Office of Capital Planning and Project Management

# DIVISION 26

# ELECTRICAL

# Table of Contents

Low voltage testing (600V and less):

1. After wires and cables are in place and connected to devices and equipment, the system shall be tested for short circuits, improper grounds, and other faults. When fault condition is present, the trouble shall be rectified, then re-tested.

2. Voltage test shall be made at each lighting and distribution panel. When potential is not within 2 percent of rated voltage, the condition shall be corrected by tap changes or power company correction of line voltage.

3. All wiring devices and electrical apparatus furnished under this contract, when grounded or shorted on any integral "live" part, shall be removed and the trouble rectified by replacing all defective parts and materials.

4. All service and feeder cables, after being pulled in place and before being connected, shall have a Megger test conducted to determine that wire and cable insulation resistance is not less than that recommended by the National Electrical Code. Copies of all tests shall be given to the Architect/Engineer. All cables failing insulation test shall be removed, replaced, and re-tested.

5. All motors shall be tested under load with ammeter readings taken for each phase, and the rpm of motors recorded at the time. All motors shall be tested for correct direction of rotation. Run tests on all motors and verify that proper overload devices have been installed. The following shall be submitted for approval by the Architect/Engineer:

a. Test and record the following on all motors:

    i. Fuse size

    ii. Heater size

    iii. Full load amp

    iv. Running amp

    v. Rated voltage

    vi. Terminal operating voltage

vii. Two (2) copies of all test data shall be delivered to the Using Agency and Architect/Engineer.

- High Voltage Testing (greater than 600V):

1. On all new installations, cables are to be tested per IEEE Standard 400-1980. Maximum test voltages shall be in accordance with Table 1 of IEEE Standard 400-1980.

2. When new cable is spliced to existing cables or tests are done on existing cables; a Facilities Management Electrical Engineer shall be present and approve voltage levels for the High-Direct-Voltage (Hi-pot) test. IEEE Standard 4001980 is to be used as a guideline except for the test voltage levels.

3. Cables above 600 volt and all associated terminations and splices installed shall be field tested in the presence of the Architect/Engineer and Facilities Maintenance personnel before being energized. All tests shall be in accordance with and under the direct supervision of an authorized, qualified representative of a certified testing company.

4. The maximum test potential shall be manufacturer recommended KVDC for new cables only. Facilities Maintenance shall specify the voltage for tests that involve existing high voltage cables. Test potentials shall be applied for 10 minutes. Allow 1 minute for voltage stabilization. Take 10 step readings at 2.5 kV increments. The following information shall be recorded:

    a. The amount of leakage current in micro-amps or milliamps at full test voltage after 10 minutes.

    b. The discharge time down to 7 KVDC between each phase conductor and ground.

    c. The voltage after one (1) minute discharge beginning immediately after each test.

    5. In addition to the above recorded information, proper Graphs shall be plotted to show the following relationships:

    a. Leakage current in micro-amps versus time in minutes.

    b. Leakage current in micro-amps versus applied potential (KVDC).

    6. Care shall be taken to properly identify the phase conductors tested in all test

recordings and graph plottings.

7. If during the field acceptance testing a high resistance fault or low resistance fault in the cable, splice, termination, etc., is apparent, the fault shall be cleared, necessary repairs made, and the cable re-tested in accordance with this specification.

8. If the acceptance test indicates a cable with possible moisture penetration, locate the cable affected, remove same, and install new cable that is free from moisture.

9. If after proper testing of the cable the independent testing representative and/or the Architect/Engineer do not approve the cable, the cable that is not approved shall be removed and a new cable installed. All cables must be tested and approved by the Architect/Engineer before final acceptance. Supply all additional cable that is required.

10. Three (3) copies of all acceptance test recordings and graphs shall be submitted to the Architect/Engineer before final acceptance of the distribution system will be authorized.

- Ground Testing:

    1. TEST: The resistance between ground grid and absolute earth shall not exceed 25 ohms and shall be measured in the presence of the Architect/Engineer before equipment is placed in operation.

