transfer equipment.
 - 14. Contactors.
 - 15. Remote-controlled switches.
 - 16. Dimmers.
 - 17. Control devices.
 - 18. Transformers.
 - 19. Power-generating units.
 - 20. Clock/program master equipment.
 - 21. Fire alarm control panel.
 - 22. Security-monitoring master station or control panel.
- N. Label information arrangement for 3 lines of text.
 - 1. Line two shall describe the first disconnecting means feeding this panel or equipment.
Line two example: "Fed from DP-XX," "Fed from RP-XX," etc.
 - 2. Line three indicates that location of the disconnecting means as identified in line two.



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Line three example: "First Floor Elect. Rm #XXX."

3. Line four shall include "Via T-XX" when panel or equipment is fed from a transformer.

O. Examples:

RP-1A FED FROM DP-1A ELECTRICAL ROOM A100 VIA T-1A	EF-1 FED FROM MCC-1A MECHANICAL ROOM F101	LP-1A LOCATED IN ELECTRICAL ROOM A100
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END OF SECTION 26 0553



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SECTION 26 0574 - 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. The short circuit, coordination, and overcurrent protective device arc flash studies shall be submitted to the design engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory. The study shall include multiple scenarios including, but not limited to, power from each service, generator on/off, and fire pump on/off.
- B. The results of the short circuit, coordination, and overcurrent protective device arc flash study shall be summarized in a final report. Two (2) bound copies of the complete final report shall be submitted. Additional copies shall be provided on CD in PDF format.
- C. The report shall include:
 - 1. Executive Summary.
 - 2. Descriptions, purpose, basis and scope of the study.
 - 3. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties.
 - 4. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, fuse selection.
 - 5. Fault current calculations including a definition of terms and guide for interpretations of the computer printout.
 - 6. Details of incident energy and flash protection boundary calculations.
 - 7. Recommendations for system improvements, where needed.
 - 8. One-Line Diagram.
 - 9. All information described in part 2.
- D. Provide Paladin v6.0 compatible packaged file with all associated breaker curves for owner future use and editing on CD. File must be full complete editable Paladin model.



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1.3 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 7823 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.4 QUALITY ASSURANCE

- A. 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.
- B. The contractor shall furnish short-circuit and protective device coordination studies as prepared by one of the following acceptable firms:
 - 1. TowerPinkster (Kalamazoo, MI) – (269) 343-6133

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Software Developers: Subject to compliance with requirements, available software developers offering software that may be used for the Work include the following:
 - 1. Power Analytics, Corporation. (Paladin)
- 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 CONTENTS

- A. Executive summary.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.
- 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. Comments and recommendations for system improvements, where needed.
- E. Protective Device Evaluation:
 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
 3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
 4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
- F. Short-Circuit Study Output:
 1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Equivalent impedance.
 2. Momentary 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. Calculated asymmetrical fault currents:
 - 1) Based on fault-point X/R ratio.
 - 2) Based on calculated symmetrical value multiplied by 1.6.
 - 3) Based on calculated symmetrical value multiplied by 2.7.
 3. 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.



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2.3 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.
- 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. Protective Device Coordination Study:
 - 1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
 - a. Phase and Ground Relays:
 - 1) Device tag.
 - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
 - 3) Recommendations on improved relaying systems, if applicable.
 - b. Circuit Breakers:
 - 1) Adjustable pickups and time delays (long time, short time, ground).
 - 2) Adjustable time-current characteristic.
 - 3) Adjustable instantaneous pickup.
 - 4) Recommendations on improved trip systems, if applicable.
 - c. Fuses: Show current rating, voltage, and class.
- E. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
 - 1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
 - 2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
 - 3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.



4. Plot the following listed characteristic curves, as applicable:
 - a. Power utility's overcurrent protective device.
 - b. Low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
 - d. Transformer full-load current, magnetizing inrush current.
 - e. Conductor damage curves.
 - f. Ground-fault protective devices.
 - g. Pertinent motor starting characteristics and motor damage points, where applicable.
 - h. Pertinent generator short-circuit decrement curve and generator damage point.
 - i. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. Comments and recommendations for system improvements.

2.4 ARC-FLASH 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".
- E. Arc-Flash 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 – where applicable.
 - 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:



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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.

2.5 ARC-FLASH WARNING LABELS

- A. Comply with requirements in Section 26 0553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch thermal transfer label of high-adhesion polyester for each work location included in the analysis.
- B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
1. Location designation.
 2. Nominal voltage.
 3. Flash protection boundary.
 4. Hazard risk category.
 5. Incident energy.
 6. Working distance.
 7. Engineering report number, revision number, and issue date.
 8. Where level 4 labels are required label "DANGER – ARC-FLASH HAZARD"
- C. Labels shall be machine printed, with no field-applied markings.
- D. Labels shall include Hazard Risk Category watermark in large print in the center of the label.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals. Proceed with short circuit, coordination and arc-flash studies 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 ANALYSIS

- 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 short-circuit current 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.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases 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. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
 - 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:
 - 1. Electric utility's supply termination point.
 - 2. Incoming switchgear.
 - 3. Low-voltage switchgear.
 - 4. Motor-control centers.
 - 5. Control panels.
 - 6. Automatic transfer switches.
 - 7. Branch circuit panelboards.
 - 8. Disconnect switches.
 - 9. Variable Frequency Drives.

3.3 PROTECTIVE DEVICE COORDINATION STUDY

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. The study shall be based on the device characteristics supplied by device manufacturer.
- D. 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.



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- E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- F. The calculations shall include the ac fault-current decay from induction motors. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
 - 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- G. Protective Device Evaluation:
 - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
 - 2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.

3.4 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Calculate maximum and minimum contributions of fault-current size.
 - 1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
 - 2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
- C. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
- D. 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.
- E. 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.
- F. 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.
- G. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds in accordance with IEEE 1584, Section B.1.2.



- H. Where level 3 or level 4 incident levels are present due to maintaining coordination, provide alternate recommended settings to lower arc flash hazard incident levels that may sacrifice coordination. Hazard risk category shall be a maximum of 2 at distribution panels and maximum of 1 at branch circuit panelboards.

3.5 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 Architect.
 - 2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
- B. Electrical Survey Data: Gather and tabulate the following input data to support 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).
 - 8. Electrical contractor shall provide all field required data to Arc Flash Study Engineer.
 - 9. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
 - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
 - b. Ratings, types, and settings of utility company's overcurrent protective devices.
 - c. Special overcurrent protective device settings or types stipulated by utility company.
 - d. Time-current-characteristic curves of devices indicated to be coordinated.
 - e. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
 - f. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
 - g. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
 - h. WMU to provide available fault current at next upstream device for both sources.



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3.6 LABELING

- A. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
 - 1. For each 480 Volt and applicable 208 Volt panelboard, one arc flash label shall be provided.
 - 2. For each low voltage switchboard, one arc flash label shall be provided.
 - 3. For each substation, one arc flash label shall be provided at incoming, one arc flash label shall be provided at each primary switch, one label shall be provided at the main of the low voltage section, one label shall be provided at the rear access for both incoming and low voltage sections.
 - 4. For each disconnect, one arc flash label shall be provided.
 - 5. For each Variable Frequency Drive, one arc flash label shall be provided.
 - 6. For each transfer switch, one arc flash label shall be provided.
 - 7. For each fire pump, one arc flash label shall be provided.

3.7 APPLICATION OF WARNING LABELS

- A. Contractor shall install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.8 ADJUSTING

- A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.
- B. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

3.9 DEMONSTRATION

- A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION 26 0574



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SECTION 26 0900 - CONTACTORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Provide contactors, rated 600 volts and less, of type and rating as specified and indicated.

1.2 REFERENCES

A. National Electrical Manufacturers Association (NEMA).

1. ICS 2 – Industrial Control Devices, Controllers and Assemblies.
2. ICS 6 – Enclosures for Industrial Control and Systems.
3. KS 1 – Enclosed Switches.

B. Underwriters Laboratories Inc. (UL).

1. 98 – Enclosed and Dead-Front Switches.
2. 508 – Industrial Control Equipment.

1.3 SUBMITTALS

A. Product Data

1. Submit manufacturer's technical product data for each type of contactor specified and indicated.

B. Shop Drawings

1. Submit wiring diagram of contactor, indicating power and control wiring.

C. Quality Control Submittal

1. Submit results of specified field tests.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications

1. Firms regularly engaged in the manufacture of lighting control products, of types, sizes, and ratings specified, and whose products have been in satisfactory use in similar



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services for not less than three years.

PART 2 - PRODUCTS

2.1 GENERAL PURPOSE CONTACTORS

A. Manufacturers

1. Siemens Energy & Automation, Inc.

B. Contactor

1. Electrically-operated mechanically-held, unless otherwise indicated contactor, per NEMA ICS2, with 120 volt, 60 hertz coil and 600 volt, 60 hertz contacts with size and number of poles indicated.
2. Provide NEMA type 1 enclosure, per NEMA ICS6, unless otherwise indicated.
3. Provide solderless pressure wire terminals.
4. Provide corrosion-resistant primer treatment with light gray baked acrylic enamel finish.
5. Provide the following control and indicating devices:
 - a. Auxiliary relay to convert maintained-contact type control circuit to momentary-contact type control circuit necessary for contactor control.
 - b. Hand-off-auto selector switch, of the heavy-duty "oil-tight", maintained-contact type, mounted on the front cover with legend plate.
 - c. Control transformer with primary voltage as indicated and 120-volt, single phase, 60 hertz secondary including fuse and fuseholder.
 - d. Green pilot light to indicate "power on" condition. Mount on front cover with

legend plate. PART 3 - EXECUTION

3.1 INSTALLATION

A. General

1. Install contactors at locations indicated.

B. Identification

1. Provide engraved plastic-laminate sign, per Section 26 0553 "Identification for Electrical Systems", indicating the following lines of information:
 - a. Contactor designation (e.g., "C-1").
 - b. Power characteristics (e.g., "408/277V, 3Ph, 4W").
 - c. Power source (e.g., "Source: PP-1A").
 - d. Load served (e.g., "Load serviced: LP-5A").

3.2 FIELD QUALITY

CONTROL A. Field

Tests

1. Operate contactor through each function.



END OF SECTION 26 0900



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SECTION 26 0913 - ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 SCOPE

- A. This section defines the low voltage embedded sub-metering for use in the AC electrical equipment as outlined in the one-line and/or riser drawings. These solutions will provide a low voltage metering system integrated into the electrical equipment. The metering system shall provide the ability to report the energy information remotely using a web-based software platform. The system must be expandable to accept non-electrical meter input for water and gas.
- B. Provide a complete system capable of monitoring the power distribution system from a single location.
- C. Include remote devices for monitoring; device communication interface hardware; intercommunication wiring; analysis software; and accessories as specified and indicated.

1.2 SYSTEM DESCRIPTION

- A. System Overview
 - 1. Provide a system which can accommodate the devices indicated and allow for a 100 percent expansion. Provide all interface cards, device drivers and other hardware and software required to accommodate the communications system expansion.
 - 2. Provide a complete power distribution system monitoring and control system, to integrate the following functions and features:
 - a. Monitoring at each panelboard as indicated and specified.
 - b. Substation monitoring at each substation is indicated and specified.
 - c. Communications system hardware and software.
 - d. Remote monitoring and control computer and related software located in Room indicated by Owner.
- B. Substation
 - 1. Provide for monitoring of the secondary main circuit breakers for all functions of specified meter.
 - 2. Provide for monitoring of the secondary feeder circuit breakers for all functions of specified meter.



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1.3 SUBMITTALS

- A. Submit shop drawings and product data for approval and final documentation in the quantities listed according to the Conditions of the Contract. Customer name, customer location and customer order number shall identify all transmittals.
- B. Submit sample output information as it will be displayed.

1.4 RELATED STANDARDS AND COMPLIANCE

- A. Meet the following recognized standards and approvals for applications:
 - 1. Accuracy:
 - a. ANSI C12.1
 - b. ANSI C12.20/0.2
 - 2. Safety/Construction
 - a. CSA C22.2 No. 1010-1 Safety Requirements for Electrical Equipment for Measurement.
 - b. UL916 Energy Management Equipment
 - c. UL61010-1 (IEC 61010-1) Test and Measurement Equipment
 - 3. Electro Magnetic Compatibility
 - a. IEC 61000-4-2 Electrostatic Discharge (B)
 - b. IEC 61000-4-3 Radiated Immunity (A)
 - c. IEC 61000-4-4 Electric Fast Transient (B)
 - d. IEC 61000-4-5 Surge Immunity (B)
 - e. IEC 61000-4-6 Conducted Immunity
 - f. FCC Part 15 subpart B, Class A Digital Device, Radiated Emissions

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer of this equipment shall have a minimum of years experience producing electronic submetering system equipment.
- B. Manufacturer shall provide both external and embedded metering solutions.
- C. Manufacturer shall offer both a 1% and 0.2% accuracy solution.
- D. Comply with requirements of latest revisions of applicable industry standards.
- E. Manufacturer shall have remote web-based tenant billing software solutions.
- F. Metering hardware shall be designed, factory installed and tested before shipping to site.
- G. Embedded solution must be a standard product offering by the panel manufacturer. Custom "one off" installed metering solutions are not acceptable.



1.6 DELIVERY, STORAGE AND HANDLING

- A. Store and handle in strict compliance with manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. If the meters are installed in equipment, store the equipment so condensation will not form on or in it. If necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. The low voltage power meter shall be SEM3 metering solution by Siemens. Approved manufacturers are as follows:

- 1. Siemens (ACCESS)

2.2 LOCAL ELECTRONIC METERING UNIT

- A. Substations, distribution panelboard and branch panelboards as indicated.
 - 1. Provide local metering unit on each assembly, to directly display the following metered values for each selected circuit breaker or panelboard.
 - a. Amperes: phase A, B, C at 1 percent accuracy.
 - b. Volts: phase A-B, B-C, C-A, (A-N, B-N, C-N) within 1 percent accuracy.
 - c. Present demand: kW or MW and kVAR or MVAR within 2 percent accuracy.
 - d. Peak demand: kW or MW within 2 percent accuracy.
 - e. Cumulative energy: kWh or MWh within 2 percent accuracy.
 - f. Power factor: within 4 percent accuracy.
 - 2. Provide monitoring device which includes the following features:
 - a. Semi-flush panel mounting suitability.
 - b. Front-panel accessible user input and display control switches.
 - c. Screw terminals for connection to voltage and current transformer outputs.
 - d. Field selection of transformer ratios.

2.3 HARDWARE OVERVIEW

- A. The meters and the ancillary equipment shall meet revenue approval by the recognized authorities in Section 1.4.A.
- B. Current Transformers (CTs) – Manufacturer shall offer solid core designs and be rated for at least the following maximum amperage ratings; 50, 125, 250, 400, 600, 800 and 1200 amps. Solid core CTs shall meet Accuracy standard IEC 60044-1, Class 0.2s
 - 1. CT's shall only have milliamp (100mA) output and measure accurately down to 1% of



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- the maximum range.
 2. CT's shall be self-protecting and not require shorting blocks.
 3. CT's shall support 1.3 times CT rating.
 4. CT's shall be rated for (CAT IV UL metering)
 5. CT's shall be rated for 600VAC.
- C. Micro Meter Modules – Individual micro metering modules shall be provided, one for each phase of the metered circuit. These meter modules will tie to the milliamp CT's. The CT's must be supplied by the manufacturer of the Meter Modules.
1. Meter modules shall measure data at 1% accuracy as tested in accordance with ANSI C12.20.
 2. When grouped together, the Meter Modules shall allow for measurement of 1, 2 and 3 phase circuits.
 3. Meter Modules shall incorporate a dip switch selector to select phase A, B, or C, and have a LED indicator to indicate the phase.
 4. The Meter Module shall be able to accept inputs from all available milliamp CTs ranging from 50 to 1200A.
 5. Setup for the CT sizing on each Meter Module shall be done through the controller web page.
 6. Meter modules shall plug directly into the metering rack without any additional installation work or tools needed.
 7. All embedded metering solutions shall have the metering modules installed at the electrical equipment manufactures factory. No field installation shall be required.
 8. Meter modules shall be pre-calibrated and will never need future calibration.
 9. Meter modules shall provide a LED indicator to indicate if the unit has power and is communicating.
 10. Micro Metering module shall record the kWh reading and retain it for over 45 years without external power.
- D. Racks – Micro Meter Modules are to be mounted on scalable Racks. The Rack Assembly shall be designed to allow the Micro Meter Modules to be snapped into the Rack without use of any tools.
1. Rack Assemblies shall be available in sizes of 3, 9, 15 and 21 Micro Meter Modules.
 2. Rack Assemblies shall be sized to meter all circuits denoted for metering on the drawings accept up to 3, 9, 15 or 21 Micro Meter Modules.
 3. Rack Assemblies will allow for open slots to accommodate future expansion as noted on the drawings.
 4. Rack Assemblies shall be connected to the controller using a 600v rated communications cable.
- E. Controllers – The controller shall function as the collection, processing and setup point for the Micro metering units with a built-in web page interface.
1. Built-in Web page configuration and real-time data screens will include:
 - a. System settings: CT Ratios, PT Ratios, System type, Alarm Settings, communications settings and passwords
 - b. Global settings: for threshold and set-point alarms.
 - c. Branch Meter configuration: for one, two or three pole; and individual meter



warnings, CT ratings, and labels. Dynamic logic shall be built-in to the web configuration tool as to prevent the user from setting up an incorrect arrangement.

- d. Real-Time data monitoring.
 - e. Diagnostics data to be used to monitor Modbus register address information being passed to other monitoring or control systems.
 - f. No third-party software shall be required to configure the Controller or Micro Metering modules.
2. The Controller shall communicate metered values to outside systems by:
 - a. HTML Web page interface, Modbus RTU or Modbus TCP.
 3. One Controller shall be able to manage up to 45 Micro Meter Modules from the same voltage.
 4. The Controller shall have two digital pulse inputs for receiving pulse inputs from other metering devices, such as gas and water.
 5. The Controller shall have one configurable (KY or KYZ) digital pulse output that can be used to output total Kwh data from one or more Micro Metering modules totalized together.
 6. The Controller shall be powered from its own voltage inputs and rated suitable for 480V, 240V, 208V and 120V AC applications.

F. Service Types

1. Poly-Phase Four Wire.

G. Metering Data – Data recorded and calculated that can be passed on to an external system or displayed on the Controllers web page shall include for each breaker:

1. Energy: The meters shall provide true RMS, fully bi-directional and either 4-quadrant, revenue accurate or revenue certified energy metering for the following parameters.
 - a. kWh (Active Energy)
 - b. kVarh (Reactive Energy)
 - c. KVAh (Apparent Energy)
 - d. kW Demand
 - e. Integration of any instantaneous measurement
2. Instantaneous: The meters shall provide high accuracy, 1 second, ½ cycle measurements, including true RMS per phase and total for the following parameters.
 - a. Voltage and current
 - b. Active, Reactive, and Apparent power (kW, kVAR, kVA)
 - c. Phase Angle
 - d. Power Factor
 - e. Current Demand f. kW Demand
3. Instantaneous Max: The meters shall record each new maximum value for the following parameters:



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- a. Current Demand
 - b. Current
 - c. kW Demand
 - d. kW
4. Alarming/Monitoring: The system shall display and configure alarming for the following parameters
 - a. Phase Loss
 - b. Over Current Warning
 - c. Over Current Alarm
 - d. Over kW Demand Alarm
 - e. Under/Over Voltage Alarm

2.4 SOFTWARE

- A. Provide software and graphics update to headend on a per project basis.

2.4 OUTPUT

- B. Provide output information to owner supplied monitors.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

1. Connect the communication network to monitoring devices.
2. Install the required software.
3. Load specified graphics.

B. Communication System Wiring

1. Install communication system wiring in dedicated conduit, separate from any other system wiring.
2. Provide minimum 19-mm (3/4 inch) conduit.
3. Install wire without splices or taps. Provide terminals blocks and make connections device terminals and at communication modules.

- C. The Contractor shall furnish, install and terminate all communication conductors and associated conduits external to any factory supplied equipment.

- D. All communications conductor wiring, and routing shall be per the manufacturer's recommendations and as shown on the contract drawings.

- E. Additional connections to metering systems, where applicable, shall be done in the field by the manufacturer's start-up service group.

3.2 FIELD QUALITY CONTROL



A. System Startup Service

1. Furnish the services of a manufacturer's representative for a period of not less than five consecutive 8-hour days, exclusive of travel time, to assist in startup and programming of the system.
2. Manufacturer's representative is to be trained and have a thorough knowledge of the hardware and system software and programming.
3. Provide the following services:
 - a. Verify integrity of the communications wiring.
 - b. Program the system to communicate with the remote devices and to perform as specified.
 - c. Verify and demonstrate all monitoring and control functions.
 - d. Assist the contractor in troubleshooting and repair of defects.
 - e. Correct any software-based monitoring or control defects.

B. Field Tests

1. Verify operation of communications system hardware and software.
2. Verify operation of computer and related software.
3. Verify operation of each monitoring device.
 - a. Verify that each parameter is being monitored.
 - b. Verify that each control point functions as specified.
4. Demonstrate energy analysis software.

3.3 DEMONSTRATION

A. Initial Training

1. Furnish the services of a manufacturer's representative for a period of not less than two weeks, consisting of five consecutive 8-hour days exclusive of travel time, to conduct on-site training of Owner's personnel in operation and programming of the system.
 - a. Conduct training after all site systems have been installed.
2. Require manufacturer's representative to be trained and have a thorough knowledge of the hardware and system software and programming.
3. Provide training for a minimum of two persons, to include the following:
 - a. Explanation of system operation.
 - b. Explanation of devices.
 - c. Hands-on training. Use of systems simulators is acceptable for introduction purposes but include operation of the installed system.
 - d. Explanation of the site-specific system.

3.4 ADJUSTING AND CLEANING



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- A. The meters and CT's shall be pre-calibrated and require only basic setup via the embedded web pages.
- B. Clean exposed surfaces using manufacturer recommended materials and methods.

3.5 TESTING

- A. Perform factory and installation tests in accordance with applicable NEC, NEMA, UL, ANSI, Weights and Measures California requirements.

3.6 WARRANTY

- A. Equipment manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for two year from date of initial operation, but not more than thirty months from date of shipment.

3.7 STARTUP SERVICES

- A. Engage a factory-authorized service representative to perform startup service of the metering system.

The representative shall be trained and qualified for metering

systems. B. Provide a qualified tradesman to assist in the

commissioning of system.

- C. Obtain and submit as part of final documents a field commissioning report.

- D. Verify that the meters are installed and connected according to the Contract

Documents. E. Complete installation and startup checks according to

manufacturer's written instructions.

3.8 SUPPORT

- A. The electrical equipment manufacturer shall provide a 1-800 number for telephone support.

- B. The vendor shall provide factory training at a dedicated training facility, complete with software, devices and demonstrations or offer remote training services if required.

- 1. Include all travel cost (transportation, lodging and meals) for two people.

- C. The vendor shall also provide on-line support for technical information and

literature. **END OF SECTION 26 0913**





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SECTION 26 0923 – LIGHTING CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.
- B. Division-26 Basic Electrical Materials and Methods sections apply to work specified in this section.
 - 1. Section 26 0400, "Basic Electrical Materials and Methods."
 - 2. Section 26 2726, "Wiring Devices."
 - 3. Section 26 5100, "Interior Lighting."
 - 4. Section 26 5600, "Exterior Lighting."
 - 5. Section 26 0930, "Architectural Dimming Systems"

1.2 SUMMARY

- A. Extent of lighting control equipment work is indicated by drawings and schedules, and is hereby defined to include, but not by way of limitation, dimming system, photocells, lighting contactors, and time switches.
- B. Types of lighting control equipment specified in this section include the following:
 - 1. Dimming System.
 - 2. Photocells.
 - 3. Lighting Contactors.
 - 4. Time Switches.



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- C. Refer to other Division-26 sections for wires/cables, electrical boxes and fittings, and wiring devices which are required in conjunction with lighting control equipment work; not work of this section.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show installation details for occupancy and light-level sensors.
 - 1. Interconnection diagrams showing field-installed wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Installer's Qualifications: Firm with at least 5 years of successful installation experience on projects with lighting control equipment work similar to that required for this project.
- B. Codes and Standards:
 - 1. Electrical Code Compliance: Comply with applicable local electrical code requirements of the authority having jurisdiction and NEC as applicable to construction, installation of lighting control and communications equipment.
 - 2. UL Compliance: Comply with applicable requirements of UL Std 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors". Provide lighting control equipment and components which are UL-listed and labeled.
 - 3. NEMA Compliance: Comply with applicable requirements of NEMA's Stds Pub No. 250, "Enclosures for Electrical Equipment (1000-Volts Maximum)."



4. 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.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver lighting control equipment and components in factory-fabricated type containers or wrappings, which properly protect equipment from damage.
- B. Store lighting control equipment in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.
- C. Handle lighting control equipment carefully to prevent physical damage to equipment and components. Do not install damaged equipment; remove from site and replace damaged equipment with new.

1.6 COORDINATION

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide lighting control equipment of one of the following (for each type and rating of equipment):
 1. Dimming Systems:
 - a. Lutron.
 2. Photocells:



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- a. Tork.
 - b. Intermatic.
 - c. Paragon.

- 3. Lighting Contactors:
 - a. Automatic Switch Company.
 - b. Siemens/ITE.
 - c. Square D.

- 4. Time Switches:
 - a. Intermatic, Inc.

- 5. Indoor Electric Control
 - a. Watt Stopper
 - b. Hubbell
 - c. Sensor Switch

- 6. Time Switches
 - a. Copper Industries, Inc.
 - b. Intermatic, Inc.

2.2 DIMMING SYSTEMS

- A. General: Provide complete dimming system for auditoriums.

- B. Dimmer Control Station shall have 6 presets and 9 channels capability. Provide remote stations for activation of the dimmer control station. Remote stations shall provide preset control and entrance control.

2.3 PHOTOCELLS

- A. Photocells shall be conduit mounted, 120 volt or 277 volt depending on the application, rated 2000 watts with single pole, single throw contacts.

- B. Adjustment range 2 fc to 50 fc.

- C. Photocell shall not be affected by moisture and operate from -40 deg C to +60 deg. C.

- D. Photocell shall have manufacturer's 5-year warranty.



2.4 LIGHTING CONTACTORS

- A. Mechanically held lighting contactors shall have 120 volt or 277 volt coils, coil clearing contacts, contacts rated 20 amperes at 277 volts, and number of poles as shown on the drawings or required. Contactors shall be furnished with NEMA 1 enclosure for surface mounting. Contactor shall be controlled by photocell.
- B. Provide for manual override of photo cell.

2.5 TIME SWITCHES

- A. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Contact Configuration SPST.
 - 3. Contact Rating: 30-A inductive or resistive, 240-V ac.
 - 4. Programs: Eight on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
 - 5. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
 - 6. Astronomic Time: All channels.
 - 7. Automatic daylight savings time changeover.
 - 8. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.
- B. Electromechanical-Dial Time Switches: Comply with UL 917.
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Contact Configuration: SPST.
 - 3. Contact Rating: 30-A inductive or resistive, 240-V ac.
 - 4. Circuitry: Allows connection of a photoelectric relay as a substitute for the on-off function of a program.
 - 5. Astronomic time dial.
 - 6. Eight-Day Program: Uniquely programmable for each weekday and holidays.
 - 7. Skip-a-day mode.
 - 8. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.



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- C. Time switch to be 7 day with manual bypass switch, double pole, double throw, rated 20 amperes, 120 volt or 277 volt as required, with reserve power, mounted in general purpose enclosure.
- D. Seven-day dial will allow for turning Off light at different times on different days of the week.
- E. Use of an astrological time switch, which automatically adjusts for daylight savings time and light changes over season changes.
- F. Reserve power, spring driven, shall be sufficient to operate contacts at least 24 hours after power failure. On restoration of power, time switch shall transfer to synchronous motor and automatically rewind reserve.
 - 1. If electronic time switch is provided, the reserve power shall be a rechargeable nickel-cadmium battery and charger that shall automatically recharge the battery after a power outage.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which lighting control equipment is to be installed and notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.

3.2 INSTALLATION OF LIGHTING CONTROL EQUIPMENT

- A. Install lighting control system components and ancillary equipment as indicated, in accordance with equipment manufacturer's written instructions, and with recognized industry practices, to ensure that lighting control equipment complies with requirements. Comply with requirements of NEC, and applicable portions of NECA's "Standard of Installation" pertaining to general electrical installation practices.
- B. Coordinate with other electrical work, including raceways, and electrical boxes and fittings, as necessary to interface installation of lighting control equipment work with other work.



- C. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Std 486A and B.

3.3 GROUNDING

- A. Provide equipment grounding connections for lighting control equipment as indicated. Tighten connectors to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounding.

3.4 FIELD QUALITY CONTROL

- A. Upon completion of installation and after circuitry has been energized, demonstrate capability and compliance of system with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting. Testing and retesting at no cost to Owner.

3.5 PERSONNEL TRAINING

- A. Building Operating Personnel Training: Train Owner's building personnel in procedures for starting-up, testing and operating lighting control system equipment. Provide at least 3 hours of training.

END OF SECTION 26 0923



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SECTION 26 0930 – ARCHITECTURAL DIMMING SYSTEMS

PART 1 - GENERAL

DESIGNER NOTE: Lighting system design shall comply with the current Michigan Energy Code

1.1 RELATED DOCUMENTS

- A. The entire lighting control system shall be U.L., CSA or CE listed as appropriate. Dimmers shall be U.L. and CSA Listed specifically for the required loads (i.e., LED, fluorescent, magnetic low voltage transformer).
- B. All lighting control equipment - dimming panels, switching panels, control panel and controls - shall be manufactured by a single manufacturer. Dimming ballasts shall be compatible with dimming panel.
- C. Manufacturer shall maintain ISO 9001 certification.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Available Manufacturers: Subject to compliance with requirements. Equipment not meeting this operation and performance specification will not be accepted. It shall be removed from the project and replaced with equipment meeting the specifications, at no charge to the Owner. If manufacture is not specified use the following or approved equal:
 - 1. Lutron Electronics Co, Inc.



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2.2 Power Panels

- A. Panels shall be wall or floor mounted NEMA grade, constructed of sheet steel plates not less than #16 U.S. gauge. Contractor shall reinforce wall as required for wall-mounted panels.
- B. Panels shall be completely pre-wired by the manufacturer. The contractor shall be required to provide input feed wiring, load wiring, and control wiring. No other wiring or assembly by the contractor shall be permitted.
- C. Unless the panel is a dedicated feed through switching panel or otherwise indicated, panels shall contain branch circuit protection for each dimming module. Branch circuit breakers shall have the following performance characteristics:
 - 1. Be U.L. listed under U.L. 489 as a molded case circuit breaker for use on lighting circuits.
 - 2. Contain a visual trip indicator and shall be rated at 10,000 AIC (120V) or 22,000 AIC (277V), unless otherwise noted.
 - 3. Be thermal-magnetic in construction for both overload and dead short protection. The use of fully magnetic breakers shall not be acceptable, even when used in conjunction with individual dimmer thermal cut-outs.
 - 4. Be switching duty (SWD) rated so that the loads can be switched off via the breakers.
- D. Panels shall be shipped with each dimmer in a BYPASS position via a jumper bar inserted between the input and load terminals. These jumpers shall carry the complete load current and shall be reusable at any time.
- E. Panels shall be cooled via free-convection, unaided by fans, and capable of continuous operation to all of these section specifications within an ambient temperature range of 0°C (32°F) to 40°C (104°F). To provide the utmost in reliability, panels which normally use cooling fans must have the panel capacity derated by 50%. A lesser derating shall be allowed providing that manufacturer can substantiate, via an independent test laboratory, that with no fans operating, and at full-rate dimmer capacity, the temperatures of the main semiconductors are at least 20°C below maximum temperature rating and the temperatures of the filter chokes are within the maximum allowable temperatures of these components at an ambient temperature of 40 degree C.
- F. Panels shall have the following additional performance characteristics:
 - 1. Be designed to prevent any foreign objects from coming in contact with any part of the panel which would be at an elevated temperature, such as the dimmer extrusions or heat fins.