- Fire alarm detection system:

    1. See Section 283100 (Fire Detection and Alarm) for Fire Alarm acceptance testing.

**TABLE 10.6** Medium Voltage Cables Maximum Field Acceptance Test Voltages (kV, dc)

| Insulation Type | Rated Cable Voltage | Insulation Level | Test Voltage kV, dc |
|---|---|---|---|
| Elastomeric: | | | |
| Butyl and Oil Base | 5 kV | 100% | 25 |
| | 5 kV | 133% | 25 |
| | 15 kV | 100% | 55 |
| | 15 kV | 133% | 65 |
| | 25 kV | 100% | 80 |
| Elastomeric: | | | |
| EPR | 5 kV | 100% | 25 |

| | | | |
|---|---|---|---|
| | 5 kV | 133% | 25 |
| | 8 kV | 100% | 35 |
| | 15 kV | 133% | 45 |
| | 15 kV | 100% | 55 |
| | 15 kV | 133% | 65 |
| | 25 kV | 100% | 80 |
| | 25 kV | 133% | 100 |
| | 28 kV | 100% | 85 |
| | 35 kV | 100% | 100 |
| Polyethylene | 5 kV | 100% | 25 |
| | 5 kV | 133% | 25 |
| | 8 kV | 100% | 35 |
| | 8 kV | 133% | 45 |
| | 15 kV | 100% | 55 |
| | 15 kV | 133% | 65 |
| | 25 kV | 100% | 80 |
| | 25 kV | 133% | 100 |
| | 35 kV | 100% | 100 |

Derived from ANSI/IEEE Standard 141-1993 Table 12-9 and by factoring the applicable ICEA/NEMA Standards. NOTE: AEIC CS5 and CS6, and ANSI/IEEE Standard 400 do not differentiate cables based upon insulation thickness and, consequently, list differing test voltages.

- Inspection and Test Procedures

1. Medium-Voltage, 69 kV Maximum:

    1. Visual and Mechanical Inspection:

    1. Compare cable data with drawings and specifications.

    2. Inspect exposed sections of cables for physical damage.

    3. Verify tightness of accessible bolted connections by calibrated torque wrench in accordance with manufacturer's published data or Table 10.12. Perform

thermographic survey in accordance with Section 9.

4. Inspect compression-applied connectors for correct cable match and indention.
5. Inspect for shield grounding, cable support, and termination.
6. Verify that visible cable bends meet or exceed ICEA and/or manufacturer's minimum allowable bending radius.
7. Inspect for adequate fireproofing in common cable areas, if specified.
8. If cables are terminated through window-type current transformers, make an inspection to verify that neutral and ground conductors are correctly placed and that shields are correctly terminated for operation of protective devices.
9. Visually inspect jacket and insulation condition.
10. Inspect for correct identification and arrangements.

2. Electrical Tests:
    1. Perform a shield-continuity test on each power cable by ohmmeter method.
    2. Perform an insulation-resistance test utilizing a megohmmeter with a voltage output of at least 2500 volts. Individually test each conductor with all other conductors and shields grounded. Test duration shall be one minute.
    3. Perform a dc high-potential test on all cables. Adhere to all precautions and limits as specified in the applicable NEMA/ICEA Standard for the specific cable. Perform tests in accordance with ANSI/IEEE Standard 400. Test procedure shall be as follows, and the results for each cable test shall be recorded as specified herein. Test voltages shall not exceed 80 percent of cable manufacturer's factory test value or the maximum test voltage in Table 10.6.
    4. Insure that the input voltage to the test set is regulated.
    5. 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.
    6. Record wet- and dry-bulb temperatures or relative humidity and temperature.

7. Test each section of cable individually.

8. Individually test each conductor with all other conductors grounded. Ground all shields.

9. Terminations shall be adequately corona-suppressed by guard ring, field reduction sphere, or other suitable methods as necessary.

10. Insure that the maximum test voltage does not exceed the limits for terminators specified in IEEE Standard 48 or manufacturer's specifications.

11. 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.

12. Raise the conductor to the specified maximum test voltage and hold for 15 minutes on shielded cable and five minutes on non-shielded cable. Record readings of leakage current at 30 seconds and one minute and at one-minute intervals thereafter.

13. Reduce the conductor test potential to zero and measure residual voltage at discrete intervals.

14. Apply grounds for a time period adequate to drain all insulation-stored charge.

15. When new cables are spliced into existing cables, the dc high-potential test shall be performed on the new cable prior to splicing in accordance with Section 7.3.2. After test results are approved for new cable and the splice is completed, an insulation-resistance test and a shield-continuity test shall be performed on the length of new and existing cable including the splice. After a satisfactory insulation-resistance test, a dc high-potential test shall be performed on the cable utilizing a test voltage acceptable to owner and not exceeding 60 percent of factory test value.

16. Test Values:

17. Shielding must exhibit continuity. Investigate resistance values in excess of ten ohms per 1000 feet of cable.

18. Graphic plots may be made of leakage current versus step voltage at each increment and leakage current versus time at final test voltages.

19. The step voltage slope should be reasonably linear.

20. Capacitive and absorption current should decrease continually until steady state leakage is approached.

High-Voltage - Reserved

## 26 05 00 COMMON WORK RESULTS FOR ELECTRICAL

The following is a guide to all Architects and Engineers performing work for the University of Illinois at Chicago Campus, pertaining to review and comment procedures as required by the University. Deviations will be allowed only by special permission of the University.

- "Procedures, Codes and Planning Requirements," Divisions 0 and 1 shall also apply to the work under Division 26, Electrical.
- Refer to the UIC Telecommunications Building Standards for specific requirements regarding computing and communications.

## 26 05 13 MEDIUM VOLTAGE CABLES

Refer to the UIC Telecommunications Building Standards for specific requirements regarding computing and communications.

- Medium Voltage Ground Conductor for Power and Lighting: All medium voltage power circuits in duct must be paralleled by a grounded conductor intended to minimize fault current in power cable shields. The ground conductor shall be THWN insulation, rated at 600 volts, and minimum size of number 2/0 AWG.
- Building Wire: All branch circuit wiring in new buildings should be in accordance with an established color code. Wiring installed during remodeling should be in accordance with the color code established when the building was constructed, or in accordance with an established color code if none exists. Conductors #10 and larger shall be stranded wire.
- Power cable (5,000 and 15,000 Volt) is for extension of campus electric distribution system to buildings and should be installed in strict accordance with manufacturer's recommendations. Cables should be installed in rigid conduit inside buildings and in concrete encased duct outside of buildings. Wye splices in power cables are not allowed, and no splices should be installed in duct runs. Where cables pass through

manholes, they should be placed on racks with insulators. Where cables pass from manholes into duct runs or conduits, duct shields are required for protection of the cable. Cables shall be fireproofed and tagged in manholes and other locations where exposed and labeled with plastic tags.

- Medium Voltage Ground Conductor cable is necessary to limit power cable shield current when power cable failures occur. Between manholes, the cable may be installed in the same duct cell as power circuits. Splices in duct runs are unacceptable. Where this cable passes through manholes, it should be bonded to ground rod and power cable shields of all spliced power cables. At source and load ends of power cables, this cable should be bonded to source and building grounding systems. At cable splices, the power cable shields should be extended individually to this ground conductor system.

- Grounding rods shall be copper clad flashed in 8 ft. lengths with exothermic weld connections for wiring attachment.

## 26 05 26 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

The steel enclosures and supports of the electrical equipment and all metal conduits in the transformer room shall be connected to earth by copper bar ground bus. The neutral of the secondary winding of the transformer and the neutral bus of the secondary switchgear compartment of the unit sub-station shall be grounded. The ground shall be bolted to the walls every 4 feet. An equivalent bare copper conductor installed in conduit shall be extended from the ground bus in the switchgear to the water main ahead of the meter, and secured by means of a ground clamp. A full size bonding jumper shall be furnished across the water meter. For additional protection, a supplemental ground consisting of at least three copper weld ground rods, spaced 20 ft. or more apart and each 10 ft. long x 3/4 in. diameter shall be driven into the earth through the floor of the basement and connected to the ground bus by bare copper ground conductors and clamps. The grounding system shall be complete including the metal frame of the building and the building rebar.