2. Be designed to provide air flow across the heat sink areas and through the dimmer chassis. Panel sections which provide air flow only across heat sinks shall not be mounted one above another in order to allow for adequate heat dissipation.
- G. Panel shall provide capability to electronically assign each circuit to any zone in the dimming system. Panels using mechanical switches, rewiring, or EPROMS shall not be acceptable.
- H. Multiple panels shall be capable of operating in one system.
- I. For panels fed with a normal/emergency feeder, panel shall include electronics to bring all circuits to a full-on condition upon the loss of normal power and the subsequent presence of emergency power. Electronics shall switch both the intensity signal and the on/off signal of each dimmer connected to an emergency circuit between the local control stations and a full-on constant drive supply. This type of emergency full-on may be used with either a normal/emergency generator or a constant hot secondary utility feed where the emergency transfer occurs on the line side (upstream) of the dimming panel and requires only a single normal/emergency feeder.

2.3 MODULAR DIMMING CARDS

- A. A positive air gap relay shall be employed with each card in the power panel to ensure that the load circuits are open when the "off" function is selected at a control station. These relays need not be integral to the module but must be integral to the panel. Lighting control manufacturer shall provide and warrant both the relays and the necessary control interface(s) as part of the control system.
- B. One type of modular dimming card shall be used for all sources. Systems requiring different types of modules or modular dimming cards shall not be acceptable.
- C. All dimmers shall be voltage regulated so that an 10% variation in line voltage shall cause no more than an 5% variation in load voltage when dimmer is operating at 40V (5% light output).
- D. Under full-load conditions in a 40°C environment, all silicon thyristors shall operate at a minimum 20°C safety margin below the component temperature rating.
- E. The maximum allowable asymmetry in the load waveform shall be 1 VDC.
- F. Each dimmer shall incorporate an electronic "soft- start" default at initial turn-on that smoothly ramps the lights up to the appropriate levels within 0.5 seconds.



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- G. Once installed as part of a complete system, the silicon thyristors used to control the power furnished to the loads shall be both designed and tested to withstand surges, without impairment to performance, of 6000V, 3000A (equivalent to a near lightning strike) as specified by ANSI/EEE std. C62.41. Upon request, the manufacturer shall provide a means to demonstrate conformance to this specification using the appropriate surge-generation equipment.
- H. Filtering shall be provided in each dimmer so that current rise time shall be at least 400msec at 50% rated dimmer capacity as measured from 10-90% of the load current waveform at a 90° conduction angle, and at no point rise faster than 30mA/msec. Manufacturers should note that additional filters may be required to meet this specification. These filters need not be integral to the dimming module but must be integral to the dimming cabinet.
- I. Dimmer output voltage shall be a minimum 95% of input voltage at maximum intensity setting.
- J. Minimum and maximum light levels shall be user adjustable on each dimmer.
- K. In the event of a dimmer failure, only that dimmer shall be affected. Systems that affect more than one dimmer shall not be acceptable. Replacement of the dimmer, after power is OFF, shall require only the reconnection of the new dimmer card. Systems requiring programming or DIP switch setting after dimmer shall not be acceptable.

2.4 SWITCHING MODULE

- A. Relays shall be mechanically latching.
- B. A positive air gap relay shall be employed with each card in the power panel to ensure that the load circuits are open when the "off" function is selected at a control station. These relays need not be integral to the module but must integral to the panel. Lighting control manufacture shall provide and warrant both the relays and the necessary control interface(s) as part of the control system.
- C. Once installed as a complete system, the relays used to control the power furnished to the loads shall be both designed and tested to withstand surges, without impairment to performance, of 6000V, 3000A (equivalent to near lighting strike) as specified by ANSI/EEE std. C62.41. Upon request, the manufacture shall provide the means to demonstrate conformance to this specification using the appropriate surge-generation equipment.
- D. Relays shall be rated for 16 Amps continuous duty, for the following load types: incandescent/tungsten - electronic and magnetic low-voltage - neon/cold cathode - high intensity discharge - high inrush electronic and magnetic fluorescent lamp ballasts.



- E. Load shall be switched in a manner that ensures no arcing will occur at the mechanical contacts when power is applied to the load circuits.
- F. The voltage drop across the switching circuit shall not exceed 100 millivolts RMS when in the closed state. Power efficiency shall be in excess of 99 percent at full load RMS voltage.

2.5 SOURCES

- A. Dimmers shall operate the following sources/load types with a smooth continuous Square Law dimming curve. Dimmers shall also be capable of operating these sources on a non-dim basis. Dimmers shall be electronically assigned to the appropriate load type/dimming curve and can be reassigned at any time. Universal-type dimmers that do not adjust the dimming curve shall not be acceptable.

- 1. Electronic Low Voltage Transformer
 - a. No flicker or interaction shall occur at any point in the dimming range.
 - b. For integral dimming, an interface shall be required.
- 2. Fluorescent Electronic Dimming Ballasts: Dimmer shall be rated to control LED, T-8, T-5 and T-4 lamps. All lamps on the same circuit must have the same current rating (i.e., T-8), but may be different lengths (i.e., 3',4'). Ballasts for fluorescent fixtures must be Lutron Hi-lume "FDB", Eco-10" series, or Advance Mark X. See fixture schedule and/or dimming schedule for specific ballast model numbers. The dimming performance shall be as follows:
 - a. All lamps on the same circuit must have the same current rating (i.e., T-8), but may be different lengths (i.e., 3',4'). See fixture schedule and/or dimming schedule for specific ballast model numbers. Manufacturer shall provide single, two, or three lamp electronic dimming ballasts as required.
 - 1) Architectural dimming ballasts -Lutron Hi-lume FDB series with dimming performance in accordance with 2.04k.
 - 2) Controllable ballasts - Lutron Eco- 10 series with dimming performance in accordance with 2.041.
 - b. Ballasts shall withstand 4000 volt surges as specified in ANSI C62.41.
 - c. Ballast shall preheat lamp cathodes before applying arc voltage to ensure rated lamp life is not diminished.
 - d. Ballasts shall internally limit inrush current to not exceed three amps at 277 volts or seven amps at 120 volts to avoid computer problems, nuisance circuit breaker trips, and control contact malfunctions.
 - e. Light level output shall be continuous, even and flicker-free over the entire dimming range.
 - f. Ballast shall be inaudible in a 27dB ambient throughout the dimming range.



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- g. Ballast shall be capable of striking lamps at any light level. This shall be accomplished without first flashing to full light.
- h. Ballasts must comply with FCC Part 18 regulations for non-commercial RF lighting devices.
- i. Ballasts shall have a minimum starting temperature of 10°C.
- j. Ballasts shall not be damaged by miswiring line voltage and control wire inputs.
- k. Architectural dimming ballasts ("Hi-lume FDB")
 - 1) Dimming range of ballasts shall be from 100% to 5% light level for T-8 lamps, 100% to 5% light level for T-5 and T-4 lamps.
 - 2) Ballast shall have:
throughout the entire dimming range, magnitude of harmonic distortion shall not exceed 10% THD of current at full light output lamp current crest factor less than or equal to 1.6.
- l. Controllable ballasts ("Eco-10"):
 - 1) Dimming range of ballasts shall be from 100% to 10% light level.
 - 2) Ballast shall have:
throughout the entire dimming range, magnitude of harmonic distortion shall not exceed 10% THD of current at full light output lamp current crest factor less than or equal to 1.6.
 - 3) For integral dimming, an interface shall be required.
- 3. Neon and Cold Cathode Dimmer shall provide the ability to dim lamps down to 10% of full light output when used with normal (low) power factor transformers.
 - a. The lamp performance over the range specified shall be continuous and free of flicker or striations.
 - b. Neon/cold cathode lamps shall be manufactured with strict attention paid to proper lamp pressurization and exclusion of any impurities to ensure best dimming performance.
 - c. For optimum performance, transformers shall be sized per transformer sizing tables developed by the dimming manufacturer.
 - d. The electrical contractor is responsible for proper neon or cold cathode lamp and wiring installation.

2.6 CONTROL

A. General

- 1. Definitions: A "scene" or "preset" is a specific look or mood created by different lighting zones set at different intensities. A "zone" is one or more lighting circuit which are controlled together as a group.
- 2. Preset dimming control shall provide power failure memory. Should power be interrupted and subsequently returned, the lights will come back on to the same levels set prior to the power interruption. Restoration to some other default level is not acceptable, unless specifically noted elsewhere.
- 3. Faceplate shall attach using no visible means of attachment.



4. Wiring from dimming panel to preset dimming control and accessory control shall be low voltage type Class 2 wiring (SELV).
- B. Four Scene Preset Control Where indicated on the drawings, control shall provide 4 preset lighting scenes and off for up to 24 control zones. Control shall be capable of storing an additional 12 preset lighting scenes. Up to 64 zones may be tied together in one system. Controls shall incorporate built-in wide-angle infrared receiver, providing control via a separate wireless remote-control transmitter from up to 50 feet away. Preset shall be set via easy- to-use raise/lower switches, one raise and lower switch per zone. The intensity for each zone shall be indicated via an illuminated bargraph, one bargraph per zone. More than one zone may be proportionately raised or lowered at the same time. Programming of preset scenes shall be accomplished without the use of an ENTER or STORE button. Additionally, one or more zones may be temporarily overridden without altering the scene values which are stored in memory. Lighting levels shall fade smoothly between scenes at time intervals of 0-59 seconds or 1 to 60 minutes. The fade time shall be separately selectable for each scene and shall be indicated by a digital display for the current scene. Pressing a scene select button will all light the corresponding scene LED and simultaneously begin changing the bargraph levels to reflect the currently selected scene. In the event that a preset scene with a fade time greater than 5 seconds is initially selected from an OFF condition, the programmed fade time shall be temporarily overridden, unless otherwise noted, and the lights shall fade up to that scene over a five- second time span.
 1. Where indicated, control shall be capable of complete setup of all parameters locally, or when used with the appropriate interface, via a PC. Parameters shall include scenes (including both light levels in 1% increments and fade times), load types, low end trim, tamperproof protection of scenes, and communication between control units (if more than one control unit exists in the system). Permanent installation of the PC shall not be required unless indicated on the drawings.
- C. Wallstation Accessory Control Options Provide the following controls for use with the preset control(s) as shown on the drawings:
 1. Two Scene Entrance Control(s) shall be capable of recalling Scene One plus Off.
 2. Four Scene Control(s) shall be capable of recalling any one of four scenes, master raise/lower and Off. Control shall provide access to up to 16 scenes.
 3. Fine Tuning Control(s) shall allow the temporary override of a particular zone or zones from the preset light level.
 4. Wireless Infrared Transmitter(s) shall be capable of recalling any one of four preset scenes and Off. In addition, a master raise/lower shall be provided. The transmitter shall be manufactured by the dimming system manufacturer. The range of the transmitter to any single receiver shall be at least 50 feet.
 - a. Wall receiver shall incorporate four scene select, master raise/lower, and off buttons.
 - b. Ceiling receiver shall provide 360° view and an integral LED to provide feedback of proper IR signal.
5. Special Function Control(s) shall provide the following functions:



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- a. Sequencing shall allow the user to set up and operate a sequence of 4, 12, or 60 steps. A sequence shall be defined as a series of steps, while a step shall be defined as the recall of a scene. Each step interval is adjustable from 1 second to 60 minutes.
 - b. Zone lockout shall allow temporary changes without altering the light levels preset for each scene.
 - c. Scene lockout shall lockout the control, maintaining current scene and disabling all buttons on the preset dimming control.
 - d. Fade override shall set all fade times to zero.
6. Partition Control(s) shall provide two or four buttons for operating multiple preset units independently or in combination. Each button shall have a corresponding LED to indicate status of a specific partition or "door."
7. Photocell Interface Control(s) shall provide scene selection via daylight photosensor.
8. Interface Control Options Interface(s) shall allow access to preset dimming control(s) via one of the following methods:
- a. Isolated momentary/maintained dry contact closures. Where indicated on the drawings, each interface shall provide isolated maintained or momentary contact closures rated at 200mA at 30VDC for pilot light status feedback.
 - b. RS232 serial communication.
 - c. RS232 serial communication and an integral astronomic timeclock providing four schedules with 60 events each via a PC with WINDOWS 3.1 or 95 compatible software.
 - d. RS232 serial communication and an integral astronomic timeclock providing four schedules with 60 events each via a PC with WINDOWS 3.1 or 95 compatible software. Software shall also be capable of programming the following: scenes, including both light levels in 1% increments and fade times; load types; low end trim; tamperproof protection of scenes after setup; communication between control units; and temporary scenes. Interrogation of the above parameters, including control unit type, shall also be available via the RS232 connection.

2.7 Quality Control

- A. All components shall be inspected following U.S. military standard 105D or equivalent.
- B. Equipment shall be fully tested for proper operation prior to shipment from the factory.

PART 3 - EXECUTION

3.1 Installation



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- A. Wiring from preset dimming control to dimming panel and accessory control shall be low voltage Class 2 (SELV) wiring.
- B. Contractor shall furnish all equipment, labor, system setup, and other services necessary for the proper installation of the devices as indicated on the drawings and specified herein. System setup shall include defining each dimmer's load type, assigning each load to a zone, and setting the control functions.
- C. Unless otherwise noted, Manufacturer shall provide a five-year warranty on all equipment supplied. Warranty shall cover 100% of the cost to repair or replace any parts required over the first year which are directly attributable to the manufacturer. Warranty coverage shall begin from date of final system commissioning or three months from date of delivery, whichever is the earlier.

END OF SECTION 26 0930



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 1116 - SECONDARY UNIT SUBSTATIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes installation of the indoor Secondary Unit Substation Equipment. The successful installing contractor will be assigned the responsibility to receive, store, install and start-up the equipment. Owner supplied equipment, factory start-up and Owner training is included in preorder.
- B. Each unit shall include the following but not limited to:
 - 1. Medium voltage incoming line section
 - 2. Medium voltage transformer section
 - 3. Low voltage secondary switchgear section

1.2 RELATED SECTIONS

- A. Division 26 Section "Overcurrent Protective Device Coordination" for short-circuit rating of devices and for setting of overcurrent protective devices.
- B. Division 26 Section "Medium-Voltage Cables" for requirements of terminating cables in incoming section of substation.
- C. Division 26 Section "Surge Protection" for devices with low-voltage power, control, and communication equipment that may be located in secondary section.

1.3 DEFINITIONS

- A. NETA ATS: Acceptance Testing Specification.

1.4 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories. Include manufacturer's technical data on features, performance, electrical characteristics, ratings and finishes.



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- B. Shop Drawings: Detail equipment and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Time-Current Characteristic Curves: For overcurrent protective devices. For each type of switchgear, switchboards and related equipment:
 - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:
 - a. Tabulation of installed devices with features and ratings.
 - b. Enclosure types and details.
 - c. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
 - d. Bus configuration with size and number of conductors in each bus run, including phase, neutral, and ground conductors of main and branch buses.
 - e. Current rating of buses.
 - f. Short-time and short-circuit current rating of secondary unit substation.
 - g. Nameplate legends.
 - h. One-line diagram.
 - i. List of materials.
 - j. Mimic-bus diagram.
 - k. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Primary Fuses: Submit recommendations and size calculations using S&C SM5 fuses.
- D. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where pipe 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. Indicate field measurements. Provide reflected ceiling 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. Dimensioned concrete base outline of secondary unit substation, conduit entries, and ground rod locations.
 - 2. Location of structural supports for structure-supported raceways, and busways.
 - 3. Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.
- E. Submit guaranteed efficiencies at full, $\frac{3}{4}$, $\frac{1}{2}$, and $\frac{1}{4}$ loads, guaranteed regulation at unity and 80% P.F., and core loss.
- F. Product Certificates: For secondary unit substations, signed by product manufacturer.
- G. Material Test Reports: For secondary unit substations.
- H. Factory test reports.
- I. Coordination of overcurrent protection devices:



1. The primary fuses, main, secondary breakers, and feeder breakers shall be completely coordinated by the manufacturer of the unit substation equipment. Shop drawing submittal shall include complete coordination curves of the exact equipment furnished.

1.5 ACTION SUBMITTALS

- 1.6 Product Data: Include rated capacities, furnished specialties, and accessories.

- 1.7 Shop Drawings:

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

- 1.9 Include composite dimensioned drawing showing overall plan and elevation of substation equipment.

- 1.10 Time-Current Characteristic Curves: For all overcurrent protective devices (electronic and magnetic) provide detail information on breaker and trip device including model numbers, available trip settings, instruction manuals and time current curves.

- 1.11 Primary Fuses: Submit recommendations and size calculations and time current curve.

1.12 INFORMATIONAL SUBMITTALS

- A. Source quality-control test reports.
- B. Field quality-control test reports.

1.13 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data: Hard copies and electronic PDF's for secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.

1.14 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Refer to Electrical Specification "Electrical Testing".
- B. Source Limitations: Obtain secondary unit substation through one source from a single manufacturer.



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- C. Product Options: Drawings indicate size, profiles, and dimensional requirements of secondary unit substations and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- D. 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.
- E. Factory testing of Substation components (primary switches, transformers, secondary distribution) to be witnessed by WMU personnel. Include transportation and lodging costs for three (3) WMU personnel to attend testing at the factory. Provide notice of travel three weeks prior to date. Combine trips to maximize efficiency, ground transportation shall not exceed five hours one way.
- F. Comply with NFPA 70 and IEEE C2.
- G. The unit substation shall conform to the following:
 - 1. ANSI C37 20
 - 2. IEEE Standard 27
 - 3. NEMA SG-5
 - 4. Transformers shall be in accordance with the latest applicable standards as recommended by A.S.A., N.E.M.A., and I.E.E.E.
 - 5. Comply with IEEE C37.121.

1.15 DELIVERY, STORAGE, AND HANDLING

- A. Coordinate delivery, receive, unload and store equipment. Protect from weather and so that condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions if required. Coordinate to allow movement into designated space.
- B. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.
- C. Store secondary unit substation components protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.
- D. Handle secondary unit substation components according to manufacturer's written instructions. Use factory-installed lifting provisions.
- E. Deliver switchgear in sections of lengths that can be moved past obstructions in delivery path.

1.16 COORDINATION

- A. Coordinate layout and installation of equipment and components with other construction, including conduit, piping, equipment, construction that penetrates floors and ceilings or is supported by them, light fixtures, HVAC equipment, fire suppression-system components and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.



- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.17 PROJECT CONDITIONS

- A. Service Conditions: IEEE C37.121, usual service conditions, except for the following:
 - 1. Select and modify conditions in subparagraphs below and specify features required to provide satisfactory service.
 - 2. Exposure to significant solar radiation.
 - 3. Altitudes above 3300 feet.
 - 4. Exposure to fumes, vapors, or dust.
 - 5. Exposure to explosive environments.
 - 6. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
 - 7. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
 - 8. Exposure to excessively high or low temperatures.
 - 9. Unusual transportation or storage conditions.
 - 10. Unusual grounding resistance conditions.
 - 11. Unusual space limitations.
- B. Field Measurements: Indicate measurements on Shop Drawings
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Ambient Temperature: Not exceeding 40 deg C.
 - 2. Altitude: Not exceeding 6600 feet.
- E. Interruption of Existing electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Owner no fewer than fourteen days in advance of proposed interruption of electric service.
 - 2. Do not proceed with interruption of electric service without Owner's written permission.

1.18 EXTRA MATERIALS

- A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Spare fuses: Furnish quantity equal to 10 percent of each type and size installed, but not less than three (3) of each type and size. Include spares for the following:
 - a. Primary disconnect fuses.



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- b. Potential transformer fuses.
- c. Control power fuses.
- d. Fuses for secondary main switch.
- e. Fuses for secondary fusible devices.
- f. Spare fuse cabinet.
- g. Touch up paint
- h. Contact lubricant, primary switch

1.19 WITNESS TESTING

- A. Include transportation, lodging and meal costs for witness testing of secondary unit substation.
- B. Include all costs for three individuals for paragraph A above
 - 1. Provide notice of travel three weeks prior to date.
 - 2. Combine trips for maximum efficiency.
 - 3. Ground transportation shall not exceed five hours one way.



1.20 COORDINATION

1.21 Edit first paragraph below to delete or add types of construction that should be submitted as part of Contractor's layout.

1.22 Coordinate layout and installation of secondary unit substations with other construction that penetrates floors and ceilings, or is supported by them, including light fixtures, HVAC equipment, and fire-suppression-system components.

1.23 Coordinate layout and installation of secondary unit substations with other construction that penetrates floors and ceilings, or is supported by them, including light fixtures, HVAC equipment, and fire-suppression-system components.

1.24 Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.25 EXTRA MATERIALS

1.26 Extra materials may not be allowed for publicly funded projects.

1.27 Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.28 Revise first subparagraph below to suit Project. Spare medium-voltage fuses are contained within primary switch.

1.29 Spare fuses: Furnish one set of primary disconnect fuses.

1. Touchup Paint: **[Three]** <Insert number> half-pint containers of paint matching enclosure's exterior finish.
2. Primary Switch Contact Lubricant: **[One]** <Insert number> container[s].
3. **[One]** <Insert number> set[s] of spare mounting gaskets for bushings, handholes, and the gasket between relief cover and flange of pressure relief device.

PART 2 - PRODUCTS

- 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:



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2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Siemens Energy & Automation, Inc

2.3 MANUFACTURED UNITS

- A. Indoor Unit Arrangement: Single assembly consisting of transformer, primary switch and secondary switchboard section.
- B. General:
 - 1. The entire unit shall be metal enclosed and provided with ventilation and access. Complete unit shall be rustproofed and painted two coats. Units shall be mounted on leveling channels in concrete bases. Leveling channels shall be furnished by the Contractor.
 - 2. Solderless lugs and ground connections shall be provided at each end of the structure and a copper ground bus shall be furnished running the entire length of the structure providing positive ground connections.
 - 3. Mimic Bus: Substation shall include a mimic bus utilizing same symbology as on contract documents. Mimic bus to indicate bussing, connections, and devices in single line form on the front of primary switches, transformer, and secondary switchgear using black acrylic strips ½ wide mechanically fastened flat against the substation using machine screws or rivets.
- C. Physical Size Limitations:
 - 1. Must fit thru 40" door opening.
 - 2. Maximum width of any section - 42".
 - 3. Maximum overall length – 14 feet.
 - 4. Unit shall be disassembled and shipped in not more than four sections, consisting of primary switch, transformer, and secondary switchboards.
- D. Outdoor Unit Arrangement: [Single assembly] [Separate secondary distribution equipment connected with busway].
- E. Weatherproof, complying with IEEE C37.2.1.
- F. Enclosure Finish: Factory-applied finish in manufacturer's standard color including under surfaces treated with corrosion-resistant undercoating.



2.4 INCOMING SECTION

2.5 Incoming Line: Terminal assembly with adequate space for incoming-cable terminations and surge arresters.

2.6 Incoming Line: Transformer cover-mounted bushings.

A. Incoming Line: Enclosed, air-interrupter, primary switch. UL listed.

1. Three pole, single throw, dead front, metal enclosed, with manual stored energy operator, with fuses mounted on a single frame, complying with IEEE C37.20.3.
2. Mechanical interlocking system to prevent opening switch compartment door unless switchblades are open, and prevent closing switch if door is open. Additionally, interlock air-interrupter switch with transformer secondary main circuit breaker, preventing switch from being opened or closed unless secondary main circuit breaker is open.
3. Phase Barriers: Located between blades and fuses of each phase, designed for easy removal, allows visual inspection of switch components when barrier is in place.
4. Window: Permits viewing switch-blade positions when door is closed.
5. Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include fuse-handling tool as recommended by switchgear manufacturer.
6. Switch position indicator dry contact switch wired to electric metering system.
7. Maximum depth of 48".
8. Continuous-Current Rating: 600 A.
9. Short-Circuit Rating:
 - a. Short-time momentary asymmetrical fault rating of 40 kA.
 - b. 3-second symmetrical rating of 25-kA RMS.
 - c. Fault close asymmetrical rating of 40 kA.

B. Surge Arresters: Comply with IEEE C62.11, Distribution class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device. Surge arresters may be located in the transformer compartment.

C. Fuses: Sizes as recommended by secondary unit substation manufacturer, considering fan cooling, temperature-rise specification, and cycle loading. Comply with applicable requirements in NEMA SG 2 and the following:

1. Fuses shall be S&C SM-5 type, current-limiting, rated for not less than 50kA RMS symmetrical current-interrupting capacity.
2. Mounting: Positively held in position with provision for easy removal and replacement from front without special tools.
3. Indicator integral with each fuse to show when it has blown.
4. Spares: Include three fuses in use and three spare fuses in storage clips in each switch. Provide spare set of S&C fuse holders.

D. Insulators: Shall be porcelain or cyclo-aliphatic insulators.



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- E. Rotation shall be ABC as referenced to WMU Power Plant. Coordinate verification with WMU. WMU to provide equipment necessary for verification. Perform any required changes deemed necessary by WMU as result of testing.
- F. Ground Bus: Copper, accessible from front. Continuous through transformer section with shipping split jumper. Provisions for connecting to building ground system on right and for terminating equipment ground cable and cable ground shields.
- G. Incoming Cable Connection: Front accessible, entering from the top. Provide sufficient space for cable bend radius and make up of cable stress control device.

2.7 LIQUID-FILLED DISTRIBUTION AND POWER TRANSFORMERS

- A. Description: Comply with IEEE C57.12.00 and UL 1062 for liquid-filled, 2-winding unit substation transformer.
- B. Energy Efficiency: Transformer must be DOE 2016 compliant.
- C. Insulating Liquid: Less flammable, edible-seed-oil based, and listed by a NRTL acceptable to authority having jurisdiction 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.
- D. Insulation Temperature Rise: 75/55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. Insulation system shall be rated to continuously allow an additional 12-percent kVA output, at 75 deg C temperature rise, without decreasing rated transformer life.
- E. Sound level may not exceed audible levels shown below:

Self-Cooled, Two Winding kVA Rating	NEMA Average	
	dB, KNAN	dB, KNAF
500	56	67
501-700	57	67
701-1000	58	67
1001-1500	60	67
1501-2000	61	67
2001-2500	62	67
2501-3000	63	67



- F. Basic Impulse Level: 95kV minimum, comply with UL 1062.
- G. Full-Capacity Voltage Taps: Four, 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable, de-energized tap changer; position indicator; and padlock hasp.
- H. The high voltage bushings shall be provided with Spade Terminals for 15kV cable connection to transformer primary switches.
 - 1. Insulate after connection.
- I. Cooling System: Class KNAN/KNAF, liquid cooled. Cooling system shall include auxiliary cooling equipment, automatic controls, and status indicating lights.
- J. Impedance: 5.75 percent \pm 0.25%.
- K. Windings: Provide copper primary and secondary windings.
- L. Ground Bar: Copper, continuous through transformer, primary switch and switchboard section with appropriate jumpers at shipping splits.
- M. Accessories:
 - 1. Grounding pads, lifting lugs, and provisions for jacking under base.
 - 2. Insulated, low-voltage, neutral bushing with removable ground strap.
 - 3. Liquid-level gauge.
 - 4. Pressure-vacuum gauge.
 - 5. Liquid temperature indicator.
 - 6. Drain, sampling and filter valves.
 - 7. Pressure relief device.
 - 8. Nameplate
 - 9. Provisions for padlocking tap changer handle.
- N. Transformers shall have sealed tanks with bolted on cover for preservation of the insulating liquid. The transformer base construction shall be of the fabricated type and suitable for using rollers or skidding in any direction.
- O. Provide containment accessory for indoor liquid filled unit substation designed to hold entire insulating fluid capacity.
- P. Provide temperature controller with RS485 modbus module wired to meter and integrated to WinPM.

2.8 LIQUID-FILLED TRANSFORMER SECTION

- A. Description: IEEE C57.12.00 and UL 1062, liquid-filled, 2-winding, secondary unit substation transformer.
- B. Mineral-Oil Insulating Liquid: ASTM D 3487, Type II, tested according to ASTM D 117.



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- C. Less-Flammable Insulating Liquid: Comply with NFPA 70 requirements as having a fire point of not less than 300 deg C, tested according to ASTM D 92, and having a dielectric strength of not less than 33 kV when tested according to ASTM D 877. If silicone is used as a "less-flammable insulating liquid," oil-immersed tap changers shall have seals and gaskets that show no evidence of shrinkage, swelling, or absorption when tested according to ASTM D 3455.
- D. Retain one of first two paragraphs below if appropriate temperature rise for Project is other-than-standard 55 deg C.
- E. Insulation Temperature Rise: 65/55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. Insulation system shall be rated to continuously allow an additional 12-percent kVA output, at 65 deg C temperature rise, without decreasing rated transformer life.
- F. 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.
- G. Basic Impulse Level: Comply with UL 1062.
- H. Retain paragraph above or below. See Evaluations for standard Basic Impulse Level values.
- I. Basic Impulse Level: [60] [75] [95] [110] kV.
- J. Full-Capacity Voltage Taps: 4 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.
- K. Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps below rated primary voltage, with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
- L. Cooling System: Class [OA, liquid cooled] [OA/FA, liquid cooled, and with forced-air rating] [OA/FFA, liquid cooled, and with provisions for future forced-air rating]. Cooling systems shall include auxiliary cooling equipment, automatic controls, and status indicating lights.
- M. Sound level may not exceed 58 dB, without fans.
- N. Impedance: <Insert value> percent.
- O. 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.



2.9 DRY-TYPE TRANSFORMER SECTION (ALTERNATE PRICING)

- A. Description: NEMA ST 20, IEEE C57.12.01, IEEE C57.12.50, C57.12.51, C57.12.52, and dry-type, 2-winding, secondary unit substation transformer.
- B. Energy Efficiency: Transformer must be DOE 2016 compliant.
- C. Enclosure: Indoor, ventilated, vacuum-pressure, impregnated type and with insulation system rated at 220 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C. Unit nameplate shall list dual rating for 80 deg/150 deg operation.
- D. Cooling System: Class AA, air cooled complying with IEEE C57.12.01.
 - 1. If retaining first option in paragraph above, delete both subparagraphs below.
 - 2. 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.
 - 3. If retaining second option in paragraph above, delete subparagraph below.
 - 4. Include mounting provision for fans.
- E. Insulation Materials: IEEE C57.12.01, rated 220 deg C.
- F. Insulation Class: 220 deg C.
- G. Insulation Temperature Rise: 80deg C, maximum rise above 40 deg C.
- H. Basic Impulse Level: 95 kV Primary.
- I. Full-Capacity Voltage Taps: 4 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.
- J. Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps below rated primary voltage, with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
- K. Sound level rating a minimum of 57 dB or less.
- L. Impedance: <Insert value> percent.
- M. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm. RS485 modbus communication to WinPM system.
- N. Coils shall be wound with copper conductors.
- O. Ground Bar: Copper, continuous through transformer, primary switch and switchboard section with appropriate jumpers at shipping splits.



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2.10 SECONDARY DISTRIBUTION SECTION

- A. Secondary Distribution: Low-voltage switchgear as specified in Division 26 Section "Low Voltage Switchgear."
- B. Secondary distribution section shall be bus connected to transformer secondary (for either dry type or oil filled secondary unit substation transformer).
- C. Factory assemble and test complying with IEEE C37.20.1.
- D. The complete switchgear structure shall be metal enclosed and fabricated from sheet steel with separate bus and circuit breaker compartments. No live parts shall be exposed. Air vents and general design of the housing shall match that of transformer and switch sections.
- E. A full height rear compartment shall be provided for the bare busses, instrument transformers and outgoing feeder cable connections. All bus bars shall be bare copper. Bus supports shall be designed to withstand the stress produced by a fault current of 65,000 amperes.
- F. Finish: IEEE C37.20.1, manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.
- G. Section barriers between main, and circuit-breaker compartments shall be extended to rear of sections.
- H. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.
- I. Circuit-breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors.
- J. Fabricate enclosure with removable, hinged, rear cover panels to allow access to rear interior of switchgear.
- K. Auxiliary Compartments: Match and align with basic switchgear assembly. Include the following:
 - 1. Bus transition sections.
 - 2. Incoming-line pull sections.
 - 3. Hinged front panels for access to metering, accessory, and blank compartments.
- L. Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.
 - 1. Main Phase Bus: Uniform capacity the entire length of assembly.
 - 2. Neutral Bus: 100 percent of phase-bus ampacity, except as indicated. Equip bus with pressure connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.
 - 3. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
 - 4. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
 - 5. Use copper for connecting circuit-breaker line to copper bus.