## 26 05 33 RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

Raceways:

Refer to the UIC Telecommunications Building Standards for specific requirements regarding computing and communications.

- Electrical Standards for Low Voltage Systems:

1. New Buildings: In new buildings the University Building Standards require compliance with applicable portions of the current National Electric Code regarding low voltage

systems. All wiring must be installed in metallic raceways, and in finished areas the raceways are to be concealed.

2. Existing Buildings: In existing buildings, all fire alarm and emergency lighting system changes and additions shall meet requirements for new buildings, with each system having its own metallic raceway system. For other low voltage systems and low voltage wiring in existing buildings, the National Electric Code shall be followed.

a. In finished areas, where it is difficult to use existing concealed raceways, surface metallic rectangular raceways and boxes shall be installed in approved locations. All holes through walls and floors shall have galvanized or plastic sleeves and be finished in a neat manner. Patching and refinishing shall match that of existing adjacent construction with regard to both material and appearance. Holes, sleeves and cables in exterior walls and foundations shall be permanently sealed on the outside to prevent entrance of water and insects. Surface raceways and boxes must be firmly and permanently attached to walls and ceilings by use of anchors. Sleeves through floors shall extend at least 3/8" above the floor line and be sealed to prevent leaks to the floor below.

b. Installation of exposed low voltage circuits for other systems is not permitted.

- Boxes:

1. Outlet boxes for recessed fixtures shall be installed with max. 4ft. Greenfield from fixture outlet box to allow fixture to be dropped for servicing.

2. Switch and receptacle boxes shall be:

a. Complete with 1" minimum depth tile ring where used in exposed tile.

b. Complete with 1" minimum depth plaster ring where used in plastered walls.

c. Installed with 1/2" raised galvanized device covers where used for exposed conduit work.

3. Pull boxes and junction boxes shall be entirely accessible.

Raceway and Cable Labels:

1. Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

a. Color: Black letters on orange field.

b. Legend: Indicates source, destination, voltage and substation.

2. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl with legend overlaminated with a clear, weather- and chemical-resistant coating.

3. Pretensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the line it identifies and arranged to stay in place by pretensioned gripping action when placed in position.

4. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

5. Underground-Line Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape.

a. Not less than 6 inches wide by 4 mils thick.

b. Compounded for permanent direct-burial service.

c. Embedded continuous metallic strip or core.

d. Printed legend indicating type of underground line.

6. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

7. Aluminum, Wraparound Marker Bands: Bands cut from 0.014-inch-thick aluminum sheet, with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.

8. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.

9. Aluminum-Faced, Card-Stock Tags: Weather-resistant, 18-point minimum card stock faced on both sides with embossable aluminum sheet, 0.002 inch thick, laminated with moisture-resistant acrylic adhesive, punched for fasteners, and preprinted with legends to suit each application.

10. Brass or Aluminum Tags: 2 by 2 by 0.05-inch metal tags with stamped legend, punched for fastener.

- Nameplates and Signs:

1. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

2. 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.

a. Engraved legend with black letters on white face.

b. Punched or drilled for mechanical fasteners.

3. 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.

4. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, non-fading, 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.

5. 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.

- Miscellaneous Identification Products:

1. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.

a. Minimum Width: 3/16 inch.

b. Tensile Strength: 50 lb minimum.

c. Temperature Range: Minus 40 to plus 185 deg F.

d. Color: According to color-coding.

2. Paint: Formulated for the type of surface and intended use.

a. Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.

b. Primer for Concrete Masonry Units: Heavy-duty-resin block filler.

c. Primer for Concrete: Clear, alkali-resistant, binder-type sealer.

d. Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

- Installation:

1. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.

2. 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.

3. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.

4. Self-Adhesive Identification Products: Clean surfaces before applying.

5. 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:

a. 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.

b. Wall surfaces directly external to conduits concealed within wall.

c. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in the building, or concealed above suspended ceilings.

d. Entire surface of exposed conduits.

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

a. Clean surfaces of dust, loose material, and oily films before painting.

b. Prime surfaces using type of primer specified for surface.

c. Apply one intermediate and one finish coat of enamel.

7. Color Banding Raceways and Exposed Cables: Band exposed and accessible raceways of the systems listed below:

a. Bands: Pretensioned, wraparound plastic sleeves; colored adhesive tape; or a combination of both. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.

b. Band Locations: 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.

c. Apply the following colors to the systems listed below:

i. Fire Alarm System: Red.

ii. Fire-Suppression Supervisory and Control System: Red and yellow.

iii. Security System: Blue and yellow.

iv. Mechanical and Electrical Supervisory System: Green and blue.

v. Telecommunication System: Green and yellow.

8. 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.

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

a. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.

b. Concealed Boxes: Plasticized card-stock tags.

c. Labeling Legend: Permanent, waterproof listing of panel and circuit number or

equivalent.

10. Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communication lines, 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. Install line marker for underground wiring, both direct-buried cables and cables in raceway.

11. Color-Coding of Secondary Phase Conductors: Use the following colors for service feeder and branch-circuit phase conductors:

a. 208/120-V Conductors:

i. Phase A: Brown.

ii. Phase B: Orange.

iii. Phase C: Yellow.

b. 480/277-V Conductors:

i. Phase A: Brown.

ii. Phase B: Orange.

iii. Phase C: Yellow.

c. Factory apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire for sizes larger than No. 10 AWG:

i. 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.

ii. 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.

12. Power-Circuit Identification: Metal tags, wraparound marker bands for cables, feeders, and power circuits in vaults, pull and junction boxes, manholes, and switchboard rooms.

a. Legend: 1/4-inch-steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.

b. Tag Fasteners: Nylon cable ties.

c. Band Fasteners: Integral ears.

13. Apply identification to conductors as follows:

a. Conductors to Be Extended in the Future: Indicate source and circuit numbers.

b. 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.

c. 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.

14. Apply warning, caution, and instruction signs as follows:

a. 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.

b. 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.

15. 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-high lettering on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high. Use white lettering on black field. Apply labels for each unit of the following categories of equipment using mechanical fasteners:

a. Panelboards, electrical cabinets, and enclosures.

b. Access doors and panels for concealed electrical items.

c. Electrical switchgear and switchboards.

d. Electrical substations.

e. Emergency system boxes and enclosures.

f. Motor-control centers.

g. Disconnect switches.

h. Enclosed circuit breakers.

i. Motor starters.

j. Push-button stations.

k. Power transfer equipment.

l. Contactors.

m. Remote-controlled switches.

n. Dimmers.

o. Control devices.

p. Transformers.

q. Inverters.

r. Rectifiers.

s. Frequency converters.

t. Battery racks.

u. Power-generating units.

v. Telephone switching equipment.

w. Clock/program master equipment.

x. Call system master station.

y. TV/audio-monitoring master station.

z. Fire alarm master station or control panel.

aa. Security-monitoring master station or control panel.

bb. Card reader control enclosure.

## 26 10 00 MEDIUM VOLTAGE ELECTRICAL DISTRIBUTION

Where possible, distribution and branch circuit panels installed in finished areas shall be flush mounted and served through concealed conduit. Branch circuit panels shall be located so that they will be not more than 65 feet from any portion of the floor served, so that branch circuits will not exceed 100 feet in total length. All flush mounted panels shall have at least four spare one-inch conduits extended to space above or near the ceiling.

- Protective devices in branch circuit and distribution panels which are rated 400 amperes or less shall be circuit breakers with appropriate short circuit ratings to maintain building coordination. Circuit breakers shall have bolt or screw mounting to bus. Push-in mounting to bus is unacceptable.

- Branch circuit breakers for lighting and convenience receptacles shall be 20 amperes. Lighting and receptacles shall be connected to separate circuits.

- All new distribution and branch circuit panels shall have a minimum of 42 spaces. In addition, all new panels shall have a minimum of nine spare spaces when installation is complete.

- New branch circuit panels shall have minimum of five-inch gutters, with additional gutter space being provided for feeder lugs or main breaker as required for particular installations.