6. Contact Surfaces of Buses: Silver plated.
 7. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
 8. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size ¼ by 2 inches.
 9. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.
 10. Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.
 11. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
 12. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.
 - a. Sprayed Insulation Thickness: 3 mils minimum.
 - b. Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.
- M. Empty compartments are only allowed in the main vertical sections. All other vertical sections not occupying a circuit breaker must be bussed ready to accept a circuit breaker. Configured for storage.
- N. Provide extra deep sections, when rear access required.

2.11 CIRCUIT BREAKERS

- A. Description: Comply with IEEE C37.13.
- B. Ratings: 65,000 symmetrical amperes interrupting and 30 cycle withstand rating at 480 volts.
- C. All air circuit breakers in the low-voltage switchgear shall be drawout type, rated 600 volts and front removable.
 1. Feeder breakers must be full size. Only one feeder breaker may occupy a 20-inch-wide compartment.
 - a. Side by side breakers in one 20-inch-wide compartment is not acceptable.
- D. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
 1. Normal Closing Speed: Independent of both control and operator.
 2. Slow Closing Speed: Optional with operator for inspection and adjustment.
 3. Stored-Energy Mechanism: Manually charged.
 4. Operation counter.
- E. Trip Devices: Solid-state, overcurrent trip-device system which requires no external power connections consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
 1. Main breakers (Siemens ETU776) with “Metering +” (Electrically operated with remote control.)
 - a. Long time trip.



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- b. Long time trip delay.
 - c. Short time trip.
 - d. Short time trip delay.
 - e. Ground fault trip.
 - f. Ground fault trip delay.
 - 2. Feeder breakers: (Siemens ETU 776) with "Metering +"
 - a. Long time trip.
 - b. Long time trip delay.
 - c. Short time trip.
 - d. Short time trip delay.
 - e. Instantaneous trip.
 - f. Ground fault trip.
 - g. Ground fault trip delay.
 - h. Provide ZSI
 - 3. Temperature Compensation: Ensure accuracy and calibration stability from minus 5 to plus 40 deg C.
 - 4. Field-adjustable, time-current characteristics.
 - 5. Current Adjustability: Dial settings and ratings plugs on trip units or sensors on circuit breakers, or a combination of these methods.
 - 6. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
 - 7. Pickup Points: Five minimum, for longtime- and short-time-trip functions. Equip short-time-trip function for switchable I²t operation.
 - 8. Pickup Points: Five minimum, for instantaneous-trip functions.
 - 9. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:
 - a. Three-wire circuit or system.
 - b. Four-wire circuit or system.
 - c. Four-wire, double-ended substation.
 - 10. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault (overload, short circuit and ground fault).
 - 11. Loads shall be connected ABC – clockwise.
 - 12. Provide one spare trip unit for each type used and spare communication module.
- F. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:
- 1. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed and prevent closure of circuit breaker unless it is connected, test, or disconnected position.
 - 2. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:
 - a. Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.



- b. Disconnected Position: Primary and secondary devices and ground contact disengaged.
 - 3. Provide shutters installed over bus when the breaker is removed.
 - G. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position and arranged to permit inspection of contacts without removing circuit breaker from switchgear. Solid block silver inlaid main contacts with arc chutes totally enclosing arcing contacts.
 - H. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
 - I. Operating Handle: Insulated, one for each circuit breaker capable of manual operation.
 - J. Electric Close Button: One for each electrically operated circuit breaker.
 - K. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.
 - L. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.
 - M. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices. Indicator lights shall be LED.
 - N. Manual trip button.
 - O. Solderless clamp type side connectors sized in accordance with feeder sizes as shown on riser diagram.
 - P. Each drawout circuit breaker shall be enclosed within an individual compartment fashioned from sheet steel. A steel door shall be provided with concealed hinges and ventilating grilles.
 - Q. All breakers shall have handles extending through the door so that the breaker can be operated with positive safety.
- 2.12 METERING
- A. Provide Siemens model number 9610-EH-1156-JZZB meter mounted in substation.
- 2.13 COMPONENTS
- A. Instrument Transformers: Comply with IEEE C573.13.
 - 1. Potential Transformers: Secondary-voltage rating of 120V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.



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2. Current Transformers: Ratios as indicated; burden and accuracy class suitable for connected relays, meters, and instruments.
- B. Surge Arrestors: Distribution class, metal-oxide-varistor type. Comply with IEEE C62.11 and NEMA LA1.
 1. Install in cable termination compartments and connect in each phase of circuit.
 2. Coordinate rating with circuit voltage.
- C. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.
- D. Control Power Supply: Control power transformer supplying 120V 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 a relay or relays to control bus to affect an automatic transfer scheme.
 3. Control Power Fuses: Primary and secondary fuses with current-limiting and overload protection.
 4. Fuses are specified in Division 26 Section "Fuses"
- E. 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 conductors for interconnections between shipping units.
 2. Conductors sized according to NFPA 70 for duty required.

2.14 ACCESSORIES

- A. Accessory Set: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.
 1. Racking handle to manually move circuit breaker between connected and disconnected positions.
 2. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
 3. Remote racking device.
- B. Circuit-Breaker Removal Apparatus: Provide breaker traveling lifting device (hoist) mounted on top of the low-voltage section of each of the units. Lifting device shall include guide tracks, travel carriage, moveable hoist, pulleys, supports, cable of adequate length, lifting hook, etc., as required for complete installation.
- C. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.



- D. Provide HMI in Substation to allow remote operation of breaker – manual charge.

2.15 SURGE SUPPRESSION

- A. Surge Suppression: Factory installed as an integral part of the low-voltage switchgear, complying with UL 1449 SPD, Type 1.
- B. Surge Protection Devices:
 - 1. Modular design (with field-replaceable modules).
 - 2. Fuses rated at 200-kA interrupting capacity.
 - 3. Fabrication using bolted compression lugs for internal wiring.
 - 4. Integral disconnect switch.
 - 5. Redundant replaceable modules.
 - 6. Redundant suppression circuits.
 - 7. Arrangement with copper bus bars and for bolted connections to phase buses neutral bus, and ground bus.
 - 8. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - 9. LED indicator lights for power and protection status.
 - 10. Audible alarm, with externally-accessible silencing switch, to indicate when protection has failed.
 - 11. Form-C contacts rated at 5 A and 250V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of a surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - 12. Four-digit transient-event counter set to totalize transient surges.
- C. Peak Single-Impulse Surge Current Rating: 240 kA per mode / 480kA per phase.
- D. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2
 - 1. Line to Neutral: 70,000 A.
 - 2. Line to Ground: 70,000 A.
 - 3. Neutral to Ground: 50,000 A.
- E. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 V, 3-phase, 4-wire circuits shall be as follows:
 - 1. Line to Neutral: 800V for 480Y/277V.
 - 2. Line to Ground: 800V for 480Y/277V.
 - 3. Neutral to Ground: 800V for 480Y/277V.

2.16 TEST EQUIPMENT

- A. Provide the substation manufacturers supplied circuit breaker tester for setting and calibrating the breakers. Only one tester is needed per project.



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2.17 IDENTIFICATION NAMEPLATES

- A. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."
- B. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved 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 selected by Architect.
 - 3. Color: Contrasting with factory-finish background; as selected by Architect from manufacturer's full range.
 - 4. Provide Lamicoid Mimic bus per WMU standards.

2.18 RISER DIAGRAMS

- A. Provide an electrical one line for each substation, and emergency power framed, under plexiglass, and mounted on the wall of substation room, (minimum 30" x 42").

2.19 SOURCE QUALITY CONTROL

- A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90. Conduct switchgear and switchboard tests according to ANSI C37.51.
- B. Factory Tests: Perform the following factory-certified tests on each secondary unit substation:
 - 1. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.
 - 2. Ratios on the rated voltage connection and on tap extreme connections.
 - 3. Polarity and phase relation on the rated voltage connection.
 - 4. No-load loss at rated voltage on the rated voltage connection.
 - 5. Exciting current at rated voltage on the rated voltage connection.
 - 6. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.
 - 7. Applied potential.
 - 8. Induced potential.
 - 9. Temperature Test: If a 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 FA rating.
 - a. Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.
 - 10. Owner will witness all required factory tests. Notify Architect at least 21 days before date of tests and indicate their approximate duration.



- a. Refer to paragraph 1.13.
- 11. Temperature Test: If a 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 FA rating.
 - a. Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.
- 12. Owner will witness all required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.



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PART 3 - EXECUTION

3.1 EXAMINATION

3.2 Examine areas and space conditions for compliance with requirements for secondary unit substations.

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

3.4 Wiring entries comply with layout requirements.

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

3.6 Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit substation installation.

3.7 Adjust 5-ohm value below to suit Project conditions.

3.8 Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at secondary unit substation location.

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

3.10 INSTALLATION

3.11 Install secondary unit substations on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

3.12 Revise below to suit anchoring requirements for Project.

3.13 Anchoring: Tack-weld or bolt secondary unit substation components to channel-iron sills embedded in concrete base. Install sills level and grout flush with floor or base.

3.14 IDENTIFICATION



- 3.15 Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- 3.16 Operating Instructions: Frame printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of secondary unit substation.
- 3.17 CONNECTIONS
- 3.18 Ground equipment to main electrical ground bus as indicated.
- 3.19 Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- 3.20 CLEANING
- 3.21 After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.
- 3.22 EXAMINATION
- A. Examine areas and space conditions for compliance with requirements for secondary unit substations.
 - 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 conditions for secondary unit substation installation.
 - D. Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at secondary unit substation location.
 - E. Proceed with installation only after unsatisfactory conditions have been corrected.



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3.23 INSTALLATION

- A. Receive, inspect, unload and install Unit Substation equipment. Provide Owner with written inspection report. Report any damage immediately to Owner's representative before unloading equipment.
- B. Install secondary unit substation in accordance with Manufactures recommendations.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from substation unit and components.
- D. Install secondary unit substations on concrete bases.
 - 1. Anchor substation assembly to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 26 Sections "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 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section".
 - 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 anchoring equipment to the concrete base.
 - 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. Bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.
 - 8. Use care to keep highest operating handle within NFPA 70.
- E. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
- F. Devices shall be programmed into existing WinPM.Net 6.0 Software.
- G. Provide a copper ground bus around the perimeter walls of the substation, mount at 24 inches AFF. Keep continuous by routing above and around obstacles.
- H. Anchoring: Tack-weld or bolt secondary unit substation components to channel-iron sills embedded in concrete base. Install sills level and grout flush with floor or base.

3.24 IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
 - 1. Provide engraved plastic-laminate sign per Section 26 0553 "Electrical Identification", located on each component listed below and indicating the following lines of information:
- B. Operating Instructions: Frame printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency



procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of secondary unit substation.

- C. Phasing: For buildings equipped with multiple transformers and tie switches verify substations are in phase with each other.

3.25 CONNECTIONS

- A. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B
- B. Connect wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables" and Division 26 Section "Medium-Voltage Cables" per 26 0519 and 26 0513.
- C. Ground equipment to main electrical ground bus as indicated and per 26 0526.

3.26 CLEANING

- A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.
- B. All bussing and circuit breakers shall be wiped down per WMU Standards.
 - 1. All equipment to be cleaned a second time two weeks after substantial completion.

3.27 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.
 - 1. Provide full testing of transformer after reassembly by factory-authorized service representative.
- B. Testing: Owner will engage a qualified testing agency to perform the following field quality-control testing:
- C. Testing: Engage a qualified testing agency to perform the following field quality-control testing:
- D. Testing: Perform the following field quality-control testing:
 - 1. Perform each visual and mechanical inspection and electrical test for each component of substation according to NETA ATS, including secondary injection testing. Certify compliance with test parameters.
 - a. Verify all trip functions by means of primary injection.



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- b. Verify all functions of trip unit by means of secondary injection.
 - c. Verify all trip functions of main and tie circuit breakers by means of primary injection.
 - d. Verify all functions of trip units for all feeder circuit breakers by means of secondary injection.
 - 2. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation tested at the specified value or less.
 - 3. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
 - 4. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
 - a. Remove and replace malfunctioning units and retest as specified above.
 - 5. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arrestors, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.
 - 6. After installing SPD devices but before electrical circuitry has been energized, test for compliance with requirements.
 - 7. Complete startup checks according to manufacturer's written instructions.
 - 8. SPD device will be considered defective if it does not pass tests and inspections.
- E. Perform the following test on the transformer:
- 1. Visual and Mechanical Inspection
 - a. Compare equipment nameplate information with single line diagram.
 - b. Inspect for physical damage, cracked insulators, leaks, tightness of connections, and general mechanical and electrical conditions.
 - c. Verify proper auxiliary device operation.
 - d. Verify proper liquid level in all tanks and bushings.
 - e. Perform specific inspections and mechanical tests as recommended by manufacturer.
 - f. Verify proper equipment grounding.
 - g. Verify removal of any shipping bracing after final placement.
 - 2. Electrical Tests
 - a. Perform insulation resistance tests, winding-to-winding and windings-to-ground, utilizing a meg-ohmmeter with test voltage output as shown in accordance with N.E.T.A. Acceptance Testing Specifications, Table 10.5. Test duration shall be for 10 minutes with resistance values tabulated at 30 seconds, 1 minute, and 10 minutes. Calculate Polarization index.
 - b. Perform a turns ratio test between windings at all tap positions. The final tap setting is to be set at the secondary system rated voltage at full load or as directed by the Architect/Engineer.
 - c. Insulating liquid shall be sampled in accordance with ASTM D-923. Sample shall be laboratory tested for:
 - 1) Dielectric breakdown voltage: ASTM D-877 or ASTM D-1816
 - 2) Acid neutralization number: ASTM D-974
 - 3) Interfacial tension: ASTM D-971 or ASTM D-2285
 - 4) Color: ASTM D-1500



- 5) Visual Condition: ASTM D-1524
- 6) Perform dissolved gas analysis (DGA) in accordance with ANSI/IEEE C57.104 or ASTM D-3612 for transformers 500 kVA and larger.

- d. PPM water: ASTM D-1533.
- e. Perform insulation power factor tests or dissipation factor tests on all windings and bushings. Overall dielectric-loss and power factor (C_H , C_L , C_{HL}) shall be determined. Test voltages should be limited to the line to ground voltage rating of the transformer winding.
- f. Perform tests and adjustments on tap-changer, fan and pump controls, and alarm function.
- g. Verify proper core grounding if accessible.
- h. Perform percent oxygen test on the nitrogen gas blanket for 3000 kVA or larger.

3.28 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.

3.29 ENERGIZING

- A. Contractor to verify pre-energize checklist is complete.
- B. Inspections by the following are to be completed prior to energizing equipment:
 - 1. State of Michigan
 - 2. Consulting Professional Engineer
 - 3. Commissioning Agent (Checklist provided by WMU Engineers)
 - 4. WMU Engineers
- C. Initial energizing to be outside of normal business hours (8 AM to 5 PM, Monday through Friday)

3.30 FOLLOW-UP SERVICE

- A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:
 - 1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each secondary unit substation. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
 - 2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:



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- a. Adjust transformer taps.
 - b. Rebalance loads.
 - c. Prepare written request for voltage adjustment by electric utility.
 - d. Transformer insulation fluid manufacturer test results.
3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
4. Report: Prepare a written report covering monitoring performed and corrective action taken.
- B. Transformer Tests: Perform transformer electrical tests indicated above six (6) months after substantial completion and twelve (12) months after substantial completion. Testing shall be performed by a third-party testing firm.

3.31 DEMONSTRATION

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

END OF SECTION 26 1116



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 1200 – 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes distribution and power transformers with medium-voltage primaries. Types of transformers specified in this Section include the following:
 - 1. Dry-type distribution and power transformers.
 - 2. Liquid-filled distribution and power transformers.
- B. Related Sections: The following Section contains requirements that relate to this Section:
 - 1. Division 26 Section "Secondary Unit Substations" for transformers integral to substations.

1.3 DEFINITIONS

- A. NETA ATS: Acceptance Testing Specification.

1.4 ACTION SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.



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- B. Product data for each product specified, including dimensioned plans, sections, and elevations. Show minimum clearances and installed devices and features.
- C. Wiring diagrams of transformers and accessory components, differentiating between manufacturer-installed and field-installed wiring.
- D. Product certificates signed by manufacturers certifying that their products comply with the specified requirements.
- E. Sound Level Test Reports: Certified copies of manufacturer's sound level tests applicable to equipment for this Project.
- F. Operation and maintenance data for materials and products to include in the "Operating and Maintenance Manual" specified in Division 1.
- G. Field test reports of tests and inspections conducted according to Part 3 of this Section.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced Installer of medium-voltage electrical distribution equipment to perform the installation specified in this Section. Refer to Division 1 Section "Reference Standards and Definitions" for definition of an experienced Installer.
- B. Comply with NFPA 70 "National Electrical Code."
- C. Comply with IEEE C2 "National Electrical Safety Code."

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Temporary Heating: Apply temporary heat according to manufacturer's recommendations within enclosure of each indoor ventilated dry-type transformer throughout periods during which equipment is not energized and is not in a space that is continuously under normal control of temperature and humidity.



1.7 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

1.8 WITNESS TESTING

- A. Include transportation, lodging and meal costs for witness testing of the medium voltage transformers.
- B. Include all costs for three individuals for paragraph A above
 - 1. Provide notice of travel three weeks prior to date.
 - 2. Combine trips for maximum efficiency.
 - 3. Ground transportation shall not exceed five hours one way.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
 - 1. General Electric Co.
 - 2. Siemens Energy & Automation, Inc.
 - 3. Square D, Co

2.2 TRANSFORMERS, GENERAL

- A. Windings: Two-winding type, designed for operation with high-voltage windings connected to a 3-phase, 3-wire, 60-Hz, grounded neutral distribution system.
- B. Forced-air cooling equipment consists of cooling fans, temperature-sensing devices, and controls complete with housing, mounting devices, conduit, and wiring.
 - 1. Cooling Fan Operation: Automatically and sequentially controlled by temperature-sensing devices.



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2. Cooling Fans: Propeller type, with aluminum blades and TEFC motors, direct drive. Motor circuits are individually fused or thermally protected. Fans have OSHA fan guards.
3. Fan Control: Thermally operated winding, temperature-sensing devices.

C. Windings: Copper.

2.3 DRY-TYPE TRANSFORMERS

A. Description: Comply with NEMA Standard ST 20, "Dry-Type Transformers for General Applications" and IEEE Standard C.57.12.01, "General Requirements for Dry-Type Distribution and Power Transformers."

1. Enclosure: Indoor, ventilated.
2. Cooling System: IEEE Standard C57.12.01, Class AA/FA.
3. Insulation Class: 220 deg C, Class H.
4. Insulation Temperature Rise: 80 deg C maximum rise above 40 deg C.
5. Basic Impulse Insulation Level: 95 kV
6. Impedance: 5.75% with NEMA Standard 7 - 1/2% tolerance.

B. STANDARDS AND TESTS

1. The equipment and the testing there of shall be in accordance with the latest ANSI / IEEE standards C57 series for Distribution, Power and Regulating Transformers, in force at bidding time; NEMA Standards for the same, and IEEE Standards for the same.

C. TRANSFORMER ARRANGEMENT

1. The high voltage and low voltage connections shall be terminated at bus bars drilled with four holes per bus for the external connection and located at opposite sides inside the enclosure.
2. A cutout of suitable size with bolted and gasketed cover plate shall be provided on top and at the end of transformer enclosure opposite the LV buses or as required for the connections to the existing HV and LV side equipment.

D. DIELECTRIC REQUIREMENTS

1. For the high voltage windings the dielectric insulation levels shall be those listed in tables 3 and 4 of ANSI C57.12.00 distribution class.



2. For the low voltage windings rated at 480/277 volt the dielectric insulation levels shall be those listed in tables 3 and 4 of C57.12.00 distribution class.

E. INSULATION SYSTEM

1. Class H material suitable for operation at 220°C total temperature (it does not pertain to the hot spot operating temperature of the assembled windings).
2. The insulation system shall not crack or separate from the windings under cyclical loading, short circuit stresses, or other thermal and mechanical stresses.

F. CORE AND COIL ASSEMBLIES

1. Each transformer shall have two windings. High voltage and low voltage windings shall be copper and electrically separate.
2. The coils shall be of the cylindrical wound construction. Coils shall be continuous wound without splices except for taps.
3. The high voltage and low voltage windings shall be coaxially arranged, the secondary winding, inside the primary. There shall not be any rigid mechanical connection between coils.
4. The coils shall be magnetically balanced and supported at the top and bottom with cast epoxy blocks, porcelain insulators or similar non-hygroscopic and high temperature supports and with vibration isolators if required. The coil assemblies, leads, taps and terminals shall be rigidly braced to withstand the stresses caused by short circuits and rough handling. The short circuit mechanical and thermal withstand capability shall be that specified by ANSI standards.
5. The coils shall include ventilating ducts of adequate area for cooling.
6. The coils shall be assembled on cores of high grade, non-aging grain oriented, cold-rolled silicon steel laminations. The transformer shall be sealed and protected using a VPI process. The preheated windings shall be subjected to a dry vacuum cycle, followed by wet vacuum cycle during which windings are impregnated with resin, then followed by a pressure cycle to force resin through the insulation. The windings shall be over cured to bind the resin to the insulation material. The VPI and oven curing process shall completely seal and protect the windings from moisture and dirt, and shall eliminate any voids which could create hot spots, partial discharge, or cause corona formation. Dip and bake impregnation is not acceptable. Laminations shall be free of burrs, stacked without voids. All joints shall be mitered and precisely fit.



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7. The core shall be grounded to the enclosure in one place with a flexible strap of adequate capacity.
8. The interphase connections on the high voltage side shall be with copper cable. It shall be of 90°C rating minimum and installed so that it is not in contact with any surface exceeding this limit. Interphase connections on the low voltage side shall be made with copper bus. Connections to the buses of the high and low voltage sections shall be flexible.
9. Include vibration damping pads under core and coils to isolate the base from the enclosure and all attachments to the enclosure.
10. The core assembly shall be provided with lifting lugs.

G. TAPS AND TAP CHANGER

1. Two 2 - 1/2% taps above and two 2 - 1/2% taps below nominal rated voltage shall be provided in the high voltage Windings. All shall be rated KVA taps.
2. The taps shall be brought out to tap connections on each phase coil for manual operation. They shall be accessible by removable covers. The tap connections shall be brazed.

H. ACCESSORIES

1. All accessories must be of proper design and material and the best procurable for the service.
2. Fan Cooling: Provide all devices and wiring for fan cooling (including the cooling fans) to increase the 80°C self-cooled rating to 133%. Provide the equipment for forced air cooling, temperature indication and high temperature alarm. Control of the forced air-cooling equipment and indication of high temperature alarm shall be from hottest temperature as detected by a thermocouple wound into the transformer coils at the actual hottest spot.
3. Hot spot temperature detector consisting of a bulb sensor or of the manufacturer's standard equipment so located and calibrated to indicate the hot spot. One detector shall be provided in the low voltage winding operating at the highest temperature for delta connected units and one for each winding for wye connected units.



4. A control module shall be provided to include:
 - a. Hot spot temperature indicator or indicators (one required for each phase).
 - b. The indicator shall be equipped with three normally open electrically separate contacts set to close on temperature rise as follows:
 - 1) Contact No. 1 100°C Fans
 - 2) Contact No. 2 135°C Alarm
 - 3) Contact No. 3 175°C Future use
 - 4) Any auxiliary relays required.
 - 5) Manual-Auto switch, magnetic starter and 480-120 volt control transformer.
 - 6) Alarm shut-off.
 - 7) Power ON light.
 - 8) Fans ON light.
 - 9) High temperature light and alarm contact.
 - 10) High temperature tripout.
 - 11) A fused (primary side) central power transformer of 25% extra capacity than required to run the fans and control at 480 volt -120/240 volt.
5. The ventilating fans shall be mounted inside the enclosure and so directed as to adequately cool the core and coils to standard temperatures during fan operation.
6. The control module and nameplate shall be mounted in the same side of the unit which shall be considered as the front. All wiring shall be brought to a terminal block located in the control module. The control module shall be installed in the enclosure sheet and be accessible with a cover.
7. Two grounding pads or bus.

I. NAMEPLATE

1. The transformer shall be equipped with an identifying nameplate of stainless steel or anodized aluminum suitably inscribed to include: Serial No., Shop Order No., Class of transformer, number of phases, frequency, KVA rating of all windings, voltage ratings, tap voltages, temperature rise, vector diagram, percent impedance between each pair of windings, core and coil weight, case and fittings weight, total weight, connection diagram, impulse level, and manufacturer's name.

J. REGULATION

1. The regulation shall be compatible with the specified impedance for rated KVA at 0.8 PF lagging and 1.0 PF.

K. LOSSES



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1. The transformer shall be so designed that its maximum efficiency occurs at between 50% and 75% load.
2. The core losses shall be kept low and they shall not exceed 25% - 35% of the total full load losses.
3. All losses are referred to ANSI standard reference temperature.

L. ENCLOSURE AND BASE

1. The base shall be constructed rigidly with angle iron, channels and/or I-beams and be suitable to jacking, rolling and skidding in any direction.
2. The enclosure shall be steel of ANSI standard gauge.
3. Ventilation grilles top and bottom, front and back, approximately opposite the coils of each phase. They shall be louvered and shall prevent accidental access to live components. Ventilating area shall be adequate for the losses.
4. Case, supporting steel frame and removable enclosing panels and structural steel base. The entire assembly shall be adequately brace to withstand the forces of shipping, handling and operation.
5. Ventilation grilles top and bottom, front and back, approximately opposite the coils of each phase. They shall be louvered and screened and shall prevent accidental access to live components. Area shall be adequate as required by the losses.
6. The enclosure shall be bolted to the frame with captive screws or similar to permit disassembly. The panes shall be split and arranged for lifting by one man.
7. Provide lifting lugs on the enclosure.

M. STANDARD TESTS

1. The Contractor shall be required to furnish certified copies of the standard ANSI and NEMA tests required and to include:
2. No load loss, exciting current, impedance and load loss, polarity and phase relation test, ratio tests on all connections, high and low voltage, winding resistance applied and inducted potential tests.
3. For the items listed below the values shall be from test data on similar unit for all nameplate KVA ratings.



- a. LV Winding Temperature rise HV Winding Temperature rise BIL Tests
- b. Noise Level Tests
- c. Corona Test (where applicable)

N. DRAWINGS

1. In addition to the drawings noted within these specifications, the following listed drawings are required for as they pertain to the transformer unit:
 - a. Bushing Details
 - b. Nameplate Drawing
 - c. Connection Diagrams for fan control, alarm tripout and other control wiring and alarm wiring on transformer.
2. All of the above shall be submitted for approval.

O. CONTROL WIRING

1. Control wiring shall be neatly arranged, firmly clamped, adequately protected from line voltage parts, brought to readily accessible terminal blocks with marking strip for lead identification.
2. Control wiring to which external connections are to be made shall be brought to suitably located terminal blocks.
3. All control wiring shall be flame and moisture resistant insulation (prefer type SIS) and to be minimum of No. 14 AWG copper conductor.

P. SHIPPING

1. The transformer shall be shipped completely assembled and wired including ventilating fans and accessories.
2. The equipment shall be shipped with lifting angles or approved means for lifting attached.

2.4 LIQUID-FILLED DISTRIBUTION AND POWER TRANSFORMERS

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



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- B. Energy Efficiency: Transformer must be DOE 2016 compliant.
- C. Insulating Liquid: Mineral oil, ASTM D 3487, Type II; tested according to ASTM D 117.
- D. Insulating Liquid: Less flammable, edible-seed-oil based, and listed by a NRTL acceptable to authority having jurisdiction 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.
- E. Insulating Liquid: Less flammable, dielectric, and listed by a NRTL acceptable to authority having jurisdiction 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.
- F. Insulating Liquid: Less flammable, silicone-based dielectric, and listed by a NRTL acceptable to authority having jurisdiction 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 have low toxicity and be nonhazardous.
- G. Insulation Temperature Rise: 65/55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C.
- H. Basic Impulse Level: Comply with UL 1062.
- I. Full-Capacity Voltage Taps: Four, 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable, de-energized tap changer; position indicator; and padlock hasp.
- J. Cooling System: Class FFA, forced-air-cooled rating.
- K. Accessories:
 - 1. Grounding pads, lifting lugs, and provisions for jacking under base.
 - 2. Insulated, low-voltage, neutral bushing with removable ground strap.
 - 3. Liquid-level gage.
 - 4. Pressure-vacuum gage.
 - 5. Liquid temperature indicator.
 - 6. Drain and filter valves.
 - 7. Pressure relief device.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with IEEE Standard C2, "National Electrical Safety Code" and the manufacturer's written installation instructions:



- B. Identify transformers and install warning signs according to Division 16 Section "Electrical Identification."
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.2 GROUNDING

- A. Ground transformers and systems served by transformers according to Division 16 Section "Grounding."

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services: Arrange and pay for the services of a factory-authorized service representative to supervise the field assembly and connection of components, and the pretesting and adjustment of transformer components and accessories.
- B. Tests: Include the following minimum inspections and tests according to the manufacturer's instructions. For test method and data correction factors, conform to IEEE Standard Test Codes C57.12.91 for dry-type units
 - 1. Inspect accessible components for cleanliness, mechanical, and electrical integrity, for the presence of damage or deterioration, and to ensure removal of temporary shipping bracing. Do not proceed until deficiencies are corrected.
 - 2. Dry-Type Transformers: Include internal inspection through access panels and covers.
 - 3. Inspect bolted electrical connections for tightness according to manufacturer's published torque values or where not available, those of UL Standards 486A and 486B.
 - 4. Insulation Resistance: Perform megohmmeter test of primary and secondary winding to winding, and winding to ground according to the following:

Winding Rating (Volts)	Minimum Test Volts(D.C.)	Minimum Insulation	
		Resistance (Megohms)	
		Dry Type	Liquid Filled
0 – 600	1,000	500	100
601 – 5,000	2,500	5,000	1,000
5,000 – 35,000	5,000	25,000	5,000



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- a. Duration of each test: 10 minutes
 - b. Temperature Correction: Correct results for test temperature deviation from 20 degree C standard.
 - 5. Turns Ratio: Measure between windings at each tap setting. Measured ratios deviating more than 0.5 percent from the calculated ratio or the measured ratio for adjacent coil are not acceptable.
 - 6. Winding Resistance: Measure for winding at nominal tap setting. Measured resistance deviating more than 1 percent from that of adjacent winding not acceptable.
 - 7. Overpotential Tests: Apply between high and low voltage and ground at not over 85 percent of factory test value for 1 minute.
 - 8. Provide a written report of test results.
- C. Test Failures: Compare test results with specified performance or manufacturer's data. Correct deficiencies identified by tests and retest. Verify that transformers meet specified requirements.

3.4 ADJUSTING

- A. After completing installation and cleaning, touch up scratches and mars on finish to match original finish.
- B. Adjust transformer taps to provide optimum voltage conditions at utilization equipment throughout the normal operating cycle of the facility. Record voltages and tap settings to submit with test results.

3.5 DEMONSTRATION

- A. Training: Arrange and pay for the services of a factory-authorized service representative to demonstrate transformer and accessories and train University maintenance staff. Cover at least the following:
 - 1. Safety precautions.
 - 2. Features and construction of project transformers and accessories.
 - 3. Routine inspection, test and maintenance procedures.
 - 4. Routine cleaning.
 - 5. Features, operation, and maintenance of integral disconnect and protective devices.
 - 6. Interpretation of readings of indicating and alarm devices.
 - 7. Fuse selection.
 - 8. Features, operation and maintenance of separable insulated connector system.
 - 9. Tap changing procedures.



- B. Schedule training with at least 7 day's advance notice to University.

END OF SECTION 26 1200



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 1300 - 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 RELATED DOCUMENTS

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

1.3 SUMMARY

- A. This Section includes metal-enclosed interrupter switchgear with the following optional components, features, and accessories:
 - 1. Copper, tin-plated main bus.
 - 2. Surge arresters.
 - 3. Mimic Bus
- B. Medium voltage primary switch unit shall consist of two 15 kV primary selector switches for the incoming feeders and two 15 kV fused transformer primary switches and shall be furnished complete with channels.

1.4 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
- B. GFCI: Ground-Fault Circuit Interrupter.

1.5 ACTION SUBMITTALS

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



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1. Rated capacities, operating characteristics, furnished specialties, and accessories for individual interrupter switches.
 2. Time-current characteristic curves for overcurrent protective devices, including 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.
 - e. Current ratings of buses.
 - f. Short-time and short-circuit ratings of switchgear assembly.
 - g. Nameplate legends.
 - h. Mimic bus diagram
 2. 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.
- C. 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.
- 1.6 INFORMATIONAL SUBMITTALS
- A. Source quality-control test reports.
- B. Field quality-control test reports.
- C. Operation and Maintenance Data: For switchgear and switchgear components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "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.



1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
- B. Source Limitations: Obtain each type of switchgear and associated components through one source from a single manufacturer.
- C. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- D. 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.
- E. Comply with IEEE C2.
- F. The switchgear shall conform to the following:
 - 1. ANSI C37.20
 - 2. IEEE Standard 27
 - 3. NEMA SG-5
 - 4. National Electrical Code Article 710-21(e)

1.8 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 with uniform temperature 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.

1.9 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:
 - 1. Ambient temperature not exceeding 122 deg F.
- B. Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.



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- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear and adjacent surfaces and other items. Comply with indicated maximum dimensions. **[Clear space to mobilize switchgear and substation to indicated location is limited, review drawing dimensions to insure equipment can fit prior to ordering].**
- D. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Construction Manager and Owner no fewer than ten days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Construction Manager's and Owner's written permission.

1.10 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 in Division 03.

1.11 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: 3 of each type and rating used.
 - 2. Indicating Lights: Six of each type installed.
 - 3. Touchup Paint: 3 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.
- C. Products Supplied but not installed under this section
 - 1. Provide 3 spare primary fuses for each size used in the primary interrupter switches.
 - 2. Portable control station with 50 ft. cord.
 - 3. Test accessory.
 - 4. Shotgun stick.
 - 5. Shotgun stick storage bag.



6. Universal Pole 8'-0" long.
7. Grappler handling tool.
8. Any other miscellaneous components and accessories.

D. Mount all spare equipment in spare fuse cabinet or mount on wall in substation room.

1.12 WITNESS TESTING

- A. Include transportation, lodging and meal costs for witness testing of medium-voltage switchgear.
- B. Include all costs for three individual for paragraph A above
 1. Provide notice of travel three weeks prior to date.
 2. Combine trips for maximum efficiency.
 3. Ground transportation shall not exceed five hours one way.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

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: 13.8 kV nominal; 15kV maximum.

2.3 METAL-ENCLOSED INTERRUPTER SWITCHGEAR

- A. Manufacturers:
 1. Siemens Energy & Automation, Inc.
- B. Comply with IEEE C37.20.3.
- C. Comply with IEEE C37.20.7. Provide arc-resistant switchgear, Type 1.



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- D. Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with value of fault current indicated.
- E. Ratings: Comply with standard ratings designated in IEEE C37.20.3 for maximum-rated voltage specified.
 - 1. Main-Bus Rating: 600 A, continuous.
- F. Interrupter Switches: Stationary, gang operated, and suitable for application at maximum short-circuit rating of integrated switchgear assembly.
 - 1. Rating: 600 -A continuous duty and load break.
 - 2. Duty-Cycle, Fault Closing: 40,000 indoor 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.
 - 8. The momentary and duty-cycle fault-closing ratings of switches, momentary rating of bus and interrupting ratings of fuses shall equal or exceed the short-circuit ratings of the metal-enclosed switchgear.
 - 9. Integrated switchgear assembly:
 - a. Nominal kV: 13.8
 - b. Maximum Design kV: 15
 - c. BIL kV: 95
 - d. Short Circuit Ratings
 - 1) 25,000A RM Symmetrical
 - 2) Three-Phase Symmetrical at Rated Nominal Voltage 600MVA
- G. Mechanical Interlock: Prevent opening switch compartment door unless switchblades are open, and prevent closing switch if door is open.
- H. The switch unit shall be arranged to provide control of switches from the front as indicated on the drawing. Unit shall be free standing, consisting of cubicles arranged for bolting together in the electrical room. Cubicles shall be welded, reinforced sheet steel enclosures with hinged doors. Complete unit shall be rustproofed and painted two coats.
- I. The busses shall be insulated flat copper bar, mounted on track resistant bus supports. The contact surface for each bus connection shall be silver plated and tightly bolted to insure maximum conductivity.
- J. Primary switch unit shall have a ground bus extending through each compartment for its entire length. Provide connections to ground system as indicated.
- K. The bracing supporting the switches in the enclosure shall be of sufficient strength to permit laying the unit on its side. Also, the crating shall be arranged to permit laying the unit on its side for shipping.



- L. The primary switch unit shall be completely wired, assembled, and operationally checked at the factory.
 - 1. Provide switch position switches wired to meter.
- M. Window: Permit viewing switchblade positions if door is closed.
- N. 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.

2.4 SELECTOR SWITCHES

- A. Primary selector switches shall be heavy duty, quick-make quick-break, 15 kV, 600 ampere, 3 pole, 95 KV BIL, with a minimum load interrupting rating of 600 amperes.
- B. Metal enclosure of this unit shall be strong enough to protect the operator under 25,000 ampere RMS symmetrical short circuit operation of switches. Manufacturer and supplier of these switches shall furnish written guarantee or printed test information for same, stating that the operator will not be injured under the above short circuit operation.
- C. Each primary selector switch shall have diamond mesh expanded metal inner door with an engraved plate reading – WARNING – OPEN SWITCH BLADES MAY BE ENERGIZED – (Red in color).
- D. Primary selector switch units shall each be provided with lugs inside enclosure for termination of 250 KCMIL cable.
- E. Provide cable fault indicators.
 - 1. Manufacturer:
 - a. Schweitzer Engineering Laboratories, “3CR30400A.”
- F. Wire each phase contact to electrical meter.

2.5 TRANSFORMER LOAD BREAK SWITCHES

- A. Transformer primary switches shall be fused, heavy duty, quick-make quick-break, 15 KV, 600 ampere, 3 pole, 95 KV BIL, with a minimum load interrupting rating of 600 amperes.



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- B. Transformer primary switches shall each be provided with three 15 KV fuses sized to properly protect the unit substation transformer. Fuses shall be power type with condensers and minimum interrupting rating of 600 MVA. Fuses shall be S&C SM-5 series.
- C. Switches shall be provided with bus, 15 KV cable connection to transformer primary and sufficient space for termination of cables and terminators.

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. Key Interlocks: Arranged to effect interlocking schemes indicated.
- G. 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 and silver plated at connection points; full length of switchgear.
- B. Ground Bus: Copper, tin plated; minimum size 1/4 by 2 inches; full length of switchgear.
- C. Bus Insulation: Covered with flame-retardant insulation.
- D. 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.
- E. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.
- F. 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.
- G. 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 Division 26 Section "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: Black.
 - 4. Provide Lamicoid Mimic bus per WMU Standards.
- C. Phasing shall be marked at each termination location of 15KV cable in switchgear using 1 inch high, white, adhesive labels. Markings to be A, B, C reading from front or front to back while facing front of switchgear.
 - 1. This shall be reference to WMU Power Plant rotation clockwise, (ABC).

2.9 SOURCE QUALITY CONTROL

- A. Before shipment of equipment, perform the following tests and prepare test reports:
 - 1. Production tests on completed switchgear assembly according to IEEE C37.20.2.
 - 2. Production tests on circuit breakers according to ANSI C37.09.
- 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.



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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 and according to seismic-restraint details. See Division 26 Section "Hangers and Supports for Electrical Systems" and Division 26 Section Vibration and Seismic Controls for Electrical Systems.
 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 Division 26 Section "Identification for Electrical Systems."



- B. Provide engraved plastic-laminate signs, per Section 26 0553 "Identification for Electrical Systems", located on the front of each component, indicating the lines of information as follows:
 - 1. Incoming line section
 - a. Designation (e.g., "Incoming line A102")
 - b. Incoming line electrical characteristics (e.g., 13.8kV, 3PH, 3W, ungrounded").
 - 2. Feeder Section
 - a. Designation (e.g., "Feeder brkr. A-10")
 - b. Load served (e.g., "Load served: sub A1, A3, A5")
- C. 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
 - a. Maintenance manual.
 - b. Arc flash study.

3.4 CONNECTIONS

- A. Cable terminations at switchgear are specified in Division 26 Section "Medium-Voltage Cables."
- B. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables" and Division 26 Section "Medium-Voltage Cables."

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:



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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.
- E. Remove and replace malfunctioning units and retest as specified above.
- F. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
 2. Instrument: Use an infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes infrared-scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

- A. Set field-adjustable, protective-relay trip characteristics.

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.
- B. Wipe down all insulators.
- C. Construction may require additional cleaning at construction completion.



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. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 26 1300



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SECTION 26 2200 – LOW VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes general-purpose and specialty dry-type transformers and voltage regulators with windings rated 600 V or less.

1.3 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for each product specified, including dimensioned plans, sections, and elevations. Show minimum clearances and installed features and devices.
- C. Product Test Reports: Certified copies of manufacturer's design and routine factory tests required by referenced standards.
- D. Sound Level Test Reports: Certified copies of manufacturer's sound level tests applicable to equipment for this project.



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- E. Operation and maintenance data for materials and products to include in the "Operating and Maintenance Manual" specified in Division 1.
- F. Field test reports of tests and inspections conducted according to Part 3 of this section.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A firm experienced in manufacturing components that comply with the requirements of these Specifications and that have a record of successful in-service performance.
- B. Comply with NFPA 70 "National Electrical Code."
- C. Comply with IEEE C2 "National Electrical Safety Code."
- D. Listing and Labeling: Products are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Temporary Heating: Apply temporary heat according to manufacturer's recommendations within the enclosure of each ventilated type unit throughout periods during which equipment is not energized and is not in a space that is continuously under normal control of temperature and humidity.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:
 - 1. Transformers:
 - a. General Electric Co.



- b. Siemens Energy & Automation, Inc.
- c. Square D Co.

2.2 GENERAL-PURPOSE, DRY-TYPE TRANSFORMERS

- A. Comply with NEMA Standard ST 20 "Dry-Type Transformers for General Applications."
- B. Provide factory-assembled, premium quality, ventilated, 600 volt class, dry-type distribution transformers. All cores shall be constructed of high grade, non-aging silicon steel with high magnetic permeability. Transformer coils shall be continuous and wound copper. Provide primary windings with 4 taps; 2, 2-1/2% increments above full-rated voltage, and 2, 2-1/2% increments below full-rated voltage. For de-energized tap-changing operation. Full capacity taps.
- C. Insulate with 220 degrees C UL component recognized insulation system. Rate transformer for continuous operation at rated kVA; limit transformer temperature rise to maximum of 80 degrees C rise above a 40 degree C ambient.
- D. Provide terminal enclosure, with hinged cover, to accommodate primary and secondary coil wiring connection and electrical supply raceway terminal connector. Provide terminal board with clamp type connectors. Provide wiring connections suitable for copper wiring. Integrally mount vibration isolation supports between core and coil assembly and transformer enclosure; electrically ground core and coil to transformer enclosure by means of flexible metal grounding strap.
- E. Do not exceed maximum sound-level ratings as determined in accordance with ANSI/NEMA standards: 10.kVA - 45 dB, 51 to 150 kVA - 50 dB, 151 to 300 kVA - 55 dB, 301 to 500 kVA - 60 dB, 501 to 700 kVA - 62 dB, 701 to 1000 kVA - 64 dB, 1001 to 1500 kVA - 65 dB, 1501 to 2000 kVA - 66 dB.
- F. Provide transformers with heavy gauge steel enclosures and lifting lugs/holes. Apply manufacturer's standard light gray baked enamel over cleaned and phosphatized steel enclosure. Provide transformers suitable for floor mounting.
- G. Electrostatic Shielding: Insulated metallic shield between primary and secondary windings.
 - 1. Connect shield to terminal marked "shield" for grounding connection.
 - 2. Capacitance: Arrange shield to provide a maximum of 33 picofarads primary - to secondary capacitance over a frequency range of 20 hz to 1 mhz.



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- H. Windings: All copper.

2.3 DRY-TYPE DISTRIBUTION TRANSFORMERS FOR NON-LINEAR LOADS:

- A. Provide transformers satisfying the above requirements for general purpose Dry-Type Transformers and the following requirements. Transformers shall have a UL K-4 rating as indicated on the drawings. The K factor shall be based in accordance with ANSI/IEEE C57.1 10-1986. Manufacturer's rating K factors by average temperature rise alone shall not be acceptable. The transformer secondary neutral terminal shall be sized for 200% of the secondary phase current.

2.4 CONTROL AND SIGNAL TRANSFORMERS

- A. Comply with NEMA Standard ST 1, "Specialty Transformers," and UL Standard 506, "Specialty Transformers."
- B. Ratings: Continuous duty. Where ratings is not indicated, provide capacity exceeding peak load by 50 percent minimum.
- C. Type: Self-cooled, 2-winding, dry type.
- D. Enclosure: Suitable for the location where installed.

2.5 FINISHES

- A. Indoor Units: Manufacturer's standard paint over corrosion-resistant pretreatment and primer.

2.6 SOURCE QUALITY CONTROL

- A. Factory Tests: Design and routine tests conform to referenced standards.

PART 3 - EXECUTION



3.1 INSTALLATION

- A. Arrange equipment to provide adequate spacing for access and for cooling air circulation.
- B. Provide 4 inch concrete housekeeping pads for all floor mounted transformers. Coordinate with Division 03310, Concrete Work.
- C. Connect transformer units to conduit system using liquid tight flexible conduit.
- D. Identify transformers and install warning signs according to Division 26 Section "Electrical Identification."
- E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not furnished, use those specified in UL 486A and UL 486B.

3.2 GROUNDING

- A. Ground transformers and systems served by transformers according to Division 26 Section "Grounding and Bonding For Electrical Systems."

3.3 FIELD QUALITY CONTROL

- A. Test Objectives: To ensure transformer installation is operational within industry and manufacturer's tolerances, install according to Contract Documents, and suitable for energizing.
- B. Test Labeling: Upon satisfactory completion of tests for each unit, attach a dated and signed "Satisfactory Test" label to the tested component.
- C. Schedule tests and provide notification at least one week in advance of test commencement.
- D. Tests: Include the following minimum inspections and tests according to the manufacturer's instructions. Conform to IEEE Standard Test Code C57.12.91 for dry-type units, test method, and data correction factors.



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1. Inspect accessible components for cleanliness, mechanical, and electrical integrity, for presence of damage or deterioration, and to ensure removal of temporary shipping bracing. Do not proceed with tests until deficiencies are corrected.
 - a. Include internal inspection through access panels and covers.
 - b. Inspect bolted electrical connections for tightness according to manufacturer's published torque values or, where not available, those of UL standards 486A and 486B.
2. Insulation Resistance: Perform megohmmeter test of primary and secondary winding to winding and winding to ground.

3.4 ADJUSTING

- A. After completing installation, cleaning, and testing, touch up scratches and mars on finish to match original finish.
- B. Adjust transformer taps to provide optimum voltage conditions at utilization equipment throughout the normal operating cycle of the facility. Record voltages and tap settings to submit with test results.

END OF SECTION 26 2200



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 2300 – LOW VOLTAGE POWER SWITCHGEAR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements of the following Division 26 Sections apply to this Section:
 - 1. "Basic Electrical Requirements."
 - 2. "Basic Electrical Materials and Methods."

1.2 SUMMARY

- A. This Section includes the following low-voltage power switchgear and associated equipment:
 - 1. Metal-enclosed low-voltage power switchgear assemblies (LV switchgear assemblies).
 - 2. Low-voltage drawout power circuit breakers.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
- B. Product data for each product and component specified.



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- C. Shop drawings for each switchgear lineup. Include dimensioned plans, sections, and elevations. Show minimum clearances, installed devices, major features, and materials lists. Include the following:
 - 1. Nameplate legends.
 - 2. Size and number of bus bars in each bus run including mains and branches of phase, neutral, and ground buses.
 - 3. Current ratings of buses.
 - 4. Short-time and short-circuit ratings of switchgear assembly.
 - 5. Features, characteristics, and ratings of individual power circuit breakers.
- D. Time-current characteristic curves for overcurrent protective devices including circuit breaker trip devices and fusible devices.
- E. Maintenance data for materials and products, for inclusion in Operating and Maintenance Manual specified in Division 1 and in Division 16 Section "Basic Electrical Requirements."

1.4 QUALITY ASSURANCE

- A. Listing and Labeling: Provide switchgear assemblies that are listed and labeled.
 - 1. The terms "listed" and "labeled" shall be as defined in the National Electrical Code, Article 100.
- B. Manufacturer's Qualifications: Manufacturer shall be a member of NEMA, regularly engaged in manufacturing LV power switchgear complying with the requirements of these Specifications and experienced with at least 5 projects of similar size and scope.
- C. Electrical Component Standard: Components and installation shall comply with NFPA 70, "National Electrical Code."

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.
- B. Store so condensation will not form on or in switchgear units. Provide temporary heaters as required to prevent condensation.



- C. Handle switchboards in accordance with manufacturer's instructions. Use factory-installed lifting provisions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Siemens Energy & Automation, Inc.
 - 2. Square D Co.

2.2 LOW-VOLTAGE POWER SWITCHGEAR ASSEMBLIES. GENERAL

- A. Description: Factory assembled and tested, with functions and circuit assignments and types, characteristics, ratings, and arrangements of buses and components as indicated. Conform to IEEE Standard C37.20.1. "Standard for Metal Enclosed Low-Voltage Power Circuit-Breaker Switchgear," and UL Standard 1558. "Metal Enclosed Low-Voltage Power Circuit Breaker Switchgear."
- B. Meet NEC requirements for service entrance.
- C. Ratings: Provide nominal system voltage, continuous main bus, and short-time and short-circuit-current ratings as indicated.
 - 1. Nominal System Voltage: 480/277 V, 60 Hz, 4 wire.
 - 2. Main Bus Continuous: _____ amperes.
 - 3. Main Bus Continuous: _____ amperes
 - 4. Short-Time and Short-Circuit-Current Ratings: Provide Short-Circuit rating of 35,000 RMS Symmetrical Amperes for Retrofit Bldg. and Addition Bldg.
- D. Fabrication: Include the following:
 - 1. Enclosure: Steel. Protect openings against entrance of falling dirt, water, and other substances.
 - 2. Finish: IEEE C37.20.1, paragraph 6.2.2, including manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing treated metal surfaces.
 - 3. Circuit Breaker Compartments: Equipped to house drawout power circuit breakers.
 - 4. Removable Hinged Rear Covers: Secured by captive thumb screws for access to rear interior of switchboard.



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5. Hinged Front Panels: Provide to allow access to breaker, metering, accessory, and blank compartments.
- E. Meter: Provide electronic metering package on the secondary of all unit substation transformers. The microprocessor-based meter shall be "revenue-class". All potential transformers (Pts) and current transformers (Cts) required shall be furnished with the meter. Siemens Model 9500 ONLY.
1. The meter shall be phase selectable and include the following measurements:
 - a. Amps on each phase.
 - b. Amps on the neutral.
 - c. Volts (L-L & L-N) · Watts.
 - d. Voltamperes.
 - e. VARs.
 - f. Power factor.
 - g. Watthour.
 - h. Watt demand.
 - i. VAR hours
 - j. Peak watts.
 - k. Frequency
 - l. Waveform Capture
 - m. Harmonic Analysis
 2. Communication: The meter shall support plug-in communication cards which allow remote access to the device data. Electrical contractor shall provide empty 3/4" conduit for cabling by others for communications capability.
 3. Security: The meter shall allow user definition of a password to provide security protection. The password shall be entered via the keypad on the faceplate. Any or all of the user-defined configuration settings may be password protected.
 4. Monitor Software: Provide three (3) copies of a software package to communicate with every circuit breaker and meter in the unit substation. The software shall be menu driven, mouse compatible program with on-line HELP support. The software shall operate on a remote pentium based personal computer and communicate via LAN which are compatible with the software package. Software shall be compatible with owner's network system.
 - a. The software package shall provide the following features:
 - 1) All meter readings as listed above.
 - 2) Real-time data display.
 - 3) Min/max. data display.
 - 4) Harmonic analysis.
 - 5) Voltage and current unbalance.
 - 6) Event log.
 - 7) Discrete input display.
 - 8) Password protection.
 - 9) Circuit breaker status.
 - 10) Device configuration.
 - 11) User-defined graphics.



- 12) Down-loading to disk.
 - 13) Alarming.
 - 14) Trend analysis.
 - 15) Wave form capture.
 - 16) Disturbance analysis.
 - 17) Printing.
 - 18) Manual control.
5. The software shall be Siemens Win PM or approved equal.
6. Mount the electronic meter flush in the door of the top cube in the first section of switchgear next to the transformer.
- F. Buses and Connections: 3-phase. 4-wire except as otherwise indicated. Features are as follows:
1. Phase and Neutral Bus Material: Hard-drawn copper of 98 percent conductivity, with copper feeder circuit-breaker line connections.
 2. At load terminals of feeder breakers, provide silver-plated copper bus extensions equipped with approved-type pressure terminal connectors for outgoing circuit conductors.
 3. Ground Bus: Hard-drawn copper of 98 percent conductivity, with pressure-type connector termination's for feeder and branch circuit ground conductors.
 4. Minimum size: 1/4 inch by 2 inches.
 5. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents of 35,000 RMS Symmetrical Amperes for the Retrofit Building and the Addition Building.
 6. Contact surfaces of buses: Silver plated.
 7. Power Interconnections Between Vertical Sections and Compartments: Bus bars. Cable connections are not permitted.
 8. Main Phase Buses, Neutral Bus, and Equipment Ground Bus: Uniform capacity the entire length of the assembly. Provide for future extensions from either end by means of pre-drilled bolt holes and connecting links.
 9. Vertical Section Bus Size: IEEE C37.20.1, with cumulative circuit-breaker loading calculated assuming spaces for future breakers are fully equipped with breakers carrying current at 100 percent of their maximum frame size current ratings and spare breakers are loaded to the same degree.
 10. Neutral Buses: 50 percent of the ampacity of the phase buses except as indicated. Equip bus with pressure connector termination's for outgoing circuit neutral conductors. Provide braced neutral bus extensions for busway feeders with neutral conductors.
 11. Neutral Disconnect Link: For switchgear assembly having main service disconnect. Arrange to permit disconnecting the switchgear assembly neutral bus from the common ground bus and the incoming service neutrals. Also provide a bolted, uninsulated, 1/4-inch by 2-inch copper bus (main bonding jumper). Arrange to interconnect the neutral and the ground buses to establish the system common ground point.
- G. Bus Bar Insulation: Factory-applied flame-retardant 105 deg C minimum tape wrapping of individual bus bars or flame-retardant spray-applied insulation of the same temperature rating.



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1. Sprayed Insulation Thickness: 3 mils, minimum.
 2. Bolted Bus Joints: Insulate with joint covers after assembly. Use secure covers that are easily removed and reinstalled.
 3. Phase Bar Load Runbacks from Circuit Breakers: Increase insulation thickness where clearances prior to insulation are less than required for bare bus.
 4. Substitute insulation methods will be considered upon submission, and where they are shown to provide equivalent electrical and mechanical characteristics to those specified, will be found acceptable.
- H. Indicating Lights: Breaker open and breaker closed, for main and bus tie circuit breakers interlocked either with each other or with external devices. Lights shall be LED.
- I. Control Wiring: Factory installed, complete with bundling, lacing, and protection, and complying with the following:
1. Flexible Conductors: Use for size No. 8 and smaller and for conductors across hinges, and conductors for interconnections between shipping units.
 2. Conductors Sizes: In accordance with NEC for the duty required. All wire shall be single conductor, standard copper, with insulation for 600 volts working and 1500 volts test, rated 90°C for switchboard wiring.
- J. Provision for Future Devices: Where "provision for future breaker," "future breaker," "space," "equipped space," or "blank" is indicated for switchgear compartments, equip compartments with rails, mounting brackets, supports, and necessary appurtenances, with bus connections designed for the ampacities as indicated or as assigned on shop drawings for future insertion of circuit breaker.

2.3 LOW-VOLTAGE DRAWOUT POWER CIRCUIT BREAKERS

- A. Standards: Conform to UL 1066, Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures," and to IEEE C37.13, "Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures."
- B. Transformer Main Secondary Breakers:
1. Provide electrically operated, drawout type air circuit breaker, three pole, single throw, 600 volt, 60 hertz, of the frame size indicated, 65,000 symmetrical ampere interrupting rating at 480 volts, of ampere trip rating. In the Retrofit Bldg. and 65,000 RMS Symmetrical Ampere interrupting rating at 480 volts of the Ampere trip rating in the Addition Bldg.
 2. Equip breaker with an electrically operated stored energy type of mechanism for quick-make closing and with a field adjustable solid state selective trip device providing long time overcurrent tripping, short time overcurrent tripping, and ground fault protection



- complete with arc quenchers interpole barriers, position indicator, charge/close/open pushbuttons and manual override feature, 120 volt AC shunt trip coil, auxiliary switch for remote signaling and manual operating handle.
3. The solid-state protective tripping device shall consist of:
 - a. Current sensing transformers, mounted on the circuit breaker, one for each pole, shall be provided. Each current sensor shall be adjustable in the field.
 - b. Provide current level and time logic circuits to sense the current magnitudes and to provide the time delays at which long-time- delay and short-time-delay, characteristics circuits become operative. The logic circuits shall measure the true RMS value of sinusoidal and non-sinusoidal current waves. Provide resettable fault trip indicators for overload, short circuit, and ground fault trip indication. The current level and time logic circuits shall be capable of being field adjustable by means of rotary switches mounted on the front of the programming unit. The logic circuits shall be capable of being field modified through the addition of a module for zone interlocking for all the trip elements. The use of auxiliary source of power is allowable for the zone interlock control of the trip elements only.
 4. The solid-state tripping system shall incorporate:
 - a. Long time pickup field adjustment capable of being varied at least from 50 to 110% of trip element rating.
 - b. A long time tripping delay element field adjustment with 4 marked points capable of providing a minimum of 2 seconds and a maximum of 20 seconds delay at 600% pickup.
 - c. A short time element pickup field adjustment capable of being varied from 150% to 900% of trip element rating with 7 marked steps.
 - d. A short time element tripping delay field adjustment with 3 marked points same as for the long time delay element except with 0.10 second minimum and 0.30 seconds maximum delay.
 - e. the short time element shall incorporate an $I^2t = C$ feature which can be inserted or removed by means of a switch.
 - f. An instantaneous pick-up, field adjustable and able to be field disconnected.
 - g. Deviations considered minor by the Engineers in the ranges
 - h. indicated in the above are acceptable.
 5. Time/current curve shaping as follows:
 - a. Long time trip.
 - b. Long time trip delay.
 - c. Short time trip.
 - d. Short time trip delay.
 - e. Ground fault trip.
 - f. Ground fault trip delay.
 6. All trip elements shall be part of the breaker assembly and not require external control power or voltage availability at the power buses during a fault. All poles of the breaker shall open upon fault detection on any one pole.
 7. Power for tripping under fault conditions shall be derived from fault sensing current transformers, through the breaker logic.
 8. The components of the solid state tripping device shall be free from aging and shifting characteristics due to temperature changes from 20°C to 55°C.
 9. The breaker shall include indicators to indicate:



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- a. Breaker "ON" - "OFF" position target.
 - b. Stored energy mechanism condition.
 - c. "CHARGED" - "DISCHARGED".
 - d. Manual reset fault indicators.
 - e. Overload - Short Circuit – Ground Fault.
10. Provide an interlock arrangement that will prevent breaker withdrawal from the return to the operating position with main contacts closed, as well as an interlock to prevent closure of the breaker in any position except test or normal.
 11. Equip the transformer main secondary breaker with a key interlock complementary to the one on the primary transformer switch.
 12. Provide means for padlocking the breaker in the test and withdrawn positions such that the breaker cannot be moved from the position in which it is padlocked.
 13. A device to display realtime current, voltage, power, and power factor located on main, without use of computer or other equipment.

C. Feeder Breakers:

1. Provide manually operated, drawout type air circuit breaker, single throw, 600 volt, 60 hertz, 600 ampere frame, 50,000 RMS symmetrical ampere interrupting rating at 480 volts, of ampere trip rating as indicated. Series rated breakers are not acceptable.
2. Equip breakers with a manually operated stored energy type mechanism for quick-make closing and with a field adjustable solid-state selective trip device, providing long time overcurrent tripping, instantaneous short circuit tripping, and ground fault protection, complete with arc quenchers, interpole barriers, position indicator, manual trip button, manual operating handle and auxiliary switch for remote signaling.
3. The solid-state device shall be a true rms-sensing continuously adjustable phase overcurrent tripping device, three-phase, tapped, current sensors, with the following features on each breaker:
 - a. Interchangeable rating plugs which establish the continuous trip ratings. Provide rating plugs as indicated on one-line diagram.
 - b. Information system that provides LED's to indicate and retain mode of trip following an automatic operation. Provide a trip reset button to turn off the LED indication after an automatic trip.
 - c. Display panel with a representation of the time/current curve of the trip unit, that indicates the actual protection function settings.
 - d. Prevention of closing a circuit breaker on a faulted system for those circuit breakers without an instantaneous setting.
 - e. Integral test panel, test selector switch, test pushbutton, and potentiometer to select test current values.
 - f. Provide breaker capable of being tested in the "trip" or "no trip" mode.
 - g. Time/current curve shaping as follows:
 - 1) Long time trip.
 - 2) Long time trip delay.
 - 3) Short time trip.
 - 4) Short time trip delay.
 - 5) Instantaneous trip.
 - 6) 50,000 symmetrical amperes interrupting, and 30 cycle withstand rating at 480 volts, without the use of fuses.



- 7) Frame size as indicated.
- h. Ground overcurrent tripping device and neutral current sensor.
- 4. Provide an interlock arrangement that will prevent breaker withdrawal from or return to the operating position with main contacts closed, as well as an interlock to prevent closure of the breaker in any position except test or normal.
- 5. Provide means for padlocking the breaker in the test and withdrawn positions such that the breaker cannot be moved from the position in which it is padlocked.
- 6. Equip all feeder breaker positions with solderless compression type lugs, manufacturer's standard, for cable sized indicated.
- 7. The components of the solid-state tripping device shall be free from aging and shifting characteristics due to temperature changes from 20°C to 55°C.
- 8. The breaker shall include indicators to indicate:
 - a. Breaker "ON" - "OFF" position target.
 - b. Stored energy mechanism condition.
 - c. "CHARGED" - "DISCHARGED".
 - d. Manual reset fault indicators.
 - e. Overload - Short Circuit – Ground Fault.
- 9. Provide an interlock arrangement that will prevent breaker withdrawal from the return to the operating position with main contacts closed, as well as an interlock to prevent closure of the breaker in any position except test or normal.

D. ACCESSORIES

- 1. Furnish one complete set of special tools and accessories required for the operation and maintenance of the unit substation equipment. Include:
 - a. Rackout handle for breakers.
- 2. Integral circuit breaker lifting and handling device, hoist type, capable of handling all sizes of breakers in the substation, as a permanent part of each switchgear structure.

2.4 IDENTIFICATION

- A. Identification Materials: Refer to Division 26 Section "Electrical Identification." Identify units, devices, controls, and wiring.
- B. Compartment Nameplates: Engraved laminated plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws.



WMU Design Guidelines

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install switchgear assemblies, LV power circuit breakers, and accessory items in accordance with manufacturers' written installation instructions and the following specifications
- B. Equipment Housekeeping Pads: Provide a 4 inch concrete housekeeping pad. Provide the 4-inch channel sills specified above in the pad. Fabricate pads as follows:
 - 1. Coordinate size of equipment bases with actual unit sizes provided. Fabricate base 4 inches larger in both directions than the overall dimensions of the supported unit.
 - 2. Form concrete pads with ASTM A36 steel channels; size and location as indicated. Miter and weld comers and provide cross bracing. Anchor or key to floor slab.
 - 3. Clean exposed steel form in accordance with SSPC Surface Preparation Specifications SP 2 or SP 3 and apply 2 coats of rust-preventive metal primer.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchgear units and components.
- D. Operating Instructions: Frame and mount printed, basic operating instructions for switchgear, including control and key interlocking sequences, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on the switchgear front.

3.2 IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs as specified in Division 16 Section "Electrical Identification."
- B. Mimic Bus: Apply continuously integrated mimic bus to front of switchgear lineup. Arrange in single-line diagram format, using symbols and lettered designations consistent with the approved final mimic bus diagram. Coordinate mimic bus segments with devices in switchgear sections to which applied. Produce a concise visual presentation of the principal switchgear components and connections.

3.3 GROUNDING



- A. Connections: As indicated. Tighten connections to comply with tightening torques specified in UL 486A and UL 486B.
- B. Ground equipment to main electrical ground bus. Provide minimum 5- ohm ground resistance at switchgear location.

3.4 CONNECTIONS

- A. Tighten switchgear bus joint bolts and electrical connector and terminal bolts in accordance with manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

- A. General: Comply with inspection and testing standards of the international Electrical Testing Association (INETA) including Standard ATS, "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems."
- B. Manufacturer's Field Services: Arrange and pay for the services of a factory-authorized service representative to supervise the field assembly and connection of components and the pretesting and adjustment of switchgear components for a total of 5 working days.
- C. Electrical Testing Organization: Arrange and pay for the services of an electrical testing organization to perform the following quality control testing, visual and mechanical inspections, electrical tests, and tests of overcurrent protective devices on LV power switchgear.
 - 1. Pretesting: Upon completing installation of the system, perform the following preparations for tests:
 - a. Make insulation resistance tests of switchgear buses, components, and connecting supply, feeder, and control circuits.
 - b. Make continuity tests of circuits.
 - c. Provide set of Contract Documents to test organization. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents.
 - d. Provide manufacturer's instructions for installation and testing of switchgear assembly to test organization.
 - 2. Quality Control Testing Program: Conform to the following:



WMU Design Guidelines

- a. Test Objectives: To assure switchgear installation meets specified requirements, is operational within specified tolerances, provides appropriate protection for systems and equipment, and is suitable for energizing.
- b. Procedures: Make field tests and inspections and prepare switchgear assemblies for satisfactory operation in accordance with INETA Standard ATS, applicable IEEE standards, manufacturer's recommendations, and these specifications.
- c. Schedule tests and provide notification at least one week in advance of test commencement.
- d. Reports: Prepare written reports of test results and observations. Report defective materials and workmanship. Include complete records of repairs and adjustments.
- e. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicating test results, date, and responsible person and organization.
- f. Protective Device Settings: Verify indicated settings to be appropriate for final system configuration and parameters. Where discrepancies are found, recommend revised settings. Use accepted revised settings to make the final adjustments.
- g. Visual and Mechanical Inspection: Include the following inspections and related work:
 - 1) Inspect, for defects and physical damage, testing laboratory labels and nameplate compliance with current single-line diagram.
 - 2) Verify that current transformers, potential transformers, and fuses meet specified requirement.
 - 3) Perform mechanical operational tests in accordance with manufacturer's instruction manual.
 - 4) Check switchgear anchorage, area clearances, and alignment and fit of drawout components in compartments.
 - 5) Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
 - 6) Check arc chutes for damage.
 - 7) Clean switchgear assembly including circuit breakers and other removable devices using manufacturer's approved methods and materials.
 - 8) Lubricate each circuit breaker in accordance with manufacturer's approved methods and materials.
 - 9) Exercise operable devices and components.
- h. Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:
 - 1) Contact resistance test or measurement of millivolt drop across contacts at rated current. Compare contact resistance or millivolt drop values of adjacent poles and of similar breakers. Deviations of more than 50 percent are not acceptable.
 - 2) Insulation resistance test at 1000-V d.c. for one minute from pole to pole and from each pole to ground with breaker closed and across open contacts of each phase. Insulation resistance less than 100 megohms is not acceptable.
 - 3) Insulation resistance test of buses and portions of control wiring that disconnect from solid-state devices through normal disconnecting features. Insulation resistance less than 100 megohms is not acceptable.
 - 4) Ratio and polarity tests on current and voltage transformers.
 - 5) Ground resistance test on system and equipment ground connections.
 - 6) Calibration of ammeters and voltmeters at midscale.



- 7) Verify appropriate capacity, overcurrent protection, and operating voltage of control power elements including control power transformer and control power wiring.
 - 8) Calibrate watt-hour and demand meters to 0.5 percent, and verify meter multipliers.
 - 9) Check phasing of alternate supply sources to the same bus.
- i. Tests of Overcurrent Protective Devices: Use primary current injection to check performance characteristics of trip units. Trip characteristics not falling within manufacturer's published time-current characteristic tolerance bands when adjusted to approved parameters are not acceptable. Perform the following items in accordance with manufacturer's instructions:
- 1) Determine minimum pickup current acceptable per manufacturer's instructions.
 - 2) Determine long-time delay at 300 percent pickup current.
 - 3) Determine short-time-pickup current and corresponding delay time.
 - 4) Determine ground-fault current pickup and corresponding delay time.
 - 5) Determine instantaneous-pickup current value.
 - 6) Verify trip unit reset characteristics.
 - 7) Make adjustments for final settings.
 - 8) Activate auxiliary protective devices such as ground fault and undervoltage relays, to verify operation of shunt trip devices.
 - 9) Check charging motors for proper operation of motor, mechanism, and limit switches.
 - 10) Check operation of electrically operated breakers in accordance with manufacturer's instructions.
 - 11) Check key and other interlock and safety devices for operation and sequence. Make closing attempts on locked- open and opening attempts on locked-closed devices including moveable barriers and shutters.
- D. Retest: Correct deficiencies identified by tests and observations and retest of switchgear. Verify by the system tests that the total assembly meets specified requirements.
- E. Metering: Verify following meter values for all metered devices such as, transformer bus and main, branch, and tie breakers:
1. Real power (watts) readings for all three phases is positive.
 2. Total real power (watts) reading is positive.
 3. Voltage meters are on correct phase as indicated by meter (ABC).
 4. Potential transformers (PT) and current transformers (CT) are each on appropriate phase.
 5. Verify negative or lagging power factor, note any poor readings
 6. Verify readings at gear and at software for gear (i.e. WinPM).
 7. Document readings for each metered device and provide in report.

3.6 PHASING



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- A. Match phasing on all switchgear equipped with multiple sources and tie switches.
- B. Phase testing shall be witnessed by WMU Engineering. Provide a minimum of fourteen days notice prior to testing.

3.7 CLEANING

- A. Upon completion of installation, inspect interior and exterior of switchgear. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

3.8 PROTECTION

- A. Temporary Heating: Apply temporary heat in accordance with manufacturer's recommendation within each section of switchgear throughout periods during which the switchgear is not in a space that is continuously under normal control of temperature and humidity.

3.9 DEMONSTRATION

- A. Training: Arrange and pay for the services of factory-authorized service representatives to demonstrate switchgear and train Owner's maintenance personnel. This shall include loading and operating the software, operating the modem, and data interpretation from the electronic metering system.
- B. Training: Conduct a minimum of one day of training in operation and maintenance as specified under "Instructions to Owner Employees" in the Division 1 Section "Project Closeout." Include both classroom training and hands-on experience in equipment operation and maintenance procedures.
- C. Schedule training with at least seven days advance notice.

END OF SECTION 26 2300



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 2413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes installation of the pre-ordered Switchboard Equipment. The successful installing contractor will be assigned the responsibility to receive, store, install, and start-up the unit. Factory start-up and Owner training is included in preorder.

1.2 ACTION SUBMITTALS

1.3 Product Data: For each type of product indicated.

1.4 Shop Drawings: For each switchboard and related equipment.

1.5 Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.

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

1.7 Include schematic and wiring diagrams for power, signal, and control wiring.

1.8 SUBMITTALS

- A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessories, and components indicated. Include dimensions, utility or manufacturer's anchorage and base recommendations, and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Related Submittals:



WMU Design Guidelines

1. Provide overcurrent device coordination study to demonstrate proper overcurrent device ratings, adjustments, and settings.
- C. Shop Drawings: For each switchboard and related equipment.
 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details for types other than NEMA 250, Type 1.
 - b. Bus configuration, current, and voltage ratings.
 - c. Short-circuit current rating of switchboards and overcurrent protective devices.
 - d. Descriptive documentation of optional barriers specified for electrical insulation and isolation if specified.
 - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 2. Wiring Diagrams: Power, signal, and control wiring.
- D. Field quality-control test reports including the following:
 1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- E. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1, include the following:
 1. Routine maintenance requirements for switchboards and all installed components.
 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 3. Time-current curves, including selectable ranges for each type of overcurrent protective device.
- F. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

1.9 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. Source Limitations: Obtain switchboards through one source from a single manufacturer.
- C. Comply with NEMA PB 2.
- D. Comply with NFPA 70.
- E. Comply with UL 891.



1.10 DELIVERY, STORAGE, AND HANDLING

- A. Coordinate delivery, receive, unload and store equipment.
- B. Store indoors in clean dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage. Provide temporary heating according to manufacturer's written instructions if required.
- C. Deliver in sections or lengths that can be moved past obstructions in delivery path.
- D. Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
- E. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Ambient Temperature: Not exceeding 104 DEG F.
 - 2. Altitude: Not exceeding 6600 feet.

1.11 COORDINATION

- A. Coordinate layout and installation of switchboards and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork shall meet load requirements. Requirements for concrete bases for electrical equipment are specified in Division 26 "Hangers and Supports for Electrical Systems."
- C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

PART 2 - PRODUCT

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. Siemens Energy & Automation, Inc.



WMU Design Guidelines

2.2 MANUFACTURED UNITS

- A. Front-Connected, Front-Accessible Switchboard: close coupled to transformer.
 - 1. Main devices over 1200A: Fixed, individually mounted.
 - 2. Main devices below 1200A, panel mounted.
 - 3. Branch Devices, panel mounted.
 - 4. Main or Branch devices over 1200A: with arc flash reduction maintenance settings and remote operated switch.
 - 5. Sections rear aligned.
- B. Nominal System Voltage: As noted on Drawings
- C. Main-Bus Continuous: As noted on Drawings

2.3 FABRICATION AND FEATURES

- A. Enclosure Finish for Indoor Units: Factory-applied electrostatic powder coat in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- B. Barriers: Between adjacent switchboard sections.
- C. Incoming Bus Connection: Flexible connections, matched and aligned with transformer.
- D. Hinged Front Panels: Allow access to circuit-breaker, metering, accessory, and blank compartments.
- E. Surge protective devices: Direct bus connected type as specified in Division 26 Section "Surge Protection Devices."
- F. Buses and Connections: Three phase, four wire, unless otherwise indicated. Include the following features:
 - 1. Bus braced to withstand 50,000 RMS symmetrical amps.
 - 2. Select one of first three subparagraphs below for main-bus material.
 - 3. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity with circuit-breaker line connections.
 - 4. Ground Bus: 1/4-by-2-inch minimum size, drawn-temper copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run. Connected to transformer ground bus via flexible connectors.
 - 5. Contact Surfaces of Buses: Silver plated.
 - 6. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
 - 7. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
 - 8. Neutral Buses: 100 percent of the ampacity of the phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables.
 - 9. Front accessible.



- G. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.4 SPD DEVICES

- A. Refer to surge protection device division 26 specification section.

2.5 OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker: NEMA AB 1, 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. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - 3. Electronic Trip Unit Circuit Breakers (ET): RMS sensing; field-replaceable rating plug; with the following field-adjustable settings: 100% Sensing, 100% Rating.
 - a. Power metering.
 - b. Instantaneous trip.
 - c. Long- and short-time pickup levels.
 - d. Long- and short-time time adjustments.
 - e. Ground-fault pickup level, time delay, and I^2t response, where indicated on Drawings.
 - f. Provide with Modbus communication to existing winPM.net system.
 - 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 - 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
 - 6. Provide 80 percent rated circuit breakers 250 Amp and smaller. Provide 100% rated circuit breakers for units larger than 250 Amp.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
 - 1. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.
 - 2. Application Listing: Appropriate for application; Type HACR for heating, air-conditioning, and refrigerating equipment.
 - 3. Ground-Fault Protection: Where indicated on Drawings. Internally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - 4. Shunt Trip: Where indicated on drawings. 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 - 5. Zone-Selective Interlocking: Where indicated on drawings. Integral with electronic trip unit; for interlocking ground-fault protection function.



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6. Communications Capability: Circuit-breaker-mounted communications module with functions and features compatible with power monitoring and control system, specified in Division 26 Section "Electrical Power Monitoring and Control."
 7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
- C. Enclosed, Insulated-Case Circuit Breaker: Fully rated, encased-power circuit breaker with interrupting capacity rating to meet available fault current.
1. Fixed circuit-breaker mounting.
 2. Two-step, stored-energy closing.
 3. Microprocessor-based trip units with interchangeable rating plug, LED trip indicators, and the following field-adjustable settings with restricted access cover.
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments with I^2t response.
 - d. Ground-fault pickup level, time delay, and I^2t response.
 4. Remote trip indication and control.
 5. Communication Capability: Integral communication module with functions and features compatible with WinPM.NET 6.0.
 6. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
- D. Circuit breaker selection for transformer primary protection:
1. Circuit Breaker Selection for Transformer Primary Protection: Provide circuit breakers with time-current characteristics to clear transformer inrush currents while still providing protection for the ANSI through-fault protection curve. Provide circuit breakers with adjustable magnetic trip or electronic trip units as necessary to provide time-current curve shaping to achieve long time trip indicated on drawings, inrush coordination and damage protection.
- E. Provide with arc flash reduction maintenance settings and remote operated switch for every breaker with frame size 1200A and larger.
1. Provide remote operated switch illuminated and lockable.
 2. Remote operated switch installed on face of gear.
 3. Provide with label:
 - a. "MAINTENANCE SWITCH: Arc flash hazard, utilize appropriate PPD and follow all safety precautions. Switch does not remove arc flash hazard from equipment.
- F. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

2.6 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:



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: Ratios shall be as required with accuracy class and burden suitable for connected meter. Provide with accessible shorting terminal blocks.
- B. Multifunctional Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - 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. Megawatts: Plus or minus 2 percent.
 - e. Megavars: Plus or minus 2 percent.
 - f. Power Factor: Plus or minus 2 percent.
 - g. Frequency: Plus or minus 0.5 percent.
 - h. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from 5 to 60 minutes.
 - i. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent. Accumulated values unaffected by power outages up to 72 hours.
 2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
 3. Communicate to WinPM.NET 6.0 via Modbus or Ethernet.
 4. Provide RS485 wiring as needed to nearest Ethergate meter connection.

2.7 CONTROL POWER

- A. Control Circuits: 120V, supplied through secondary disconnecting devices from control-power transformer.
- B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.8 ACCESSORY COMPONENTS AND FEATURES

- A. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Furnish portable test set of test functions of solid-state trip devices without removal from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
- C. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.



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1. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kV.
- 2.9 Delete subparagraph below except for certain ground-fault protection situations such as double-ended switchboards on four-wire, grounded neutral systems. Coordinate with Drawings.
- 2.10 Delete paragraph and subparagraphs below if conventional analog meter installation is required.
- 2.11 Delete five paragraphs and associated subparagraphs below if all metering functions can be provided by multifunction digital meters specified above.
- 2.12 CONTROL POWER
- 2.13 Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer.
- 2.14 Delete paragraph below if not required. See "Application Considerations" Article in the Evaluations for further discussion.
- 2.15 Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- 2.16 Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.
- 2.17 ACCESSORY COMPONENTS AND FEATURES
 - A. Portable Test Set: To test functions of solid-state trip devices without removal from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
 - B. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.



PART 3 - EXECUTION

3.1 PROTECTION

- 3.2 Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.3 EXAMINATION

- 3.4 Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance.

- 3.5 Proceed with installation only after unsatisfactory conditions have been corrected.

3.6 INSTALLATION

- 3.7 Install switchboards and accessories according to NEMA PB 2.1.

- 3.8 Support switchboards on concrete bases, 4-inch nominal thickness.

- 3.9 Retain paragraph below if seismic controls are Project requirement. Coordinate with Drawings.

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

- 3.11 Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

3.12 IDENTIFICATION

- 3.13 Select Division 26 Section "Common Work Results for Electrical" for projects with simple requirements and Division 26 Section "Electrical Identification" for projects with complex requirements.



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- 3.14 Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- 3.15 Switchboard Nameplates: Label each circuit breaker, fused switch and switchboard compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.
- 3.16 CONNECTIONS
- 3.17 Coordinate paragraphs below with Drawings.
- 3.18 Install equipment grounding connections for switchboards with ground continuity to main electrical ground bus.
- 3.19 Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- 3.20 PROTECTION
 - A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.
- 3.21 EXAMINATION
 - A. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.
- 3.22 INSTALLATION
 - A. Receive, inspect, unload and install Switchboard equipment. Provide Owner with written inspection report. Report any damage immediately to Owner's representative before unloading equipment.
 - B. Install switchboards and accessories according to NEMA PB 2.1 and NECA 40.
 - C. Support switchboards on concrete bases, 4-inch nominal thickness.
 - D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.



- E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- F. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation:
 - 1. Set field-adjustable switches and circuit-breaker trip ranges.

3.23 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.24 CONNECTIONS

- A. Install equipment grounding connections for switchboards with ground continuity to main electrical ground bus.
- B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.25 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Testing: After installing switchboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate. Certify compliance with test parameters.



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2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, Contractor to perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 3. Record of Infrared Scanning: Prepare a certified report that identifies switchboards checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.26 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

3.27 CLEANING

- A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.28 DEMONSTRATION

- A. As part of the pre-order package, a factory-authorized service representative will train Owner's maintenance personnel to adjust, operate, and maintain unit.

END OF SECTION 26 2413

- B. Prepare for acceptance tests as follows:
- C. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
- D. Test continuity of each circuit.
- E. Delete paragraph below if independent testing agency is not required.
- F. Testing: After installing switchboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
- G. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate. Certify compliance with test parameters.



- H. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- I. Select from options below to suit types of switchboards specified.
- J. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, Contractor to perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
- K. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
- L. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- M. Record of Infrared Scanning: Prepare a certified report that identifies switchboards checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- N. ADJUSTING
- O. Paragraph below assumes that settings are indicated on Drawings or a coordination report is available for Contractor to use.
- P. Set field-adjustable switches and circuit-breaker trip ranges.
- Q. CLEANING
- R. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.
- S. END OF SECTION 26 2413



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SECTION 26 2416 - PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes distribution panelboards and lighting and 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, sections, 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. Include evidence of NRTL listing for series rating of installed devices.
 - 6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 7. Include wiring diagrams for power, signal, and control wiring.
 - 8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

1.3 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Field quality-control reports:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- C. Submit short circuit study prior to panelboard submittal.



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- D. Panelboard schedules for installation in panelboards. (Electronic copies and panel indexes)
- E. Qualification Data: For qualified testing agency.

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. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. Comply with NEMA PB 1.
- D. Comply with NFPA 70.
- E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- F. 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.
- G. Comply with NEC Article 384 as applicable to the installation of panelboards, cabinets, and cutout boxes.
- H. Comply with applicable requirements of Std. No. 67 "Electric Panelboards", and Stds. No. 50, 869, 486A, and 1053 pertaining to panelboards, accessories and enclosures. Provide units that are U.L. listed and labeled.
- I. Comply with NEMA Stds. Pub/No. 250 "Enclosure for Electrical Equipment (1000 Volts Maximum)", Pub/No PB 1 "Panelboards", and Pub/No PB 1.1 "Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600V or less".

1.6 PROJECT CONDITIONS

- A. Environmental Limitations:
 - 1. Do not deliver or install panelboards until the spaces are enclosed and weathertight, wet work in or above spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:



- a. Ambient Temperature: Not exceeding 104 deg F.
- b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

- 1. Ambient temperatures within limits specified.
- 2. Altitude not exceeding 6600 feet.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

- 1. Warranty Period: Five years from date of Substantial Completion.

1.8 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

- 1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
 - a. Siemens Energy & Automation, Inc.
- 2. TVSS Panelboards:
 - a. Current Technology, Inc.
 - b. Liebert Corporation.
 - c. Siemens.
 - d. Square D Company.
 - e. Lea International.

2.2 FABRICATION AND FEATURES

A. Enclosures: Flush- surface- mounted cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.



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1. Outdoor Locations: NEMA 250, Type 3R.
 2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
- B. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
- C. Hinged Front Cover: Entire front trim continuous hinged to box and with standard door within hinged trim cover.
- D. Finishes:
1. Panels and Trim: Galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 2. Back Boxes: Galvanized steel.
 3. Door and cover of panels in finished areas shall be furnished with prime coat of paint and shall be painted to match adjacent area. Door and cover of panels in unfinished areas shall be furnished with standard factory finish. Upon completion of job, touchup all spots where factory finish has been marred, using paint supplied by the factory.
- E. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.
- F. Incoming Mains Location: Top and bottom
- G. Bus: Hard-drawn copper, 98 percent conductivity.
- H. Main and Neutral Lugs: Mechanical type suitable for use with conductor material.
- I. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.
- J. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.
- K. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.
- L. Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors.
- M. Isolated Equipment Ground Bus: Where indicated on Drawings. Adequate for branch-circuit equipment ground conductors; insulated from box.
- N. Extra-Capacity Neutral Bus: Where indicated on Drawings. Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
- O. Feed-through Lugs: Where indicated on Drawings. Mechanical type suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
- P. Provide all panelboards with CAT83 or B363A keys.



2.3 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following (circuit breaker type / switch-fuse type):
 - 1. Siemens Energy & Automation, Inc.
- B. Panelboards: NEMA PB 1, power and feeder distribution type.
- C. Doors: Concealed hinges:
 - 1. For doors more than 40 inches high, provide two latches, keyed alike.
- D. Mains: As indicated.
- E. Branch Overcurrent Protective Devices for Circuits: Bolt on circuit breakers or switch and fuse as indicated.
- F. Short Circuit Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- B. Circuit breaker interrupting rating shall be 10,000 RMS symmetrical amperes at 120/208/240 volts; 14,000 RMS symmetrical amperes at 277/480 volts unless noted otherwise on plans or as per study.
- C. Doors: Front mounted with concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.5 OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker: NEMA AB 1 and 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. Electronic Trip Unit Circuit Breakers: Where indicated RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
 - e. Modbus communications, provide RS485 cable as needed.



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3. Current-Limiting Circuit Breakers (where indicated): Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 4. GFCI Circuit Breakers: Single- and two-pole configurations with 5 mA trip sensitivity.
 5. AFCI Circuit Breakers: Single- and two-pole configurations 20A trip, evaluated to UL 1699, Safety Standard for ARC-fault Circuit Interrupter.
- B. Molded-Case Circuit-Breaker Features and Accessories. Standard frame sizes, trip ratings, and number of poles.
1. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.
 2. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment; HID rated for high intensity discharge lighting.
 4. Ground-Fault Protection: Where indicated on Drawings. Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 5. Shunt Trip: Where indicated on Drawings. 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
- C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
1. Fuses: Comply with requirements specified in Division 26 Section "Fuses".
 2. Fused Switch Features and Accessories: Standard ampere ratings and number of poles.

2.6 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.



3.2 INSTALLATION

- A. Provide SWD rated circuit breakers for switching fluorescent lighting; HACR rated circuit breakers for heating, air conditioning and refrigeration equipment, and HID rated circuit breakers for high intensity discharge lighting.
- B. Install panelboards and accessories according to NEMA PB 1.1 and NECA 1.
- C. Mounting Heights: Top of box 84 inches above finished floor, unless otherwise indicated.
- D. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- E. Install overcurrent protective devices and controllers not already factory installed.
- F. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits below slab where not on grade.
- G. Coordinate metering requirements with specification section 26 0913.
- H. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Incorporate Owner's final room designations and not construction room numbers. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable. Provide electronic files of directories to Owner.
- I. Distribution Panel Circuit Breaker/Switch Identification: Label each circuit breaker/switch unit with laminated-plastic nameplate mounted with corrosion-resistant screws or permanent adhesive.
- J. Install filler plates in unused spaces.
- K. Wiring in Panelboard Gutters: Arrange conductors into groups and bundle and wrap with wire ties after completing load balancing.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- B. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.
- C. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."



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3.4 CONNECTIONS

- A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.
- B. Where panelboards are located within 6 feet horizontally of any grounded structural building steel member, provide a bonding jumper between that steel member and the panelboard.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- D. Ground equipment according to Division 26 Section "Grounding and Bonding."
- E. Connect wiring according to Division 26 Section "Conductors and Cables."

3.5 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Balancing Loads: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes as follows:
 - 1. Measure as directed during period of normal system loading.
 - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data-processing, computing, transmitting, and receiving equipment.
 - 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 - 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.
- D. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, Contractor to perform an infrared scan of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.



1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.
- B. Adjust moving parts and operable component to function smoothly and lubricate as recommended by manufacturer.

3.7 CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 26 2416



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SECTION 26 2419 – MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements of the following Division 26 Sections apply to this Section:
 - 1. "Basic Electrical Requirements."
 - 2. "Basic Electrical Materials and Methods."

1.2 SUMMARY

- A. This Section includes motor-control centers (MCCs) for use on a.c. circuits rated 600 V or less.
- B. Related Sections: The following Division 26 Sections contain requirements that relate to this Section:
 - 1. "Disconnects and Circuit Breakers" for circuit breakers, fusible switches, fuses, and other similar devices used in MCCs.
 - 2. "Motor Controllers" for motor-control devices installed in MCCs.
 - 3. "Electrical Identification" for identification labels and warning signs for MCCs and their components.
 - 4. "Fuses" for Fuses used in MCCs.



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1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
- B. Product data for each product and component specified.
- C. Shop drawings for each MCC including dimensioned plans and elevations and component lists. Show ratings, including short-time and short-circuit ratings, and horizontal and vertical bus ampacities.
- D. Shop drawing of spare fuse cabinet showing material, dimensions, and features including storage provisions for fuse cartons.
- E. Schedule of features, characteristics, ratings, and factory settings of individual MCC units.
- F. Wiring Diagrams: Interconnecting wiring diagrams pertinent to the class and type specified for the MCC. Schematic diagram of each type of controller unit indicated.
- G. Maintenance data for MCCs, for inclusion in "Operating and Maintenance Manuals" specified in Division 1 and in Division 26 Section "Basic Electrical Requirements."

1.4 QUALITY ASSURANCE

- A. Listing and Labeling: Provide MCCs that are listed and labeled.
 - 1. The terms "listed" and "labeled": As defined in the National Electrical Code, Article 100.
- B. Electrical Component Standard: NFPA 70, "National Electrical Code," for components and installation.
- C. NEMA Standard: NEMA ICS 2, "Standards for Industrial Control Devices, Controllers and Assemblies."
- D. UL Standard: UL 845, "Motor Control Centers."



1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store so condensation will not occur on or in MCCs. Provide temporary heaters as required to prevent condensation.
- B. Deliver in shipping slits of lengths that can be moved past obstructions in delivery path as indicated.
- C. Handle MCCs in accordance with NEMA ICS 2.3, "Instructions for Handling, Installation, Operation, and Maintenance of Motor Control Centers." Use factory-installed lifting provisions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Allen-Bradley Co.
 - 2. Siemens Energy & Automation, Inc.
 - 3. Square D Co.

2.2 MOTOR-CONTROL CENTERS

- A. Wiring Classification: Class I, Type B, as defined in NEMA ICS 2.
- B. Enclosure: NEMA Type 1, as defined in NEMA250, "Enclosures for Electrical Equipment (1000 Volts Maximum)," except as otherwise indicated.
- C. Compartments: Modular, with individual doors with concealed hinges and quick-captive screw fasteners. For combination starter units provide interlocks so the disconnect means must be in the off position before door can be opened, and so door cannot be closed with the disconnect means in the on position, except by consciously operating a permissive release device.
- D. Interchangeability: Construct compartments so it is possible to remove units without opening adjacent doors, disconnecting adjacent compartments, or disturbing the operation of other units in the control center. Units requiring the same size compartment shall be interchangeable, and compartments shall be constructed to permit ready rearrangement of units such as replacing 3 single units with a unit requiring 3 spaces without cutting or welding.



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- E. Wiring Spaces: Provide each vertical section of structure with horizontal and vertical wiring spaces for wiring to each unit compartment in each section. Provide supports to hold wiring rigidly in place.
- F. Short-Circuit Current Rating for Each Section: 42,000 rms symmetrical amperes.
- G. Provide factory assembled, dead front, MCC standard supporting structures with enclosed vertical sections fastened together to form rigid free-standing assembly. Construct each section 90" high with 9" horizontal wireways at top and bottom, 20" wide, and 20" section depth for front-of-board unit arrangement. Construct units with 4-5/8" wide, 8" deep, 90" high vertical wireway in each vertical structure on tight side of unit, accessible through hinged doors, and with supports at proper intervals within for fastening wires/cables. Form supporting members of 13-gage, or greater, hot-rolled steel. Construct structure doors with removable pin hinges and secure with quarter- turn indicating type fasteners. Provide front accessible main lug compartment for connection of incoming cables. Coordinate top or bottom section feed for incoming cables with electrical contractor and engineer. Provide removable lifting angle full length of MCC. Design bottom channels to be removable, provide for bolting MCC units to floor.

2.3 BUSES

- A. Material: Plated copper bar.
- B. Ampacity Ratings: 600 amps for horizontal and 300 amps vertical main buses, except where otherwise specified.
- C. Equipment Ground Bus: Noninsulated, horizontal copper bus 2-inches by 1/4- inch, minimum.
- D. Horizontal Bus Arrangement: Extend main phase, neutral and ground buses with same capacity the entire length of the MCC, with provision for future extension at both ends by means of bolt holes and captive bus splice sections or approved equivalent.
- E. Short-Circuit Withstand Rating: Same as short-circuit current rating of section.

2.4 FUNCTIONAL FEATURES

- A. General: Provide a modular arrangement of motor controllers, control devices, overcurrent protective devices, transformers, panelboards, instruments, indicating panels, blank panels, and other items mounted in the compartments of the motor-control center as indicated.



- B. Provide draw-out type, full voltage magnetic motor starters. Construct each starter unit with doors, unit support pans, unit saddles and unit disconnect operators. Enclose and isolate each unit from adjacent units. Design units so that faults will be contained within compartment and be able to withstand short-circuit current ratings equal to, or greater than the short-circuit current rating of the MCC section. Equip with thermal and magnetic overload protection device for each motor circuit. Provide draw-out units with de-energized position where unit is still supported by structure, but where electrical power is not connected. Design plug-in units of same trip rating, to be interchangeable with each other.
1. Starter units shall include the following components:
 - a. Fused disconnect:
 - b. 100VA (min.), 120V control transformer with primary and secondary fusing.
 - c. Hand-off automatic selector switches or start and stop buttons for motors controlled by push button stations application. Red LED pilot for running and green LED pilot light for stopped. Two spare auxiliary contacts, in addition to any required for specific application. Phase loss relay (on motors 15HP and larger). Manual reset of overload relays.
 - d. Door interlock defeater.
 - e. Capable of being padlocked-OFF.
 2. Provide external operator handles for switches. Design handle with up-down motion and with down position indicating OFF. Provide unit doors securely mounted with rugged concealed-type hinges which allows doors to swing open of 115 degrees for ease of unit maintenance and withdrawal. Fasten doors to structure so that they remain in place when unit is withdrawn.
 3. Closed door must cover unit space when unit has been temporarily removed. Provide interlock for each unit door with associated disconnect mechanism to prevent door from opening when unit is energized.
- C. Spaces and Blank Units: Compartments fully bussed and equipped with guide rails or equivalent, ready for insertion of drawout units.
- D. Spare Units: Type, sizes, and ratings as indicated, and installed in compartments indicated "spare."

2.5 SPARE FUSE CABINET

- A. Steel Box or Cabinet: Suitably identified, wall mounted, lockable, and compartmented.



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2.6 IDENTIFICATION PRODUCTS

- A. Provide identifying devices as specified in Division 26 Section "Identification of Electrical Systems."

2.7 FINISHES

- A. Manufacturer's standard finish suitable for the environment in which installed.

2.8 CONCRETE BASES

- A. Concrete: Portland cement mix, 4000 psi.
 - 1. Cement: ASTM C 150, Type I.
 - 2. Fine Aggregate: ASTM C 33, sand.
 - 3. Coarse Aggregate: ASTM C 33, crushed gravel.
- B. Fabric Reinforcement: ASTM A 185, welded-wire fabric, plain.
- C. Reinforcement Bars: ASTM A 615, Grade 60, deformed.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install MCCs in accordance with NEMA ICS 2.3 "Instructions for the Handling, Installation, Operation, and Maintenance of MCCs," and with the manufacturer's written installation instructions.
- B. Anchor each motor-control center assembly to steel-channel sills arranged and sized in accordance with manufacturer's recommendations. Attach by tack welding or bolting. Level and grout sills flush with motor-control center mounting surface.



3.2 CONCRETE BASES

- A. General: Provide a concrete foundation pad. Install 4-inch-high sills on the pad as specified above.
- B. Form concrete equipment bases using framing lumber with form release compounds. Locate as indicated and construct 4 inches larger in both directions than supported unit. Chamfer top edges and corners.
- C. Install reinforcing bars, and place anchor bolts and sleeves using manufacturer's installation template.
- D. Place concrete and allow to cure before installation of equipment.
- E. Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from MCC units and components.

3.3 IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs as specified in Division 16 Section "Electrical Identification."
- B. Operating Instructions: Frame printed operating instructions for MCCs, including control sequences, and emergency procedures. Fabricate frame of Finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of MCCs.
- C. Install typewritten labels on the inside door of each fused MCC bucket to indicate fuse replacement information.

3.4 CONNECTIONS

- A. Tighten MCC bus joint bolts and electrical connector and terminal bolts in accordance with manufacturer's installation instructions and torque-tightening values. Where manufacturer's torque values are not stated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL



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- A. General: Comply with applicable requirements of the International Electrical Testing Association (INETA) Standard ATS, "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems."
- B. Quality Control Testing Program: Assure MCC installation meets specified requirements, is operational within specified tolerances, and provides appropriate protection for systems and equipment.
 - 1. Test and inspect MCCs in accordance with manufacturer's recommendations and these specifications.
 - 2. Schedule tests and provide notification at least 1 week in advance of test commencement.
 - 3. Reports: Prepare written reports of test results and observations. Report defective materials and workmanship. Include complete records of adjustments and corrective action taken.
 - 4. Labeling: On satisfactory completion of tests and related effort, apply a label to tested components indicating results, person responsible, and date.
 - 5. Verify appropriate capacity, overcurrent protection, and operating voltage of control power elements including control power transformers and control power wiring.
 - 6. Check phasing of supply source to the bus.
 - 7. Test motor-control devices as specified in Division 26 Section "Variable Frequency Motor Controllers."
 - 8. Test overcurrent protective devices as specified in Division 26 Section "Disconnect and Circuit Breakers."
- C. Verify all interlock devices (mechanical and electrical) are in place and working correctly.
- D. Retesting: Correct deficiencies and retest. Verify by the retests that specified requirements are met.

3.6 CLEANING

- A. Inspect interior and exterior of MCCs. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

END OF SECTION 26 2419



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SECTION 26 2500 – BUSWAYS AND ENCLOSED BUS ASSEMBLIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Busways and fittings.

1.3 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for each component. Include electrical ratings, dimensions, mounting position, mounting method, vertical supports, materials, fire stops, and weather stops.
- C. Shop drawings detailing fabrication and installation of busways, including plans, elevations, sections, details of components, and attachments to other construction elements. Detail connections to switchgear.



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1.4 QUALITY ASSURANCE

- A. Comply with NFPA 70 "National Electrical Code" for components and installation.
- B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.
- C. Single-Source Responsibility: All busway components shall be the product of a single manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle according to NEMA BU 1.1.

1.6 PROJECT CONDITIONS

- A. Field Measurements: Verify existing dimensions by field measurements. Verify clearances and locate obstructions within manufacturing and installation tolerances of busway.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide busways by one of the following or approved equal:
 - 1. Siemens Energy & Automation, Inc.
 - 2. Square D Co.

2.2 BUSWAY



- A. Feeder Busway: NEMA BU 1, low-impedance busway in nonventilated housing, single-bolt joints, ratings as indicated and specified.
 - 1. Voltage: 277/480 volts, 3 phase; 100 percent neutral capacity.
 - 2. Short-Circuit Withstand: 150,000 symmetrical rms amperes.
 - 3. Temperature Rise: 55 deg C above 40 deg C ambient maximum.
 - 4. Bus Materials: Current-carrying copper conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.
 - 5. Ground Bus: Copper.
 - 6. Enclosure: Aluminum.
 - 7. Fittings and Accessories: Manufacturer's standard elbows, equipment terminations, firestops, expansion fittings, spring-mounted vertical riser supports, rigid floor supports, horizontal hangers, tap fittings, and flange fittings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install busway level and plumb, according to manufacturer's written instructions, shop drawings, and referenced standards.
- B. Support busway independently from supports for other elements such as pipe, conduit, ceilings, and ducts.
 - 1. Design each fastener and support to carry 200 pounds (90 kg) or 4 times the supported weight of the busway, whichever is greater.
 - 2. Support busway with not less than 3/8-inch (10-mm) steel rods.
 - 3. Install side bracing to prevent swaying or movement of busway.
 - 4. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
 - 5. Fasten supports securely to building structure according to Division 16 Section "Supporting Devices."
 - 6. Support busway independently from equipment enclosure at connections to panelboards and switchboards.
- C. Coordinate busway terminations to equipment enclosures to ensure proper phasing, connection, and closure.
- D. Tighten busway joints with torque wrench or similar tool recommended by busway manufacturer. Retighten joints after busways have been energized for 30 days.
- E. Connect busway and components to wiring system and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to



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equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A.

3.2 ADJUSTING

- A. Align busway runs vertically and horizontally to eliminate sags and twists. Provide additional stiffeners if required to restrict excessive movement.

3.3 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

3.4 PROTECTION

- A. Provide final protection and maintain conditions in a manner acceptable to Manufacturer and Installer to ensure that moisture does not enter busway prior to Substantial Completion.

END OF SECTION 26 2500



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SECTION 26 2726 – WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes various types of receptacles, connectors, switches, and finish plates.

1.3 SUBMITTALS

- A. Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for each product specified. Provide manufacturers catalog cuts for each type of wiring device provided, including electrical characteristics, NEMA configuration, color, and finish.
- C. Samples of devices and device plates for color selection and evaluation of technical features.
- D. Operation and maintenance data for materials and products specified in this Section to include in the "Operating and Maintenance Manual" specified in Division 1.



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1.4 QUALITY ASSURANCE

- A. Comply with NFPA 70 "National Electrical Code" for devices and installation.
- B. Listing and Labeling: Provide products that are listed and labeled for their applications and installation conditions and for the environments in which installed.
 - 1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.

1.5 COORDINATION

- A. Wiring Devices for University Furnished Equipment: connectors for University-furnished equipment. Match devices to plug connectors for University furnished equipment.
- B. Cord and Plug sets: Match cord and plug sets to equipment requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Source all devices from same manufacturer if available. Subject to compliance with requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approve equal:
 - 1. Wiring Devices:
 - a. Hubbell Inc.
 - b. Cooper
 - c. Leviton
 - 2. Wiring Devices for Hazardous (Classified) Locations:
 - a. Crouse-Hinds Electrical Construction.
 - b. Killark Electrical Mfg. Co.
 - c. Appleton Electric Co.



3. Multi-Outlet Assemblies:
 - a. Isoduct Energy Systems
 - b. Wiremold Co.
4. Poke-Through & Floor Service Outlets:
 - a. Wiremold Co.
 - b. Hubbell Inc
5. Telephone/Power Poles:
 - a. Hubbell Inc.
 - b. Square D Co
 - c. Wiremold Co.
 - d. Walker

2.2 WIRING DEVICES

- A. Comply with NEMA Standard WD 1, "General Purpose Wiring Devices."
- B. Enclosures: NEMA 1 equivalent, except as otherwise indicated.
- C. Color:
 1. As specified.
 2. Red if connected to generator or UPS source.
 3. Gray for receptacles in surface metal raceway will alternate with ivory receptacles in raceway except as otherwise indicated or required by Code.
- D. Color: Ivory for receptacles, wall switches, and dimmer switches except as otherwise indicated or required by Code.
- E. Receptacles, Straight-Blade and Locking Type: Comply with UL Standard 498, "Electrical/HBL Attachment Plugs and Receptacles," extra heavy-duty industrial specification grade except as otherwise indicated. Hubbell #HBL5362 for NEMA 5-20R configuration or equal by acceptable manufacturers. Provide similar grade for other NEMA receptacle configuration.
 1. Place for writing circuit identification on device
 2. Brass mounting strap, binding screws, clamp plates, bridge, and contacts.
 3. Nylon face.



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- F. Receptacles, Straight-Blade, Special Features: Comply with the basic requirements specified above for straight-blade receptacles of the class and type indicated, and with the following additional requirements:
1. Ground-Fault Circuit Interrupter (GFCI) Receptacles: UL Standard 943, "Ground Fault Circuit Interrupters," feed-through type, with integral NEMA 5-20R duplex receptacle arranged to protect connected downstream receptacles on the same circuit. Design units for installation in a 2-3/4-inch (60-mm) deep outlet box without an adapter. Hubbell #GFR8300SG
 2. Isolated Ground Receptacles: Equipment grounding contacts are connected only to the green grounding screw terminal of the device and have inherent electrical isolation from the mounting strap.
 - a. Devices: Listed and labeled as isolated ground receptacles.
 - b. Isolation Method: Integral to the receptacle construction and not dependent on removable parts.
 3. Receptacles, Industrial Heavy-Duty: Conform to NEMA standard PK 4 "Plugs, Receptacles, and Cable Connectors of the Pin and Sleeve Type for Industrial Use."
 4. USB Charger Receptacle: Hubbell #USB8300AC5xx two receptacles, and one each USB Type A & C port high power 5 amp.
- G. Receptacles in Hazardous (Classified) Locations: Comply with NEMA Standard FB 11 "Plugs, Receptacles, and Connectors of the Pin and Sleeve Type for Hazardous Locations" and UL Standard 1010 "Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations."
- H. Weatherproof Receptacles:
1. Provide all weatherproof receptacles as shown on the drawings and where required by the NEC code.
 2. Outlets shall be complete with:
 - a. Weatherproof outlet box.
 - b. Duplex [GFI] receptacle, 20 amp, 125V, 3 wire. Hubbell #5352A or Leviton #8899.
 - c. Corrosion resistant plate with lip.
 - d. Proper gaskets.
- I. Wall Switches: Quiet-type a.c. switches, Heavy Duty Industrial specification grade, 20 A, 120-277 v, back and side wired, toggle handle. Single pole, Hubbell #HBL1221 or approved equal. Double pole, Hubbell #HBL1222 or approved equal. 3-way, Hubbell #HBL1223 or approved equal. 4-way, Hubbell #HBL1224 or approved equal. All switches to have ground screw.
- J. Pilot Lamp Switches:
1. Pilot lamp switches shall be same manufacturer as toggle switches.
 2. Pilot lamps shall be "Red."



- K. Wall Switches in Hazardous (Classified) Locations: Comply with UL Standard 894, "Switches for Use in Hazardous (Classified) Locations."
- L. Dimmer Switches: Modular full-wave solid-state units with integral, quiet on-off switches, and audible and electromagnetic noise filters. Meet NEMA WD-2 criteria.
 - 1. Wattage rating shall be 1500 watt minimum, unless connected load is over 1500 watts, then wattage rating shall exceed connected load by 30 percent minimum, except as otherwise indicated.
 - 2. Control: Continuously adjustable slide. Single-pole or 3-way switch to suit connections.
 - 3. Acceptable manufacturers:
 - a. Lutron.
 - b. Lightolier,
- M. Wall Plates: Single and combination types that mate and match with corresponding wiring devices. Features include the following:
 - 1. Plate-Securing Screws: Metal with heads colored to match plate finish.
 - 2. Material: 0.04-inch-thick. type 302 or 304, satin-finished stainless steel. except as otherwise indicated.
 - 3. Color: Where non stainless steel plates are specified they shall be of high impact nylon and have color matching the device.

2.3 Multi-outlet assemblies

- A. Comply with Standard UL 5, "Surface Metal Raceways and Fittings."
- B. Components of Assemblies: Products of a single manufacturer designed to be used together to provide a complete matching assembly of raceways and receptacles.
- C. Raceway Material: Metal. with manufacturer's standard corrosion-resistant finish.
- D. The receptacle harness shall consist of 15-Ampere, 125 volt. NEMA 5-15R, grounding, specification grade receptacles. The harness shall be two circuit alternating 4 wire, factory wired with #12 AWG type TW conductors to enable use on 20A branch circuits.
- E. The assemblies shall be Wiremold Co. Model 2000.



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2.4 Ceiling fans

- A. Ceiling fans to be provided as specified, Leading Edge, Inc., or approved equal by Nutone, or fans to be U.L. listed standard 507 with matching U.L. listed solid state controls. Motors shall be direct-drive permanent split capacitor type, with permanently sealed ball bearings.
- B. Motors shall be built in, self-resetting (internal) thermal overload protector Model T19700.
- C. Performance shall be certified by AMCA, an independent laboratory or a university engineering department with documented testing. All fans to have factory installed secondary support cable assembly connected to motor shaft with minimum 6 feet galvanized cable 3/32", 7x7 with rated breaking strength of 920 lbs., and must comply with CSA Standard C22.2, September 1986, and threaded "J" hook.
- D. Fan blades to be straight with contoured shaped design for maximum efficiency. Fans used with motor speed controls must be labeled in accordance with U.L. 507, "suitable for use with solid state motor speed controls."
- E. Factory supplied accessories to include:
 - 1. Special length downrods, Model #9999.
 - 2. Totally enclosed impact resistant fan guard, Model #2800-1 where specified.
 - 3. Canopy cover, Model #9999-4.
 - 4. Remote reversing toggle switch (included with fan).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install devices and assemblies plumb and secure. Install wall switches with the off position down.
- B. Install wall plates when painting/wall finish is complete.
- C. Arrangement of Devices: Except as otherwise indicated, mount flush, with long dimension vertical, and grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
 - 1. When long dimension of device is horizontal, the grounded device side shall be on top.



- D. Protect devices and assemblies during painting, replace painted devices.
- E. Adjust locations at which floor service outlets are installed to suit the indicated arrangement of partitions and furnishings. Coordinate with the existing structural conditions for poke thru locations.
- F. Install plates on all switch, dimmer and receptacle outlets. Install blank plates on all unused boxes. Use jumbo plates for outlets in masonry walls, as needed, if used all plates in same room shall be same size and type.
- G. Seal all connections on GFCI devices with seal coat compound and wrap with two layers of tape, where installed with damp/wet location cover.
- H. All switches and receptacles are to be grounded with green wire bonding jumper. Where raceway is used for equipment grounding conductor, without a separate wire self-grounding device may be used (20 amp maximum device rating) in lieu of bonding jumper wire.
- I. Provide permanent barriers for ganged switches of different voltage systems.

3.2 IDENTIFICATION

- A. Comply with Division 26 Section "Identification For Electrical Systems."
 - 1. Switches: Identify the panelboard and circuit number from which served. Use durable wire markers or tags within outlet boxes:
 - 2. Receptacles: Identify the panelboard and circuit number from which served. Use durable wire markers or tags within outlet boxes.

3.3 GROUNDING

- A. Provide green grounding conductors in all branch circuits feeding receptacles.
- B. Isolated Ground Receptacles: Connect to isolated grounding conductor routed to designated isolated equipment ground terminal of electrical system.

3.4 FIELD QUALITY CONTROL



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- A. Testing: Test wiring devices for proper polarity and ground continuity. Operate each operable device at least 6 times.
- B. Test ground-fault circuit interrupter operation with both local and remote fault simulations according to manufacturer recommendations.
- C. Replace damaged or defective components.

3.5 CLEANING

- A. General: Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION 26 2726



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SECTION 26 2728 – DISCONNECTS AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Service disconnecting means.
 - 2. Feeder and branch-circuit protection.
 - 3. Motor and equipment disconnecting means.
 - 4. Enclosures
 - 5. Molded case circuit breakers
 - 6. Fusible and non-fusible switches
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 26 Section "Fuses."

1.3 DEFINITIONS

- A. GFCI: Ground-fault circuit interrupter.
- B. RMS: Root mean square.



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- C. SPDT: Single pole, double throw

1.4 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for switches, circuit breakers, and accessories specified in this Section.
- C. Descriptive data and time-current curves for protective devices and let-through current curves for those devices with current-limiting characteristics. Include coordination charts and tables, short-circuit current rating and related data.
- D. Maintenance data for tripping devices to include in the "Operating and Maintenance Manual" specified in Division 1.

1.5 QUALITY ASSURANCE

- A. Comply with NFPA 70 "National Electrical Code" for components and installation.
- B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.
- C. Single-Source Responsibility: All enclosed switches and circuit breakers shall be the product of a single manufacturer.
- D. EXTRA MATERIALS
 - 1. Spare fuses for fusible switches.

PART 2 - PRODUCTS

2.1 MANUFACTURERS



- A. Manufacturers: Subject to compliance with requirements, provide enclosed switches and circuit breakers by one of the following or approved equal:

1. Fusible Switches:
 - a. Siemens Energy & Automation, Inc.
 - b. Square D Co.
2. Molded-Case Circuit Breakers:
 - a. Siemens Energy & Automation, Inc.
 - b. Square D Co.

2.2 ENCLOSED SWITCHES

- A. Enclosed Nonfusible Switch: NEMA KS 1, Type HD, handle lockable with 2 padlocks.
- B. Enclosed Fusible Switch, 800 Amperes and Smaller: NEMA KS 1, Type HD, clips to accommodate specified fuses, enclosure consistent with environment where located, handle lockable with 2 padlocks, and interlocked with cover in CLOSED position.
- C. Enclosure: NEMA KS 1, Type 1, unless specified or required otherwise to meet environmental conditions of installed location.
1. Outdoor Locations: Type 3R.
 2. Kitchen Areas: Type 4X, stainless steel.
 3. Other Wet or Damp Indoor Locations: Type 4.
 4. Hazardous Areas Indicated on Drawings: NEMA 7C.
- D. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded, labeled for copper and aluminum neutral conductors.
 3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 4. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
 5. Lugs: Mechanical type, suitable for number, size, and conductor material.
 6. Service-Rated Switches: Labeled for use as service equipment.
 7. Provide switches with interlock defeaters for maintenance purposes.
 8. Switches used in conjunction with variable frequency motor controllers, provide an additional 1NO/1NC auxiliary contacts for connection to VFC safety circuit.



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2.3 ENCLOSED CIRCUIT BREAKERS

- A. Enclosed Molded-Case Circuit Breaker: NEMA AB 1, handle lockable with 2 padlocks.
- B. Characteristics: Frame size, trip rating, number of poles, and auxiliary devices as indicated; interrupting capacity rating to meet available fault current, 35,000 symmetrical rms amperes minimum. With appropriate application listing when used for switching fluorescent lighting loads or heating, air conditioning, and refrigeration equipment.
- C. Interchangeable Trips: Circuit breakers, 200 amperes and larger, with trip units interchangeable within frame size.
- D. Lugs: Mechanical lugs and power-distribution connectors for number, size, and material of conductors indicated.
- E. Shunt Trip: Where indicated, 120 volts, 60 Hz.
- F. Accessories: As indicated
- G. Enclosure: NEMA AB 1, Type 1, unless specified or required otherwise to meet environmental conditions of installed location.
 - 1. Outdoor Locations: Type 3R.
 - 2. Kitchen Areas: Type 4X, stainless steel.
 - 3. Other Wet or Damp Indoor Locations: Type 4.
 - 4. Hazardous Areas Indicated on Drawings: NEMA 7C.

2.4 TOGGLE DISCONNECT SWITCH

- A. Manufacturers:
 - 1. Double Pole:
 - a. Hubbell 1372
 - b. Bryant 30102.
 - 2. Three Pole:



- a. Hubbell 1379
 - b. Bryant 30103.
 - B. Description: Heavy duty, 30A, 600 volt, double or three pole as required, single throw, motor rated switch without overload protection. Provide NEMA 1 enclosure and padlock attachment.
- 2.5 BOX COVER UNITS
- A. Provide surface mounted (flush mounted in finished rooms) fuse switch units to be used for 125 volt circuits to small boilers, furnaces, and similar equipment. Locate box cover unit adjacent to equipment controlled unless shown otherwise on plans. Provide box cover units manufactured by Bussman, Series SSU/SSW/SSY/SCY.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install enclosed switches and circuit breakers in locations as indicated, according to manufacturer's written instructions.
- B. Install enclosed switches and circuit breakers level and plumb.
- C. Install wiring between enclosed switches and circuit breakers and control/indication devices.
- D. Disconnects shall be mounted at 6'-6" AFF to top of enclosure in accessible areas, unless otherwise indicated.
- E. Fusible disconnects shall not be mounted over 12 feet AFF. Unless otherwise indicated.
- F. Disconnects mounted on equipment higher than 12 feet AFF, shall be non-fused. Fusing protection must be provided in a more readily accessible location.
- G. All motors shall have a disconnecting means within sight of, and not more than 20 feet from motor.
- H. Provide a "Lock-Out" means at disconnect for all motors, at disconnect nearest motor/equipment.



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- I. Connect enclosed switches and circuit breakers and components to wiring system and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts according to equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A.

3.2 IDENTIFICATION

- A. Install typewritten labels on the inside door of each fused switch to indicate fuse replacement information.

3.3 GROUNDING

- A. Connections: Make equipment grounding connections for disconnects as indicated.
- B. Provide ground continuity to main electrical ground bus indicated.

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals, including grounding connections, in accordance with manufacturer's published torque- tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

- A. 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. Section 7.5 for switches. Certify compliance with test parameters.
 2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS. Section 7.6 for molded-case circuit breakers. Test all NEMA AB1, molded case circuit breakers with thermal magnetic trip or auxiliary, solid-state trip units 100A and larger. Certify compliance with test parameters.
 - a. Visual and Mechanical Inspection



- 1) Circuit breaker shall be checked for proper mounting and compare nameplate data to Drawings and Specifications.
- 2) Operate circuit breaker to ensure smooth operation.
- 3) Inspect case for cracks or other defects.
- 4) Check internals on unsealed units.

b. Electrical Tests

- 1) Perform a contact resistance test.
- 2) Perform an insulation resistance test at 1000 volts DC from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase.
- 3) Perform long time delay time-current characteristic tests by passing three hundred percent (300%) rated current through each pole separately. Record trip time. Make external adjustments as required to meet time current curves.
- 4) Determine short time pickup and delay by primary current injection.
- 5) Determine ground fault pickup and time delay by primary current injection.
- 6) Determine instantaneous pickup current by primary injection using run-up or pulse method.
- 7) Perform adjustments for final settings in accordance with coordination study.
- 8) For circuit breakers 800A and larger, verify all functions of trip unit by means of secondary injection in lieu of primary injection.

c. Test Values

- 1) Compare contact resistance or millivolt drop values to adjacent poles and similar breakers. Investigate deviations of more than fifty percent (50%). Investigate any value exceeding manufacturer's recommendations.
- 2) Insulation resistance shall not be less than 100 megohms.
- 3) Trip characteristic of breakers shall fall within manufacture's published time-current characteristic tolerance band, including adjustment factors.
- 4) All trip times shall fall within N.E.T.A. Acceptance Testing Specifications, Table 10.7. Circuit breakers exceeding specified trip time at three hundred percent (300%) of pickup shall be tagged defective.
- 5) Instantaneous pickup values shall be within values shown on N.E.T.A. Acceptance Testing Specifications, Table 10.8 or manufacture's recommendations.

3. Test insulation resistance for each enclosed switch, component, and control circuit.
4. Test continuity of each line- and load-side circuit.

B. Testing: After installing enclosed switches and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.



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- C. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, perform an infrared scan of each enclosed switch. Open or remove doors or panels so connections are accessible to portable scanner.
 - 1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 2. Record of Infrared Scanning: Prepare a certified report that identifies switches and circuit breakers checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- D. Testing: After installing enclosed switches and circuit breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA Standard ATS, Section 7.5 for enclosed switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
 - a. Verify all interlock devices (mechanical and electrical) are in place and working correctly.
 - b. Correct malfunctioning units at site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units, and retest.

3.6 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, and abrasions.

3.7 DEMONSTRATION

- A. Review data in the "Operating and Maintenance Manual." Refer to Division 1 Section "Project Closeout."

END OF SECTION 26 2728



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SECTION 26 2813 – FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Division 26 Sections applying to Section:
 - 1. "Disconnects and Circuit Breakers"
 - 2. "Variable Frequency Motor Controllers"
 - 3. "Motor Control Centers"

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Fuses.
 - 2. Spare fuse cabinet.

1.3 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for each fuse type. Include the following:



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1. Descriptive data and time-current curves.
2. Let-through current curves for fuses with current limiting characteristics.
3. Coordination charts and tables and related data.
4. Fuse size for elevator feeder and disconnect applications.

- C. Maintenance data for tripping devices to include in the "Operating and Maintenance Manual" specified in Division 1.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 70 "National Electrical Code" for components and installation.
- B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.
- C. Single-Source Responsibility: All fuses shall be the product of a single manufacturer.

1.5 EXTRA MATERIALS

- A. Furnish the following extra materials that match products installed, packaged with protective covering for storage, and with identification labels clearly describing contents.
- B. Spare Fuses: Furnish quantity equal to one unit for every 5 units of each fuse type and size installed, but not less than 1 set of 3 of each type and size.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide fuses by one of the following or approved equal:



1. Bussmann Div., Cooper Industries, Inc.
2. Circuit Protection Div.; Gould, Inc.

2.2 CARTRIDGE FUSES

A. Fuses:

1. All fuses: 200,000 A. interrupting capacity at rated AC or DC voltage.
2. Fuses 1/10 through 600 A.:
 - a. UL Class: RK- 1, time delay.
 - b. Maximum operating temperature: 300 deg. F
 - c. Self protecting thermally.
 - d. Separate overload and short circuit element.
 - e. Incorporate a spring-activated "snap-trigger" thermal overload element responsive to fuse temperatures exceeding 284 deg. F.
3. Fuses 601 to 6,000 A.:
 - a. UL Class: L, time delay.
 - b. Pure silver links.
 - c. "O" ring seal.
 - d. 600 V. or less AC.
 - e. 250 V. or less DC.
4. Control Circuit Fuses:
 - a. UL Class CC.
 - b. Dual element, time delay.

2.3 PLUG FUSES

- A. Type: UL 198F, Type S, dual element, time delay.
- B. Edison base fuses shall not be used.

2.4 SPARE FUSE CABINET



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- A. Cabinet: Wall-mounted, 18-gage minimum steel unit with full-length, recessed piano-hinged door with key-coded cam lock and pull.
 - 1. Size: Adequate for orderly storage of spare fuses specified with 15 percent spare capacity minimum.
 - 2. Finish: Gray baked enamel.
 - 3. Identification: Stencil legend "SPARE FUSES" in 1-1/2-inch (40-mm) letters on door.
 - 4. Locate cabinets in main electrical rooms and penthouses.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install fuses in fusible devices as indicated. Arrange fuses so that fuse ratings are readable without removing fuse.
- B. Install spare fuse cabinet where indicated.

3.2 IDENTIFICATION

- A. Install typewritten labels on the inside door of each fused switch to indicate fuse replacement information.

END OF SECTION 26 2813



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SECTION 26 2818 – GROUND FAULT PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.
- B. Division-16 Basic Materials and Methods sections apply to work of this section.

1.2 SUMMARY

- A. Extent of ground-fault protection work is indicated by drawings and schedules, and by requirements of this section.
- B. Applications of ground-fault protection units required for project include the following:
 - 1. Unit substation main disconnect.
 - 2. Unit substation secondary circuit breakers.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's data on ground-fault protection devices and associated components including, but not limited to, types, sizes, basic ampere ratings, and control voltages.
- B. Shop Drawings: Submit layout drawings of installed ground-fault protection devices and accessories including sensors, current monitors, and test panels.



WMU Design Guidelines

1.4 QUALITY ASSURANCE

- A. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects utilizing ground-fault protection work similar to that required for this project.
- B. Codes and Standards:
 - 1. UL Compliance: Comply with applicable requirements of Std 486A "Wire Connectors and Soldering Lugs for Use with Copper Conductors", and Std 1053, "Ground-Fault Sensing and Relaying Equipment." Provide ground-fault protection systems and components which are UL-listed and labeled.
 - 2. IEEE Compliance: Comply with applicable recommended practice of IEEE Standards 142, 241 and 242 pertaining to ground-fault protection devices.
 - 3. NEMA Compliance: Comply with NEMA Stds Pub No.'s PB 2.2 and AB 1, pertaining to construction and installation of ground-fault protection devices and molded-case circuit breakers.
 - 4. Electrical Code Compliance: Comply with applicable local electrical code requirements of the authority having jurisdiction and NFPA No.'s 70 and 70B, pertaining to construction and installation of ground-fault protection devices.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver ground-fault protection units properly packaged in factory-fabricated containers.
- B. Store ground-fault protection units indoors in clean, dry space. Retain units, until installed, in original cartons and protect from dirt, weather, construction debris and traffic.
- C. Handle ground-fault protection units properly to avoid abrasing, cracking, and breaking.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide ground-fault protection units of one of the following (for each type of unit):
 - 1. General Electric Co.
 - 2. Siemens Energy & Automation, Inc.
 - 3. Square D Co.



2.2 GROUND-FAULT PROTECTION SYSTEMS AND DEVICES

- A. General: Except as otherwise indicated, provide ground-fault protection systems, including devices and components, of types, sizes, characteristics, and ratings indicated, which comply with manufacturer's standard materials, design and construction in accordance with published product information, and as required for complete installation. Where types, sizes, or ratings are not indicated, comply with NEC, UL and established industry standards for applications indicated.
- B. Ground-Fault Protection Systems:
 - 1. General: Provide ground-fault protection systems for grounded electrical systems, 600-Volts, 60Hz, comprised of current monitor, shunt trip relaying equipment, including solid-state relays, and static ground-fault current sensors of sufficient size to encircle phase conductors and neutral conductor of circuit to be monitored. Select GFP systems with monitor panels, and low-voltage power circuit-breakers; select units which function properly in conjunction with other elements of GFP system. Provide ground-fault current sensitivity and time-current response characteristics as indicated. Construct system components and devices with the following features:
 - 2. Current Sensors: Provide zero-sequence (core balance) current sensors with rectangular windows for feeder, branch devices and main service device; inputs compatible to relay. Construct sensor of split-core construction which can be opened to expedite its installation or removal without disturbing the electrical conductors being encompassed. Provide test windings in sensor for testing the operation of ground-fault protection unit including sensor pick-up, relay and circuit protection devices.
 - 3. Ground-Fault Relay: Provide solid-state ground-fault signaling relay with silicon controlled rectifier (SCR) output, to be used with electric or shunt trip, which requires no external source of electrical power, drawing its energy to operate ground-fault protection system directly from output of current sensor. Select relays capable of sensing ground currents which causes the interrupter to open after current reaches a magnitude value for time period indicated. Provide relay with adjustable pick-up current sensitivity range from 10 mA to 200 mA for ground-fault currents from 100 to 1200 amperes, with calibrated dial to show pick-up point settings. Provide factory-set time delay which is adjustable from instantaneous to 1-second and which also prevents tampering with setting after installation.
 - 4. Monitor Panels: Provide monitor panels with ground-fault indicators, control power indicators and TEST and RESET buttons, and with control circuitry capable of providing means for testing system with, or without interruption of service. Construct ground-fault system which can not be left in an INACTIVE, or OFF state.
 - 5. Tie Circuit Breaker: Provide ground fault current sensor at the tie circuit breaker which encircles the phase conductors and neutral conductors connect to ground fault current sensors at main circuit breakers of the double ended substation.



WMU Design Guidelines

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which ground-fault protection systems and devices are to be installed and notify Contractor in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.2 INSTALLATION OF GROUND-FAULT PROTECTION DEVICES

- A. Install ground-fault protection devices as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to ensure that ground-fault protection devices comply with requirements. Comply with applicable requirements of NEC and NEMA standards for installation of ground-fault protection devices to ensure that devices fulfill requirements.
- B. Coordinate with other electrical work, including electrical wiring work, as appropriate to properly interface installation of ground-fault protection devices with other work.
- C. Install ground-fault protection devices complying with electrical winding polarities indicated.
- D. Fasten ground-fault sensing devices without mechanical stresses, twisting, or misalignment being exerted by clamps, supports, bus bars or cables.
- E. Install ground-fault sensing windows symmetrically encircling power conductor bus bars or cables. Maintain clearances between conductors and ground-fault sensor body as recommended by device manufacturer.

3.3 GROUNDING

- A. Provide grounding connections for ground-fault systems and units as indicated. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 486A.



3.4 ADJUSTING

- A. Set field-adjustable GFP devices for pickup and time sensitivity ranges as indicated by engineer, subsequent to installation of devices.

3.5 FIELD QUALITY CONTROL

- A. Upon completion of installation of ground-fault protection devices and after electrical circuitry has been energized, demonstrate capability, and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

END OF SECTION 26 2818



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SECTION 26 2923 – VARIABLE FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements of the following Division 26 Sections apply to this Section:
 - 1. "Basic Electrical Requirements."
 - 2. "Basic Electrical Materials and Methods."
 - 3. "Low Voltage Electrical Power Conductors and Cables."
 - 4. "Disconnects and Circuit Breakers."
 - 5. "Identification For Electrical Systems."
 - 6. "Motor Control Centers."
 - 7. "Fuses."

1.2 SUMMARY

- A. This Section includes a.c. motor control devices rated 600 V and below that are not supplied as an integral part of motor/controller packages.
- B. Overcurrent protective devices and disconnect switches used with motor controllers are specified in Division 26 Section "Overcurrent Protective Devices."

1.3 DEFINITIONS



WMU Design Guidelines

- A. Motor Controller: A device that controls, protects, and energizes an electric motor, and where required, controls its speed or the torque or power delivered by it.

1.4 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
- B. Product data for products specified in this Section. Include dimensions, ratings, and data on features and components.
- C. Maintenance data for products for inclusion in Operating and Maintenance Manual specified in Division 1 and in Division 26 Section "Basic Electrical Requirements."
- D. Load Current and Overload Relay Heater List: Compiled by Contractor after motors have been installed. Arrange to demonstrate selection of heaters to suit actual motor nameplate full load currents.

1.5 QUALITY ASSURANCE

- A. Components and Installation: NFPA 70 "National Electrical Code."
- B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
 - 1. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.
- C. NEMA Compliance: NEMA ICS 2, "Industrial Control Devices, Controllers and Assemblies."
- D. UL Compliance: UL 508, "Electric Industrial Control Equipment."
- E. Single-Source Responsibility: Obtain similar motor-control devices from a single manufacturer.

1.6 COORDINATION



- A. General: Coordinate features of controllers and control devices with pilot devices and control circuits provided under Division 23 Sections covering control systems.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:
 - 1. ABB
 - 2. Danfoss

2.2 MOTOR CONTROLLERS, GENERAL

- A. Coordinate the features of each motor controller with the ratings and characteristics of the supply circuit, the motor, the required control sequence, the duty cycle of the motor, drive, and load, and the pilot device, and control circuit affecting controller functions. Provide controllers that are horsepower rated to suit the motor controlled.
- B. Contacts shall open each ungrounded connection to the motor.
- C. Overload Relays: Ambient-compensated type with inverse-time-current characteristic. Provide with heaters or sensors in each phase matched to nameplate full load current of the specific motor to which connected with appropriate adjustment for duty cycle.
- D. Enclosures: For individually mounted motor controllers and control devices, comply with NEMA Standard 250, "Enclosures for Electrical Equipment (1000 Volts maximum)." Provide enclosures suitable for the environmental conditions at the controller location. Provide NEMA Type 1 enclosures except as otherwise indicated.
- E. Combination starters shall be used on all three phase motors except where the starter is built into the equipment or other special equipment.
- F. Special controls such as alternators or duplex pumps, pressure switches, etc., shall be furnished by the contractor furnishing the equipment.



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2.3 MANUAL MOTOR CONTROLLERS

- A. Description: Quick-make, quick-break toggle action, and with one-piece melting alloy thermal units. Controller to become inoperative when thermal unit is removed. Provide controllers with double break silver alloy contacts, visible from both sides of the controller; red pilot lights, and switch capable of being padlocked off.

2.4 MAGNETIC MOTOR CONTROLLERS

- A. Description: Provide full-voltage, nonreversing, across, the-line, combination starters, except where another type is indicated.
- B. Control Circuit: 120V. Provide control power transformer 100VA (min.) integral with controller. Provide control power transformer with adequate capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity. Transformer shall have primary and secondary fusing.
- C. Combination Controller: Switch type; fused; quick-make, quick-break switch; factory assembled with controller and arranged to disconnect it. Switches and fuses are specified in Division 26 Section "Disconnect & Circuit Breakers" and "Fuses." Interlock switch with unit cover or door. Capable of being padlocked off.
- D. Enhanced-Protection Overload Relay: Provide overload relays with NEMA Class 10 tripping characteristics where indicated. Select to protect motor against voltage unbalance and single phasing.
- E. Provide Hand-Off-Auto switch.
- F. Provide red running and green stopped LED type indicating lights.
- G. Phase Loss Protection: Provide on motors 15 Hp and larger.
- H. Two spare Auxiliary Contacts, in Addition to any required for the specific application.

PART 3 - EXECUTION



3.1 APPLICATION

- A. Manual Controllers: Use for single-phase fractional horsepower motors except as indicated. Single pole for 120 volt circuits and two pole for 208 volt circuits. Starters shall be surface mounted with NEMA type 1 enclosure in unfinished areas and equipment rooms. Flush mounted in finished areas. Include a pilot light.
- B. Hand-Off-Automatic Selector Switches: Except as otherwise indicated, install in covers of manual and magnetic controllers of motors started and stopped by automatic controls or interlocks with other equipment. Make control connections so only the manual and automatic control devices that have no safety functions will be bypassed when the switch is in the hand position. Connect motor-control circuit in both hand and automatic positions for safety type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors. Make control-circuit connections to a hand-off-automatic switch or to more than one automatic control device in accordance with an indicated wiring diagram or one that is manufacturer approved.

3.2 INSTALLATION

- A. General: Install independently mounted motor control devices in accordance with manufacturer's written instructions.
- B. Location: Locate controllers as indicated and within sight of motors controlled. Where individual combination motor controllers are used mount within distance requirement or provide separate additional disconnecting means.
- C. Mounting: For control equipment at walls, bolt units to wall or mount on light-weight structural steel channels bolted to the wall. For controllers not at walls, provide freestanding racks fabricated of structural steel members and light-weight slotted structural steel channels. Use feet consisting of 3/8-inch thick steel plates, 6 inches square, bolted to the floor. Use feet for welded attachment of 1-1/2-inch by 1-1/2-inch by 1/4-inch vertical angle posts not over three feet on centers. Connect the posts with horizontal lightweight slotted steel channels and bolt the control equipment to the channels. Install at 6'-6" AFF to top of enclosure.
- D. Motor-Controller Fuses: Conform to requirements of Division 26 Section "Fuses."

3.3 IDENTIFICATION

- A. Identify motor control components and control wiring in accordance with Division 26 Section "Identification For Electrical Systems."



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- B. Install typewritten labels on the inside door of each fused motor controller to indicate fuse replacement information.

3.4 GROUNDING

- A. Connections: Make equipment grounding connections for disconnects as indicated.
- B. Provide ground continuity to main electrical ground bus indicated.

3.5 CONTROL WIRING INSTALLATION

- A. Install wiring between motor control devices and control/indicating devices as specified in Division 26 Section "Low Voltage Electrical Power Conductors and Cables" for hard-wired connections.
- B. Install wiring in enclosures neatly bundled, trained, and supported.

3.6 CONNECTIONS

- A. Tighten connectors, terminals, bus joints, and mountings. Tighten field connected connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, comply with tightening torques specified in UL 486A and UL 486B.

3.7 FIELD QUALITY CONTROL

- A. Visual and mechanical inspection: Include the following inspections and related work.
 - 1. Motor-Control Device Ratings and Settings: Verify that ratings and settings as installed are appropriate for final loads and final system arrangement and parameters. Recommend final protective-device ratings and settings where differences are found. Use accepted revised ratings or settings to make the final system adjustments. Prepare and submit the load current and overload relay heater list.
 - 2. Inspect for defects and physical damage, and nameplate compliance with current project drawings.
 - 3. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instructions.



4. Check tightness of electrical connections of devices with calibrated torque wrench. Use manufacturer's recommended torque values.
5. Clean devices using manufacturer's approved methods and materials.
6. Verify proper fuse types and ratings in fusible devices.

B. Electrical Tests: Perform the following in accordance with manufacturer's instructions:

1. Prior to energizing the motor controller equipment, check with ground resistance tester, phase-to-phase and phase-to-ground insulation resistance levels to ensure requirements are fulfilled. Check circuitry for electrical continuity and short-circuits. Ensure that direction of rotation of each motor is correct.

C. Verify all interlock devices (mechanical and electrical) are in place and working correctly.

D. Correct deficiencies and retest motor control devices. Verify by the system tests that specified requirements are met.

3.8 CLEANING

- A. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally using methods and materials as recommended by manufacturer.

END OF SECTION 26 2923



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SECTION 26 3213 – ENGINE GENERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements of the following Division 26 Sections apply to this Section:
 - 1. "Basic Electrical Requirements."
 - 2. "Basic Electrical Materials and Methods."

1.2 SUMMARY

- A. This Section includes engine driven generators rated 600 V and under. It includes the following items:
 - 1. Diesel fired prime movers.
 - 2. Natural or propane gas fired prime movers.
- B. Provide, install, and acceptance test a complete and operable Emergency/Standby electric generating system, including all devices and equipment specified herein, as shown on the drawings, or required for the service. Equipment shall be new, factory tested, and delivered ready for installation.

1.3 SUBMITTALS



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- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
 - B. Within 10 days after award of contract, provide six sets of the following information for review:
 - 1. Manufacturer's product literature and performance data, sufficient to verify compliance to specification requirements.
 - 2. A paragraph by paragraph specification compliance statement, describing the differences between the specified and the proposed equipment.
 - 3. Manufacturer's certification of prototype testing.
 - 4. Manufacturer's published warranty documents.
 - 5. Shop drawings showing plan and elevation views with certified overall dimensions, as well as wiring interconnection details.
 - 6. Interconnection wiring diagrams showing all external connections required; with field wiring terminals marked in a consistent point-to-point manner.
 - 7. Manufacturer's installation instructions.
 - C. Wiring diagrams, elementary or schematic, differentiating between manufacturer-installed and field-installed wiring.
 - D. Single line diagram of the unit showing connections between the automatic transfer switch, the power source and the load, plus interlocking provisions.
 - E. Operation and maintenance data for products, for inclusion in Operating and Maintenance Manual specified in Division 1 and in Division 26 Section "Basic Electrical Requirements." Operating and maintenance data shall cover each type of product, including all features and operating sequences, both automatic and manual. List all factory settings of relays and provide relay setting and calibration instructions. Provide spare parts data.
 - F. Manuals: Four Sets of Operator Manuals and spare parts manuals shall be provided for all system equipment. The manuals shall include outline, interconnection, wiring, and control drawings accurately describing the equipment provided. Provide ladder logic for all programmable logic controllers in the system.
 - G. Manufacturer's certificate of compliance to the referenced standards and manufacturer's certification of tested short circuit closing and withstand ratings.
- 1.4 QUALITY ASSURANCE
- A. Electrical Component Standard: Comply with NFPA 70 "National Electrical Code" for components and installation.



- B. NEMA Compliance: Comply with NEMA standards: ICS 1, "General Standards for Industrial Control"; ICS 2, "Industrial Control Devices, Controllers and Assemblies"; and ICS 6, "Enclosures for Industrial Controls and Systems."
- C. UL Listing and Labeling: Provided items specified in this section that are listed and labeled by UL for emergency service under UL 1008.
- D. Prototype tests shall have been performed on a complete and functional unit, component level type tests will not substitute for this requirement. Prototype testing shall comply with the requirements of NFPA 110 for level 1 systems.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Cummins/Onan Corp.
- B. Proposed substitutions shall include complete submittal data, as specified herein, clearly denoting any and all deviations and/or exceptions to the equipment specified. The complete proposal must be submitted to the engineer or architect for approval/disapproval not less than 10 days prior to the scheduled bid date. If approved, the Contractor is responsible for the charges for all necessary revisions.
 - 1. Submit the following information with the proposal package for review and evaluation:
 - 2. A paragraph by paragraph specification compliance statement, describing the differences between the specified and the proposed equipment.
 - 3. Dimensions of the generator sets, transfer switches, paralleling equipment (when specified) and accessory hardware, including plan and elevation drawings.
 - 4. Sequence of operation if required to enhance the description included in this specification.
 - 5. Indication of the nearest field service office staffed with factory trained technicians. Provide service organization data and manpower. Indicate typical response time for emergency calls. Provide typical scenario for an emergency service call.
- C. The supplier shall be the manufacturer's authorized distributor, who shall provide initial start-up services, conduct field acceptance testing, and warranty service. The supplier shall have 24-hour service availability and factory-trained service technicians authorized to perform warranty service on all products provided.



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2.2 Generator Set, GENERAL

- A. General: The following requirements apply to prime mover and alternator products:
- B. Provide complete factory assembled generator and alternator equipment with electronic controls.
- C. Four cycle, 1800 rpm, generator set. Generator ratings: rated KW assumes 0.8 PF, standby rating, based on site conditions of 500 ft altitude and ambient temperatures up to 100 degrees Fahrenheit.
 - 1. Voltage and phase rating: per schedule.
 - 2. KW rating: per schedule.
 - 3. Prime mover fuel: per schedule (natural gas if available)
 - 4. Frequency 60 Hertz.
- D. Performance: Voltage regulation shall be +/- 1.0 percent for any constant load between no load and rated load. Frequency regulation shall be within 5% from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.5%.
- E. Factory Wiring: Train and bundle factory wiring and identify consistently with shop drawings, either by color code or by numbered or lettered wire and cable tape markers at all terminations. Provide designated terminal blocks for field wiring and arrange power terminal and field wiring space to be suitable for top, side, or bottom entrance of feeder conductors as indicated. Provide pressure-type terminals suitable for copper or aluminum conductors of sizes indicated. Conductor material: Copper ONLY.
- F. Base: The engine-generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate:
 - 1. Battery tray with hold-down clamps within the rails.
 - 2. Fuel tank for Diesel units.
- G. Water Jacket Heater thermostatically controlled 120 VAC, 1500 Watts Min. Provide proper power supply circuits for the heater as required for the voltage and load of the heater, connected to a normally served distribution circuit.
- H. Vibration Isolation: Vibration isolators, spring/pad type, quantity as recommended by the generator set manufacturer.
- I. Exhaust Silencer: Exhaust muffler shall be Critical Grade. The mufflers shall be residential/critical grade. Exhaust system shall be installed according to the generator set



manufacturers recommendations and applicable codes and standards. A non-rusting rain cap shall be mounted on exhaust.

- J. Generator Set Main Circuit Breaker: Generator main circuit breaker: set-mounted and wired, UL listed, molded case type. Submittals shall demonstrate that the circuit breaker provides proper protection for the alternator by a comparison of the trip characteristic of the breaker with the thermal damage characteristic of the alternator. Field circuit breakers shall not be acceptable for generator overcurrent protection. Breaker criteria:
1. Breaker shall be sized for generator KW.
 2. Voltage appropriate for specified operating voltage per schedule.
 3. Number of poles appropriate per schedule.
 4. Mounted under locked door on genset.
 5. 100 amp or larger shall have electronic trip unit.
 6. Smaller than 100 amp, thermal magnetic type.

2.3 Generator Set, DIESEL

- A. Sub-Base Fuel Storage Tank: Provide a dual wall sub-base fuel storage tank with 24 Hours at full load capacity. The tank shall be constructed of corrosion resistant steel and shall be UL listed. The equipment, as installed, shall meet all local and regional requirements for above ground tanks. Include rupture basin alarm and low fuel alarm, wired to generator set control panel.
- B. The engine shall be diesel, 4 cycle, radiator and fan cooled. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories. Two cycle engines are not acceptable. Engine accessories and features shall include:
1. Skid-mounted radiator and cooling system rated for full load operation in 104 degrees F (40 degrees C) ambient as measured at the generator air inlet. Radiator shall be provided with a duct adapter flange. The cooling system shall be filled with 50/50 ethylene glycol/water mixture by the equipment supplier. Rotating parts shall be guarded against accidental contact per OSHA requirements.
 2. An electric starter(s) capable of three complete cranking cycles without overheating.
 3. Positive displacement, mechanical, full pressure, lubrication oil pump.
 4. Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator.
 5. An engine driven, mechanical, positive displacement fuel pump. Fuel filter with replaceable spin-on canister element.
 6. Replaceable dry element air cleaner with restriction indicator.
 7. Flexible supply and return fuel lines.
 8. Engine mounted battery charging alternator, 37 ampere minimum, and solid-state voltage regulator.



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- C. The diesel engine-generator set shall be capable of single step load pick up of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature. Motor starting capability shall be a minimum of 563 kVA. The generator set shall be capable of sustaining a minimum of 90% of rated no load voltage with the specified kVA load at near zero power factor applied to the generator set.
- D. The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.

2.4 GENERATOR SET, NATURAL GAS

- A. Confirm adequate gas supply available or to be installed.
- B. Voltage regulation shall be plus or minus 2 percent for any constant load between no load and rated load. Random voltage variation with any steady load from no load to full load shall not exceed plus or minus 1%.
- C. Frequency regulation shall be plus or minus 2.5% from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.5%.
- D. The alternator shall produce a clean AC voltage waveform, with not more than 7% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic. Telephone influence factor shall be less than 40.
- E. The automatic voltage regulator shall be temperature compensated, half wave phase controlled solid-state design and include an under-speed protection function. The regulator design shall include a torque-matching characteristic to allow the engine to use its fullest power producing capability at speeds lower than rated, to optimize motor starting capability and to provide the fastest possible recovery from transient speed dips.
- F. Engine: The engine shall be Natural gas, 4 cycle, radiator and fan cooled. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories. Two cycle engines are not acceptable. Engine accessories and features shall include:
 - 1. A mechanical governing system shall provide automatic frequency regulation as described herein.
 - 2. An electronic isochronous governing system shall be provided for the generator set.
 - 3. Skid-mounted radiator and cooling system rated for full load operation in 105 degrees F (40 degrees C) ambient as measured at the generator air inlet. Radiator shall be provided with a duct adapter flange. The cooling system shall be filled with 50/50



ethylene glycol/water mixture by the equipment supplier. Rotating parts shall be guarded against accidental contact per OSHA requirements.

4. An electric starter(s) capable of three complete cranking cycles without overheating.
5. Positive displacement, mechanical, full pressure, lubrication oil pump. Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator.
6. An engine driven, mechanical, positive displacement fuel pump. Fuel filter and water separator with replaceable spin-on canister element.
7. Replaceable dry element air cleaner.
8. Flexible supply and return fuel lines.
9. Engine mounted battery charging alternator, 45 ampere minimum, and solid-state voltage regulator.

2.5 GENERATOR SET, BATTERY SYSTEM

- A. Starting and Control Batteries: Starting battery bank, calcium/lead antimony type, 12 volt DC, sized as recommended by the generator set manufacturer, shall be supplied for each generator set with battery cables and connectors. Provide 120 volt battery heaters.
- B. Battery Charger: Provide a float charge battery charger rated 2 amps. DC output voltage shall be as required for the starting batteries. An ammeter shall display charging current. The battery charger shall have fused AC input and DC outputs. Include a DC ammeter and voltmeter, AC power failure relay, low DC voltage alarm relay and 0-24 hour equalizing timer, in NEMA 1 enclosure.

2.6 AC GENERATOR

- A. The AC generator shall be; synchronous, four pole, 2/3 pitch, revolving field, drip-proof construction, single prelubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc. All insulation system components shall meet NEMA MG1 temperature limits for Class H insulation system. Actual temperature rise measured by resistance method at full load shall not exceed 105 degrees Centigrade.
- B. The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.
- C. The generator set shall include an automatic voltage regulation system which is matched, and prototype tested with the governing system provided. It shall be immune from misoperation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below a threshold of [58-59] HZ for 60 Hz machines.



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- D. Voltage adjusting rheostat, locking screwdriver type, to adjust voltage +/- 5% from rated value;

2.7 CONTROLS

- A. The NEMA 1 enclosed control panel shall be mounted on the generator set with vibration isolators. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered. The generator set mounted control shall include the following features and functions:
 - 1. Three position control switch labeled RUN/OFF/AUTO.
 - a. In the RUN position the generator set shall automatically start, and accelerate to rated speed and voltage.
 - b. In the OFF position the generator set shall immediately stop, bypassing all time delays.
 - c. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
 - 2. RESET switch. The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
 - 3. PANEL LAMP switch. Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power.
 - 4. Generator Set AC Output Metering: The generator set shall be provided with a metering set with the following features and functions:
 - a. Analog AC Voltmeter, dual range, 90 degree scale, 2% accuracy
 - b. Analog AC Ammeter, dual range, 90 degree scale, 2% accuracy;
 - c. Analog Frequency/RPM meter, 45-65 Hz, 1350-1950 RPM, 90 degree scale, +/- 0.6 Hz accuracy.
 - d. Seven position phase selector switch with OFF position to allow meter display of current and voltage in each generator phase. When supplied with reconnectable generators, the meter panel shall be reconnectable for the voltage specified.
- B. Generator Set Alarm and Status Display: The generator set shall be provided with alarm and status indicating lamps to indicate non-automatic generator status, and existing alarm and shutdown conditions. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of the following alarm and shutdown conditions on the display panel:
 - 1. switch off (flashing)
 - 2. low oil pressure (alarm)
 - 3. low oil pressure (shutdown)
 - 4. low coolant temperature (alarm)
 - 5. high coolant temperature (alarm)
 - 6. high coolant temperature (shutdown)
 - 7. low coolant level (shutdown)
 - 8. overcrank (shutdown)



9. overspeed (shutdown)
10. low fuel-daytank (alarm)
11. ground fault (alarm)(optional--when required by code or specified)

- C. In addition, provisions shall be made for indication of two customer-specified alarm or shutdown conditions. The non-automatic indicating lamp shall be red and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.
- D. Engine Status Monitoring: The following devices shall be provided on the generator set control:
1. engine oil pressure gauge
 2. engine coolant temperature gauge
 3. engine operation hour gauge
 4. battery voltage (DC volts)
- E. The control system provided shall include a cycle cranking system, which shall be for 3 cranking periods of 15 seconds each, with 15 second rest period between cranking periods. Fail to start shall be indicated by operation of the overcrank alarm indication lamp
- F. When required by National Electrical Code or indicated on project drawings, the control system shall include a ground fault monitoring relay. The relay shall be adjustable from 100-1200 amps and include adjustable time delay of 0-1.0 seconds. The relay shall be for indication only, and not trip or shut down the generator set. Note bonding and grounding requirements for the generator set, and provide relay, which will function correctly in system as installed.
- G. Exerciser Clock: Provide solid state exerciser clock to set the day, time, and duration of generator set exercise/test period. Provide a with/without load selector switch for the exercise period. Provide as part of transfer switch.

2.8 FINISHES

- A. Clean ferrous surfaces to be painted free of oil, grease, welding slag, and spatter, mill scale, corrosion, and dirt.
- B. Outdoor Weather-Protective Housing: Generator set housing shall be provided factory-assembled to generator set base and radiator cowling. Housing shall provide ample airflow for generator set operation at rated load in the ambient conditions previously specified. The housing shall have hinged side-access doors and rear control door. All doors shall be lockable. All sheet metal shall be primed for corrosion protection and finish painted with the manufacturers standard color using a two step electrocoating paint process, or equal meeting the performance requirements specified below. All surfaces of all metal parts shall be primed



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and painted. The painting process shall result in a coating which meets the following requirements:

1. Primer thickness, 0.5-2.0 mils. Top coat thickness, 0.8-1.2 mils.
 2. Gloss, per ASTM D523-89, 80% plus or minus 5%. Gloss retention after one year shall exceed 50%.
 3. Crosshatch adhesion, per ASTM D3359-93, 4B-5B.
 4. Impact resistance, per ASTM D2794-93, 120-160 inch-pounds.
 5. Salt Spray, per ASTM B117-90, 1000+ hours.
 6. Humidity, per ASTM D2247-92, 1000+ hours.
 7. Water Soak, per ASTM D2247-92, 1000+ hours.
- C. Painting of hoses, clamps, wiring harnesses, and other non-metallic service parts shall not be acceptable. Fasteners used shall be corrosion resistant and designed to minimize marring of the painted surface when removed for normal installation or service work.
- D. Paint with rust-inhibiting primer and finish enamel. Apply primer to clean, dry surface immediately after cleaning. Use finish coat of manufacturer's approved standard color. Provide a finish free from runs, sags, peeling, and other defects.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Equipment shall be installed on wire reinforced concrete housekeeping pads. Equipment shall be permanently fastened to the pad in accordance with manufacturer's instructions and requirements of the site.
1. Inside installations 4" minimum
 2. Outside locations 6" minimum over properly prepared base, pad should protrude above grade 4". Pad shall be 1 foot larger than genset on all sides.
- B. For outside installation, install all raceways underground, and penetrate housekeeping pad inside of genset enclosure. Exact locations to be coordinated with genset cut sheets.
- C. Equipment shall be installed by the electrical contractor in accordance with final submittals and contract documents. Installation shall comply with applicable state and local codes as required by the authority having jurisdiction. Install equipment in accordance with manufacturer's instructions and instructions included in the listing or labeling of UL listed products.



- D. Installation of equipment shall include furnishing and installing all interconnecting wiring between all major equipment provided for the on-site power system. The contractor shall also perform interconnecting wiring between equipment sections (when required), under the supervision of the equipment supplier.
- E. Equipment shall be initially started and operated by representatives of the manufacturer. This startup shall be by genset manufacturers representative in addition to training sessions.
- F. All equipment shall be physically inspected for damage. Scratches and other installation damage shall be repaired prior to final system testing. Equipment shall be thoroughly cleaned to remove all dirt and construction debris prior to final testing of the system.
- G. Identify components in accordance with Division 16 Section "Electrical Identification."

3.2 FACTORY TESTS

- A. Equipment supplied shall be fully tested at the factory for function and performance. Factory testing may be witnessed by the owner and consulting engineer. Costs for travel expenses will be the responsibility of the owner and consulting engineer. Supplier is responsible to provide two weeks notice for testing.
- B. Generator set factory tests on the equipment shall be performed at rated load and rated PF. Generator sets that have not been factory tested at rated PF will not be acceptable. Tests shall include: run at full load, maximum power, voltage regulation, transient and steady-state governing, single step load pickup, and function of safety shutdowns. Minimum run time is 1 hour.

3.3 CONNECTIONS

- A. Check connectors, terminals, bus joints, and mountings for tightness. Tighten field connected connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and UL 486B.

3.4 GROUNDING



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- A. Provide equipment grounding connections for generator units as indicated and as required by NEC. Tighten connectors to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounding.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services: Provide services of a factory service representative to assist with demonstrations and field tests.
- B. Field Tests: Energize Gensets and demonstrate functioning of all devices, components, and sequences. Give seven calendar days' advance notice of the tests and perform tests in presence of Owner's representative.
- C. Tests for Gensets: Include the following:
 - 1. Cold start to fully loaded
 - 2. Proper operation of controls, and alarms.
 - 3. Verify proper startup with transfer switch signals.
- D. Checking, measuring, and optimizing all adjustable time delays.
- E. Test Failures: Correct deficiencies identified by tests and make ready for retest. Verify equipment meets the specified requirements.
 - 1. If a deficiency is found and corrected in the AC generator or other components that may fail under full load, a load bank test will be required. This testing will be at no additional cost to the University.
- F. The University will provide fuel for natural gas and propane generator testing.
- G. Reports: Maintain a written record of observations and tests. Report defective materials and workmanship and retest corrected defective items. Submit written test reports. Include a record of all adjustable relay settings and measured time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.6 DEMONSTRATION

- A. Training: Furnish the services of a factory authorized service representative to instruct Owner's personnel in the operation and maintenance of transfer



switches and related equipment. Provide a minimum of three hours of instruction scheduled seven days in advance.

- B. Initial startup shall be completed by manufacturers representative at least two days prior to scheduled training. Training will be postponed if problems discovered.

3.7 CLEANING

- A. Upon completion of installation, inspect interiors and exteriors of accessible components. Remove dust, dirt, foreign matter, paint splatters and other spots, dirt, and construction debris. Vacuum interior. Touch up scratches and mars of finish to match original finish.

3.8 WARRANTY

- A. Generator shall be warranted and serviced by factory authorized technicians for defects in materials or workmanship for one year from the startup date. During this period items covered under this will be at no cost to the University.

END OF SECTION 26 3213



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 3600 – TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements of the following Division 26 Sections apply to this Section:
 - 1. "Basic Electrical Requirements."
 - 2. "Basic Electrical Materials and Methods."

1.2 SUMMARY

- A. This Section includes transfer switches rated 600 V and under. It includes the following items:
 - 1. Automatic transfer switch. (ATS)

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
- B. Product data for each transfer switch including dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and materials lists.
- C. Wiring diagrams, elementary or schematic, differentiating between manufacturer-installed and field-installed wiring.
- D. Single line diagram of the unit showing connections between the automatic transfer switch, the power source and the load, plus interlocking provisions.
- E. Operation and maintenance data for products, for inclusion in Operating and Maintenance Manual specified in Division 1 and in Division 16 Section "Basic Electrical Requirements." Operating and maintenance data shall cover each type of product, including all features and



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operating sequences, both automatic and manual. List all factory settings of relays and provide relay setting and calibration instructions. Provide spare parts data.

- F. Manuals: Four Sets Operators and spare parts manuals shall be provided for all system equipment. The manuals shall include outline, interconnection, wiring, and control drawings accurately describing the equipment provided. Provide ladder logic for all programmable logic controllers in the system.
- G. Manufacturer's certificate of compliance to the referenced standards and manufacturer's certification of tested short circuit closing and withstand ratings.

1.4 QUALITY ASSURANCE

- A. Electrical Component Standard: Comply with NFPA 70 "National Electrical Code" for components and installation.
- B. NEMA Compliance: Comply with NEMA standards: ICS 1, "General Standards for Industrial Control"; ICS 2, "Industrial Control Devices, Controllers and Assemblies"; and ICS 6, "Enclosures for Industrial Controls and Systems."
- C. UL Listing and Labeling: Provided items specified in this section that are listed and labeled by UL for emergency service under UL 1008.
- D. UL Compliance: Comply with UL Standard 1008, "Automatic Transfer Switches," except where requirements of these specifications are stricter.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Automatic Switch Co.
 - 2. Kohler Co.
 - 3. Onan Corp.

2.2 TRANSFER SWITCH PRODUCTS, GENERAL

- A. General: The following requirements apply to automatic and nonautomatic transfer switch and bypass/isolation switch products:
- B. Provide complete factory assembled transfer equipment with electronic controls designed for surge voltage isolation and including voltage sensors on all phases of both sources, linear operator, permanently attached manual handles, positive mechanical and electrical interlocking, and mechanically held contacts.



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- C. Transfer switches shall be rated to carry 100 percent of rated current continuously in the enclosure, in ambient temperatures of -40 to +50 degrees C, relative humidity up to 95% (non-condensing), and altitudes up to 10,000 feet (3000M).
- D. Ratings: Provide as specified. _____ Ampere Rating, _____ Volts, ____ Poles.
- E. Fault Current Rating: 35,000 rms symmetrical amperes minimum.
 - 1. Transfer switch equipment shall have a withstand and closing rating (WCR) in RMS symmetrical amperes greater than the available fault currents shown on the drawings. The transfer switch and its upstream protection shall be coordinated. The transfer switch shall be third-party listed and labeled for use with the specific protective device(s) installed in the application.
- F. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 deg C to 70 deg C. Components shall meet or exceed voltage surge withstand capability when tested in accordance with ANSI Standard C37.90.1, "IEEE Guide for Surge Withstand Capability (SWC) Tests."
- G. Neutral Terminal:
 - 1. Where two- or three-pole manual switches are indicated, provide fully rated, solid, unswitched neutral terminal except as indicated.
 - 2. Where two or three-pole automatic switches are indicated, provide fully rated, switched neutral terminal except as indicated.
- H. Enclosures: General-purpose NEMA 1 in accordance with UL 508, "Electric Industrial Control Equipment," except as otherwise indicated.
- I. Factory Wiring: Train and bundle factory wiring and identify consistently with shop drawings, either by color code or by numbered or lettered wire and cable tape markers at all terminations. Provide designated terminal blocks for field wiring and arrange power terminal and field wiring space to be suitable for top, side, or bottom entrance of feeder conductors as indicated. Provide pressure-type terminals suitable for copper or aluminum conductors of sizes indicated.
- J. Electrical operation, where indicated, shall be accomplished by a nonfused momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions. Transfer switches using components of molded case circuit breakers or contactors not designed for continuous duty repetitive switching between active power sources are not acceptable.
- K. Switch action for double-throw-type switches shall be mechanically held in both directions.
- L. Switch Contacts: Heavy duty silver composition for switching load current with separate arcing contacts where rated 400 amperes and above.
- M. Overcurrent devices shall not be part of automatic transfer switch products.



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2.3 AUTOMATIC TRANSFER SWITCHES (ATSS)

- A. Transfer switches that are designated on the drawing as automatic shall be provided with a fully automatic control system, and provisions for manual operation as described in this section.
- B. Comply with requirements for Level 1 equipment per NFPA 110, "Standard for Emergency and Standby Power Systems."
- C. Features and Characteristics: Include the following:
 - 1. Double throw type switching arrangement, incapable of pauses or intermediate position stops during normal functioning except as indicated.
 - 2. Manual Operator: Capable of transferring the switch to either source position for maintenance purposes. Control circuit shall be disconnected from electrical operator during manual operation. Switches rated through 1000 amps may be manually operated while energized.
 - 3. Electrically and mechanically interlocked, and mechanically held in both positions.
- D. Transfer switches shall be mounted in enclosures as designated on the drawings. Separate enclosures shall be the NEMA type specified. The cabinet shall provide required wire bend space at point of entry as shown on the drawings. Manual operating handles and all control switches (other than key-operated switches) shall be accessible to authorized personnel only by opening the key-locking cabinet door. Transfer switches with manual operating handles and/or non key-operated control switches located on outside of cabinet do not meet this specification and are not acceptable Accessories:
- E. Control shall be solid-state and designed for a high level of immunity to power line surges and transients, demonstrated by test to IEEE Standard 587-1980. The control shall have optically isolated logic inputs, high isolation transformers for AC inputs, and relays on all outputs.
- F. Solid-state undervoltage sensors shall simultaneously monitor all phases of both sources. Pick-up and drop-out settings shall be adjustable. Voltage sensors shall allow for adjustment to sense partial loss of voltage on any phase. Voltage sensors shall have field calibration of actual supply voltage to nominal system voltage.
- G. The switch shall transfer when the emergency source reaches the set point voltage and frequency. Provide a solid-state time delay on transfer, adjustable from 0.5 to 120 seconds. Factory set at 1 second.
- H. Controls shall signal the engine-generator set to stop after a time delay, adjustable from 0 to 10 minutes, beginning on return to the normal source. Factory set at 5 minutes.
- I. Power for transfer operation shall be from the source to which the load is being transferred.
- J. Provide the following ATS accessories:
 - 1. Close differential voltage sensing on each phase of normal source. Pickup voltage shall be adjustable from 85 percent to 100 percent of nominal, and dropout shall be adjustable from 75 percent to 98 percent of the pick-up value. Factory set for pick-up at 90 percent and dropout at 85 percent.
 - 2. Time-delay override of normal source voltage sensing shall delay all transfer and engine start signals. Adjustable 0 to 6 seconds, and factory set at 1 second.



3. Voltage/frequency lockout relay and sensing of the emergency source shall be provided to prevent premature transfer. Voltage pick-up shall be adjustable from 85 to 100 percent of nominal. Factory set to pick-up at 90 percent of nominal. Pick-up frequency shall be adjustable from 90 percent to 100 percent of nominal. Factory set to pick-up at 95 percent.
4. System test switch, momentary type.
5. Retransfer time delay to normal or preferred power source: adjustable from 0 to 30 minutes and factory set at 30 minutes. Provide automatic defeat of the delay upon loss of voltage or sustained under voltage of the emergency source, provided the normal supply has been restored. Factory set at 15 minutes.
6. LED Pilot lights to indicate source to which the load is connected.
7. Unassigned Auxiliary Contacts: Two normally open SPDT contacts for each switch position.
 - a. Rating: 10 amperes at 240 VAC.
8. Source Available Indicating Lights: A green LED indicating light to supervise the normal power source with a nameplate engraved "NORMAL SOURCE AVAILABLE," and a red LED indicating light to supervise the emergency power source with a nameplate engraved "EMERGENCY SOURCE AVAILABLE." Supervision of sources shall be via the transfer switch normal and emergency source sensing circuits, respectively.
9. Transfer Override Switch: To override automatic retransfer control so the ATS will remain connected to the emergency power source regardless of the condition of the normal source. Provide a pilot light to indicate the override status.
10. Remote Control Features:
 - a. Engine exerciser contact for switches connected to generators.
 - b. Transfer test contact.
11. Front Panel Items:
 - a. Key operated switch with standby and normal positions to manually switch between the standby and normal source.
 - b. Transfer switch position and source LED lamps.
 - c. Test switch – Simulates normal power loss to control for generator testing. Control shall provide for test with or without load transfer.
 - d. Retransfer – Momentary position to override retransfer time delay and cause immediate return to normal source, if available.
 - e. Digital display to indicate voltage levels of two sources, and maintain history of switch operations
 - f. Control that can interface with a LON compliant environment.

2.4 WIRING

- A. Hard-Wired Connections: Conform to Division 16 Section "Wires and Cables" for conductors between transfer switches and remote annunciator panels.

2.5 FINISHES

- A. Clean ferrous surfaces to be painted free of oil, grease, welding slag, and spatter, mill scale, corrosion, and dirt.



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- B. Paint with rust-inhibiting primer and finish enamel. Apply primer to clean, dry surface immediately after cleaning. Use manufacturer's standard material and procedure except as required to produce a total dry film thickness not less than 2.5 mils. Use finish coat of manufacturer's approved standard color. Provide a finish free from runs, sags, peeling, and other defects.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Floor Mounting of Transfer Switches: Level and anchor the unit to the floor.
- B. Equipment shall be installed by the contractor in accordance with final submittals and contract documents. Installation shall comply with applicable state and local codes as required by the authority having jurisdiction. Install equipment in accordance with manufacturer's instructions and instructions included in the listing or labeling of UL listed products.
- C. Installation of equipment shall include furnishing and installing all interconnecting wiring between all major equipment provided for the on-site power system. The contractor shall also perform interconnecting wiring between equipment sections (when required), under the supervision of the equipment supplier.
- D. Equipment shall be initially started and operated by representatives of the manufacturer.
- E. All equipment shall be physically inspected for damage. Scratches and other installation damage shall be repaired prior to final system testing. Equipment shall be thoroughly cleaned to remove all dirt and construction debris prior to final testing of the system.
- F. Identify components in accordance with Division 26 Section "Electrical Identification."

3.2 CONNECTIONS

- A. Check connectors, terminals, bus joints, and mountings for tightness. Tighten field connected connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and UL 486B.

3.3 GROUNDING

- A. Provide equipment grounding connections for transfer switch units as indicated and as required by NEC. Tighten connectors to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounding.



3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services: Provide services of a factory service representative to assist with demonstrations and field tests.
- B. Transfer equipment factory tests: Each transfer switch supplied shall be factory tested before shipment. Factory tests shall include a complete functional test of the transfer switch controls, including calibration of the voltage sensors.
- C. Field Tests: Energize transfer switches and demonstrate functioning of all devices, components, and sequences. Give seven calendar days' advance notice of the tests and perform tests in presence of Owner's representative.
- D. Tests for Transfer Switches: Demonstrate each sequence and operational function at least five times.
- E. Tests for ATSS: Include the following:
 - 1. Simulate power failure of normal source.
 - 2. Simulate power failure of emergency source with normal sources available.
 - 3. Simulate low phase to ground voltage for each phase of normal source.
- F. Checking, measuring, and optimizing all adjustable time delays.
- G. Test Failures: Correct deficiencies identified by tests and make ready for retest. Verify equipment meets the specified requirements.
- H. Reports: Maintain a written record of observations and tests. Report defective materials and workmanship and retest corrected defective items. Submit written test reports. Include a record of all adjustable relay settings and measured time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.5 DEMONSTRATION

- A. Training: Furnish the services of a factory authorized service representative to instruct Owner's personnel in the operation and maintenance of transfer switches and related equipment. Provide a minimum of two hours of instruction scheduled seven days in advance.

3.6 CLEANING

- A. Upon completion of installation, inspect interiors and exteriors of accessible components. Remove dust, dirt, foreign matter, paint splatters and other spots, dirt, and construction debris. Vacuum interior. Touch up scratches and mars of finish to match original finish.

END OF SECTION 26 3600



WMU Design Guidelines Instructions: These guidelines are to be used by the Design Professional to inform the design process and outline WMU-specific desires for all University projects. These guidelines have been edited to reflect WMU preferences, and the intent is for the Design Professional to use this information to guide their normal specifications-writing process. Straying from what is indicated in the guidelines is not prohibited, but shall be discussed with WMU during the development of the project.

SECTION 26 4313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

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. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.
- B. Related Requirements:
 - 1. Section 26 2413 "Switchboards" for factory-installed SPDs.
 - 2. Section 26 2416 "Panelboards" for factory-installed SPDs.
 - 3. Section 26 1116 "Secondary Unit Substations" for factory-installed SPDs.

1.3 DEFINITIONS

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SPD: Surge protective device.
- H. VPR: Voltage protection rating.



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1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For SPDs to include in maintenance manuals.

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Emerson Electric Co. (Liebert)
 - 2. Schneider Electric Industries SAS.
 - 3. Siemens Industry, Inc.

2.2 GENERAL SPD REQUIREMENTS

- A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Comply with UL 1449.



- D. MCOV of the SPD shall be at least 125 percent of the nominal system voltage.
- E. LED indicator lights for power and protection status for each phase mounted in panelboard cover:
 - 1. Green indicates fully operational circuit.
 - 2. Red indicates loss of protection.
- F. Audible alarm: with silencing switch, to indicate when protection has failed.
- G. Peak Single-Impulse Surge Current Rating for service entrance equipment (B2 Rating): 240kA per phase; 120kA per mode based on a single pulse, IEEE C62.41 standard 8 x 20 microsecond waveform. Device shall not suffer more than 10% deviation in clamping voltage at specified surge current.
- H. Minimum Repetitive Surge Current Capability: 10,000 for service entrance and 5,000 for distribution panels and panelboards impulse per mode in accordance with ANSI/IEEE C62.41 and ANSI/IEEE C62.45 utilizing a Category C3 bi-wave at one-minute intervals without suffering either performance degradation or more than 10% deviation of specified UL 1449 Suppression Voltage Ratings at specified surge current.
- I. Connection Means:
 - 1. Integral: Bus mounted, parallel connection.

2.3 SERVICE ENTRANCE AND UNIT SUBSTATION SUPPRESSOR

- A. SPDs: Comply with UL 1449, Type 1.
- B. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1
 - 1. SPDs with the following features and accessories:
 - a. Integral disconnect switch.
 - b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 - c. Indicator light display for protection status.
 - d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.
 - e. Surge counter.
- C. Comply with UL 1283.
- D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 200 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:



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1. Line to Neutral: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V, 1200 V for 208Y/120 V.
3. Line to Line: 2000 V for 480Y/277 V, 1000 V for 208Y/120 V.

F. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V.
2. Line to Ground: 1000 V.
3. Line to Line: 1000 V.

G. SCCR: Equal or exceed 200 kA.

H. Inominal Rating: 20 kA.

2.4 PANEL SUPPRESSORS

A. SPDs: Comply with UL 1449, Type 1.

1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.
4. Surge Counter.

B. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

C. Comply with UL 1283.

D. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
3. Neutral to Ground: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
4. Line to Line: 2000 V for 480Y/277 V, 1200 V for 208Y/120 V.

E. Protection modes and UL 1449 VPR for 240/120-V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V.
2. Line to Ground: 700 V.
3. Neutral to Ground: 700 V.
4. Line to Line: 1200 V.

F. SCCR: Equal or exceed 100 kA.

G. Inominal Rating: 20 kA for 208V and 10 kA for 480V.



2.5 ENCLOSURES

- A. Indoor Enclosures: NEMA 250, Type 1.
- B. Outdoor Enclosures: NEMA 250, Type 3R.

2.6 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. TVSS units shall be factory mounted in respective branch circuit panelboard, distribution panel, motor control center or switchboard enclosure.
 - 1. Units to be bus connected whenever possible.
- C. Install devices at service entrance on load side, with ground lead bonded to unit substation / service entrance ground.
- D. Where TVSS unit is shown to be installed as an out-board unit (such as existing panelboard) install conductors between suppressor and points of attachment as short and straight as possible. Desired lead length for phase and neutral conductors is 16 inches or less. In no case, shall the leads exceed 30 inches. Do not bond neutral and ground.
 - 1. Provide multipole, circuit breaker (size in accordance with manufacturer's recommendations) as a dedicated disconnect for the suppressor, unless otherwise indicated.
- E. After testing, disable or disconnect TVSS unit until time of substantial completion. This is to eliminate deterioration of the unit during construction period.
- F. Install devices for building feeder equipment and panelboards with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacture's recommended lead length. Do not bond neutral and ground.



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1. Provide a dedicated disconnect for suppressor as indicated on one line or in panel schedules.
- G. Placing system into service: Do not energize or connect distribution equipment to their sources until surge protection devices are installed and connected.
- H. Wiring:
 1. Power Wiring: Comply with wiring methods in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
 2. Controls: Comply with wiring methods in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 1. Compare equipment nameplate data for compliance with Drawings and Specifications.
 2. Inspect anchorage, alignment, grounding, and clearances.
 3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. An SPD will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

- A. Complete startup checks according to manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests and reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

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

END OF SECTION 26 4313



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SECTION 26 5100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior lighting fixtures, LED modules and drivers.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.
5. Retrofit kits for LED lighting fixtures.

B. Related Sections:

1. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Division 26 Section "Network Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.
3. Division 26 Section "Wiring Devices" for manual wall-box dimmers for incandescent lamps.

1.2 ACTION SUBMITTALS

- A. General: Some lighting fixtures may require at least 3 to 4 months of lead time. The Contractor is responsible for allowing sufficient time for the review process, manufacturing and delivery of these products. Substitutions will not be accepted on the basis of the Contractor's obligation to meet project completion deadlines.
- B. Lighting Fixtures Specified: The lighting fixtures specified in these documents have been carefully chosen for their ability to meet lighting requirements for this project. Selection has been based on esthetics, durability, ease of maintenance, luminance ratios, vertical and horizontal illuminances, lumen maintenance, CRI, efficacy, LED system life and warranty as well as their ability to satisfy governing codes such as ASHRAE/IES 90.1/1999. The Contractor is cautioned that substitute products are likely to be unable to meet all of the same criteria as the product specified.
- C. Product Data: For each type of lighting fixture and lamp indicated, arranged in order of fixture designation. Submit fixture data in bound brochure. Include illustrations and dimensions of



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fixtures and showing photometric performance. Include data on features, accessories, and the following:

1. Contract Drawing light fixture type designation.
 2. Dimensions of fixtures.
 3. Certified results of independent laboratory tests of fixtures and lamps for electrical ratings and photometric data.
 4. Emergency lighting unit battery and charger.
 5. LED fixture LM79, LM80 and TM21 testing data.
 6. Written Warranty Compliance
- D. Lighting Fixture Submittals: Fixture cuts lacking sufficient detail to indicate compliance with specifications will not be acceptable.
- E. Shop Drawings: Show details of nonstandard and custom fixtures. Indicate dimensions, weights, components, features, accessories, and methods of field assembly and mounting.
1. Wiring Diagrams: Detail wiring for fixtures and differentiate between manufacturer-installed and field-installed wiring.
- F. Maintenance Data: For lighting fixtures to include in maintenance manuals specified in Division 01.

1.3 QUALITY ASSURANCE

- A. Fixtures, Emergency Lighting Units, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
- B. Comply with NFPA 70.
- C. Comply with LM 79, LM80 and TM21 LED testing standards.
- D. FM Compliance: Fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM.
- E. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.
- F. Office of Fire Safety: All plastic diffusers used in lighting fixtures or luminous ceilings shall conform with NFPA 101, Life Safety Code, 1997 Edition, Section 6-5, Interior Finish. The light fixture manufacturer(s) shall furnish an affidavit stating compliance with this requirement for submittal to the State of Michigan Department of Labor & Economic Growth, Office of Fire Safety, P.O. Box 30254, Lansing, Michigan 48909.

1.4 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.



1.5 WARRANTY

- A. Special Warranty for Batteries: Written warranty, executed by manufacturer agreeing to replace rechargeable batteries that fail in materials or workmanship within specified warranty period.
 - 1. Special Warranty Period for Batteries: Manufacturer's standard, but not less than 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for last nine years.
- B. Warranty for LED fixtures: Written warranty, agreeing to replace drivers, LED modules and any fixture housing or components that fail in materials and workmanship within minimum (5) years from date of purchase. Warranty shall provide materials necessary to restore to acceptable operation. Labor shall be warranted for two years of the project substantial completion. The warranty shall include fixture replacement or component replacement if the luminaire delivers less than 90% of the initial light level over the rated life.
 - 1. For decorative pendant and track fixtures, warranty shall be minimum of (5) years.
 - 2. All other fixtures shall match the standard warranty of the fixture specified.

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURE MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the products indicated for each designation in the Lighting Fixture Schedule on the plans.

2.2 FIXTURES AND FIXTURE COMPONENTS, GENERAL

- A. Metal Parts: Free from burrs, sharp corners, and edges.
- B. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.
- D. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
 - 4. Laminated Silver Metallized Film: 90 percent.
- E. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or annealed crystal glass, unless otherwise indicated.



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1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
 2. Lens Thickness: 0.125 inch (3 mm) minimum, unless greater thickness is indicated.
- F. Disconnecting Means: Provide disconnecting means for all LED fixtures. Disconnect shall comply with NEC Section 410.73(G).

2.3 LED FIXTURES

A. GENERAL

1. LED light fixtures shall meet all of the specified parameters with published independent testing in accordance with LM79, LM80 and TM21 testing standards.
2. LED light fixtures shall be sold as a complete system. Light fixtures shall have minimum efficacy as follows:
 - a. Linear Recessed LED (2x2,2x4,1x4,1x2): 95 Lumens per watt.
 - b. Linear Recessed LED (~4", Narrow Aperture): 74 Lumens per watt.
 - c. Linear Pendant LED (~4" Aperture): 95 Lumens per watt up, 74 Lumens per watt down.
 - d. Downlight LED: 80 Lumens per watt.
3. LED light fixtures shall have delivered lumen output within 5% of the delivered lumen output of the fixtures specified.
4. LED light fixtures shall be dimmable down to 20% or less of full output. If the specified fixture is dimmable to a level lower than 20%, equivalent fixture must be dimmable to the same level or lower than the fixture specified.
5. LED light fixture shall produce no noticeable variation in color temperature from one fixture to another by the same manufacturer. Color temperature shall be within 3-step MacAdam Ellipse.

B. LED DRIVERS

1. High performance LED driver to be 120/277V and wired for dimming or non-dimming. Provide with manufacturer tested compatible battery backup where indicated.
2. Driver expected lifetime shall be over 100,000 hours.
3. Total Harmonic Distortion Rating: Less than 20 percent.
4. Minimum power factor shall be 94%.

C. LED ENGINES

1. Manufacturers: Refer to light fixture schedule, light fixture is ordered as a complete system including LED driver, light engine and housing from the LED light fixture manufacturer.
2. LED Color Temperature and Minimum Color-Rendering Index:
 - a. Downlights: 4100 K and over 85 CRI
 - b. Linear LED: 4100 K and over 80 CRI



3. LED Life:

- a. Downlights: Rated average shall be 50,000 hours rated per LM79, LM80 and TM-21 standards.
- b. Linear LED: Rated average shall be 100,000 hours rated per LM79, LM80 and TM-21 standards.
- c. Track and pendant heads: Rated average shall be 50,000 hours to 70% rated per LM79, LM80 and TM-21 standards.

2.4 EXIT SIGNS

A. General Requirements: Comply with UL 924 and the following:

1. Refer to Lighting Fixture Schedule on the plans.

B. Internally Lighted Signs: Features as follows:

1. Lamps for AC Operation: Light-emitting diodes, 70,000 hours minimum rated lamp life.

C. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.

1. Battery: Sealed, maintenance-free, nickel-cadmium type.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically energizes lamp from unit when circuit voltage drops to 80 percent of nominal or below. When normal voltage is restored, relay disconnects lamps, and battery is automatically recharged and floated on charger.

D. Wire Guard: Provide heavy chrome plated wire guards to protect fixtures installed in gymnasiums and multi-purpose rooms.

2.5 FINISHES

A. Fixtures: Manufacturer's standard, unless otherwise indicated.

1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.
2. Metallic Finish: Corrosion resistant.

2.6 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports, and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.



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- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.
- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.
- F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Interior Lighting Systems shall be installed in accordance with NECA/IESNA 500, Recommended Practice for Installing Indoor Commercial Lighting Systems and NECA/IESNA 502-1999, Recommended Practice for Installing Industrial Lighting Systems.
- B. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials.
- C. Support for Fixtures in or on Grid-Type Suspended Ceilings: Support fixture using grid plus the following:
 - 1. Fixtures shall be positively attached to the ceiling grid system.
 - 2. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches from fixture corners.
 - 3. Support Clips: Fasten to fixtures and to ceiling grid members at or near each fixture corner.
 - 4. Fixtures of Sizes Less Than Ceiling Grid: Arrange as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently of panel, with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
- D. Suspended Fixture:
 - 1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
 - 2. Stem-Mounted, Single-Unit Fixtures: Suspend with two separate stem hangers.
 - 3. Continuous Rows: Use tubing or stem for wiring at one point and tubing, stem, or rod for suspension for each unit length of fixture chassis, including one at each end.
 - 4. Continuous Rows: Suspend from cable installed according to fixture manufacturer's written instructions and details on Drawings.
 - 5. Fixtures to be aligned and level, insure lenses are fastened properly in place.
 - 6. Any supports used to suspend fixture in exposed ceiling areas shall be installed as high as possible out of view and painted with ceiling.
 - 7. Mount remote type drivers out of site above ceilings or in painted enclosure.
- E. In Mechanical and Boiler Rooms, coordinate lighting fixture installation with mechanical piping, duct work, etc. Provide all required supporting rods and channel to bridge duct work and piping. Generally, mount fixtures 8-9 feet above floor unless noted otherwise. Avoid positioning above mechanical piping and ducts.



3.2 CONNECTIONS

- A. Ground equipment.
 - 1. Tighten electrical connections and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 IDENTIFICATION

- A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Provide instruments to make and record test results.
- C. Tests:
 - 1. Verify normal operation of each fixture after installation.
 - 2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.
 - 3. Verify normal transfer to battery source and retransfer to normal.
- D. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units are acceptable.
- E. Corroded Fixtures: Replace during warranty period.

3.5 STARTUP SERVICE

- A. Burn-in all fixtures that require specific aging period to operate properly, prior to occupancy by Owner.

3.6 CLEANING AND ADJUSTING

- A. Clean fixtures internally and externally after installation. Fixture cones, reflectors, baffles, and visible trim shall be turned over to the owner clean and free of dust, drywall mud, smudges, fingerprints, and scratches. Only use methods and cleaning materials in accordance with respective fixture manufacturer recommendations.
- B. All adjustable light fixtures shall be aimed, focused and locked by the Contractor under the observation of the Architect/Engineer. When daylighting interferes with the aiming and focusing, aiming shall be accomplished during hours of darkness.



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- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
 - 1. Adjust aimable luminaires in the presence of Architect.

END OF SECTION 26 5100



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SECTION 26 5600 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exterior luminaires with LED modules and drivers.
2. Luminaire-mounted photoelectric relays.
3. Poles and accessories.

1.2 ACTION SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
2. Details of attaching luminaires and accessories.
3. Details of installation and construction.
4. Luminaire materials.
5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.
 - a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
6. Photoelectric relays.
7. LED fixture compliance of lumen maintenance, CRI, efficacy and LED system rated life and warranty.
8. LED fixture LM79, LM80 and TM21 testing data.
9. Materials, dimensions, and finishes of poles.
10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
11. Anchor bolts for poles.
12. Manufactured pole foundations.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.



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1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
3. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
4. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- B. Field quality-control reports.
- C. Warranty: Sample of special warranty.
- D. LED fixture written warranty compliance.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and poles to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Glass and Plastic Lenses, Covers, and Other Optical Parts: One for every 10 of each type and rating installed. Furnish at least one of each type.
 2. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.6 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.
- B. 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.
- C. Comply with IEEE C2, "National Electrical Safety Code."
- D. Comply with NFPA 70.
- E. LED fixtures to be tested in compliance with LM79, LM80 and TM21 testing standards.



1.7 DELIVERY, STORAGE, AND HANDLING

- A. Package aluminum poles for shipping according to ASTM B 660.
- B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch deep. Do not apply tools to section of pole to be installed below ground line.
- D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.
- E. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
 - 1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
 - 2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
 - 3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
 - 4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.
 - 5. Warranty Period for LED fixtures: Minimum (5) years from date of Substantial Completion.
 - a. LED fixture warranty shall state agreement to replace LED drivers, LED light engine modules, fixture housing, components or accessories under the warranty coverage term.
 - b. Warranty shall include replacement of fixtures or components if the luminaire delivers less than 90% of the initial light level over the 100,000 hour life.
 - c. Fixture warranty to be extended to meet all requirements at a minimum of the warranty of the basis of design fixture specified.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the products indicated for each designation in the Lighting Fixture Schedule on the plans.



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2.2 LUMINAIRES

- A. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- B. Metal Parts: Free from burrs, sharp corners, and edges.
- C. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.
- D. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- E. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit servicing without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during servicing and when secured in operating position. Provide for door removal for cleaning or replacing lens. Arrange to disconnect driver when door opens.
- F. Exposed Hardware Material: Stainless steel.
- G. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
- H. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- I. Fixture to be provided with all required accessories including (but not limited to) Luminaire, Arm or Mount, Pole, specified accessories.
- J. Lenses and Refractors: Materials as indicated. Use heat- and aging-resistant, resilient gaskets to seal and cushion lens and refractor in luminaire doors.
- K. Photoelectric Relays: As follows:
 - 1. Contact Relays: Single throw, arranged to fail in the on position and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay.
 - 2. Relay Mounting: In luminaire housing.

2.3 LED LIGHT FIXTURES:

- A. Light fixtures shall be UL listed and meet all of the specified parameters with published independent testing in accordance with LM79, LM80 and TM21 testing standards.
- B. Light fixtures shall be sold as a complete system. Light fixtures shall have a minimum efficacy of 75 lumens per watt or equal to that of the light fixture specified.



- C. Light fixtures shall have rated delivered lumen output within 5% of the rated delivered lumen output of the fixture specified.
- D. Light fixtures shall have accessible and replaceable drivers and LED light engine boards.
- E. LED drivers shall be 120/277V or 480V to match specified. LED drivers and light engines shall be Class 1 and have 100,000 hour rated life.
- F. Exterior fixtures to have one dimming driver per fixture head where dimming drivers are specified.
- G. LED driver Total Harmonic distortion shall be less than 20%.
- H. Light fixture minimum power factor shall be 90%.
- I. Light fixture color temperature shall be 4000K and minimum 90 CRI.
- J. Transient voltage surge suppression shall be 10kV integral to the fixture in accordance with IEEE/ANSI C62.41.2.
- K. Fixture shall be dark sky friendly.
- L. Fuses: One in each ungrounded supply conductor. Voltage and current ratings as recommended by ballast manufacturer. Fuses shall be installed in handhole near base of pole, not at fixture head.
- M. Occupancy Sensor: When occupancy sensor on the fixture is specified, the fixture shall be equipped with an integral passive infrared occupancy sensor device that changes the light level by dimming the light engine.
 - 1. The sensor shall also have the capability of providing ambient light sensing and adjusting light levels accordingly.
 - 2. The sensor shall have an adjustable time delay feature.
 - 3. The low and high dimming shall be field adjustable.

2.4 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

- A. Comply with UL 773 or UL 773A.
- B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.
 - 1. Relay with locking-type receptacle shall comply with ANSI C136.10.
 - 2. Adjustable window slide for adjusting on-off set points.



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2.5 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

- A. Structural Characteristics: Comply with AASHTO LTS-4-M.
 - 1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
 - 2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
- B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.
- C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
 - 1. Materials: Shall not cause galvanic action at contact points.
 - 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
 - 3. Anchor-Bolt Template: Plywood or steel.
- D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.
- E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."
- F. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.
- G. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

2.6 ALUMINUM POLES

- A. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6 with access handhole in pole wall.
- B. Poles: ASTM B 209, 5052-H34 marine sheet alloy with access handhole in pole wall.
 - 1. Shape: Round, straight.
 - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.



- D. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
 - 1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
 - 2. Finish: Same as luminaire.
- F. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- G. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
 - 3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 - 4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
 - a. Color: As selected by Architect from manufacturer's full range.

2.7 POLE ACCESSORIES

- A. **[Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Division 26 Section "Wiring Devices" for ground-fault circuit-interrupter type.**
 - 1. **Recessed, 12 inches above finished grade.**
 - 2. **Nonmetallic polycarbonate plastic or reinforced fiberglass, weatherproof in use, cover, color to match pole, that when mounted results in NEMA 250, Type 3R enclosure.**
 - 3. **With cord opening.**
 - 4. **With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.]**
- B. **[Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.]**
- C. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.



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PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

- A. Install lamps in each luminaire.
- B. Fasten luminaire to indicated structural supports.
 - 1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

3.2 POLE INSTALLATION

- A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
- B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:
 - 1. Fire Hydrants and Storm Drainage Piping: 60 inches.
 - 2. Water, Gas, Electric, Communication, and Sewer Lines: 5 feet.
 - 3. Trees: 10 feet from tree trunk.
- C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- D. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level recommended by pole manufacturer.
 - 1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
 - 2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
 - 3. Install base covers unless otherwise indicated.
 - 4. Use a short piece of 1/2-inch- diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- E. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch below top of concrete slab.
- F. Raise and set poles using web fabric slings (not chain or cable).



3.3 BOLLARD LUMINAIRE INSTALLATION

- A. Align units for optimum directional alignment of light distribution.
- B. Install on concrete base with top 4 inches above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

- A. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 GROUNDING

- A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole unless otherwise indicated.
 - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- B. Ground nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole.
 - 2. Install grounding conductor and conductor protector.
 - 3. Ground metallic components of pole accessories and foundations.

3.7 FIELD QUALITY CONTROL

- A. Inspect each installed unit for damage. Replace damaged units.
- B. Advance Notice: Give dates and times for field tests.
- C. Provide instruments to make and record test results.



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- D. Tests and Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source, and as follows:
 - 1. Measure light intensities at night if specific illumination performance is indicated. Use photometers with calibration referenced to NIST standards.
 - 2. Check intensity and uniformity of illumination.
 - 3. Check excessively noisy ballasts.
- E. Prepare a written report of tests, inspections, observations and verifications indicating and interpreting results.
- F. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

3.8 CLEANING AND ADJUSTING

- A. Clean units after installation. Use methods and materials recommended by manufacturer.
- B. Adjust aimable luminaires and luminaires with adjustable lamp position to provide required light distributions and intensities.

END OF SECTION 26 5600