- All distribution and branch circuit panels shall be lockable. Panels with interiors and trims which do not allow use of this lock are unacceptable.

- Each panel shall contain a typewritten schedule. The schedule shall contain complete and detailed information for loads on each circuit.

- Electrical Room and Distribution Equipment:
- 1. Buildings shall be equipped with interior transformer rooms as herein described. The rooms shall contain the primary disconnect switch; building transformer; main circuit breaker and secondary switchgear; signal cable terminal box; and McCulloh Loop fire alarm cable terminal.
- 2. Management should be consulted to verify what primary voltage is available.
- 3. A building with expected maximum demand of over 750 KVA generally should have two separate transformer rooms of equal capacities in different parts of the building or in a double-ended arrangement in one transformer room. Buildings with large auditoriums and other structures that may be occupied by large numbers of people should have two separate transformers to insure reliability of the lighting. Equipment, where the maximum demand is approximately 150 KVA or more, shall be of the "unit sub-station" type, all in one factory assembled unit. Switchboard equipment shall include watt-hour demand metering with 15-minute interval demand - multiplier of 1, 10, 100, 1000 and pointer type for KW indicators and dial type for KWH indicators, (Westinghouse type Mark IA, or GE type M-30 are preferred) ammeter and voltmeter with phase selection switches. Facilities Management shall be consulted if there are questions on metering arrangements and the multiplier. Potential fuses for watt-hour meter shall be provided inside the switchboard and be readily accessible from the exterior. The secondary buses in large units shall be located and sectionalized for quick disconnecting so as to facilitate moving the transformer and load break switch portion of the unit sub-station in and out of the room separately from the secondary switchgear portion of the unit. All sub-station bus conductors shall be silver plated copper.
- 4. If the transformer in the room is 150 KVA capacity or more, the secondary distribution shall be part of a floor-mounted switch group. This switch group shall contain the current transformers, the kilowatt-hour meter, the demand meter, and all necessary overcurrent protection devices. Buildings with smaller room capacity than 150 KVA may have the secondary distribution in cabinets mounted in the transformer compartment.
- 5. The short circuit current calculations shall be required and shall form the basis for the following:

- a. All secondary overcurrent protective devices to be utilized within the building unit substations, distribution panels, branch circuit panels, motor control centers, and devices on plug-in bus-duct circuit current to the proper value for the protection of connected downstream components.
- b. All protective devices are to be coordinated for a purely selective system and fusible switch type equipment shall be used where required.
- c. The main secondary overcurrent protective devices shall be selected for protection of the transformer and shall provide a selective system between the primary fuse and each feeder protection device.
- d. Each feeder protection device shall be selected for protection of the feeder conductors and coordination between the primary fuse, secondary main and other load side components fed by the feeder device.
- 6. There should be no fire protection sprinkler, steam, gas, water, sewer or air pipes in the transformer room, or any other equipment requiring attention by anyone except authorized electrical personnel. Fluorescent lighting fixtures shall be provided, illuminating both the front and back of the unit sub-station. Provide a switched duplex outlet located near the door. Connect the lights to an emergency circuit. All transformer rooms are to be heated.
- 7. Provide a one-line diagram of the building distribution system from the incoming high voltage feeder to the last low voltage distribution panel. This drawing is to be framed under glass and securely mounted to the wall in the transformer room. The following information shall be shown on the drawing: all conduit sizes, wire sizes and types, maximum amperage of devices, voltage of devices, fuse or circuit breaker rating, main lugs or size of the main breaker for panels, the number of circuits for panels and panel locations.
- 8. The electrical design shall take into consideration power system harmonics. The transformer shall be K factor rated where applicable.
- 9. Transformer rooms should be heated and ventilated year round with a minimum of 4 cfm per KVA of transformer capacity. The exact configuration of the ventilation shall be determined during the formal review process.
- 10. All unit substations are to have cooling fans that are controlled by a digital temperature controller. Each coil of the transformer is to be monitored by the temperature controller. The temperature controller is to have a local alarm feature and is to be capable of initiating a

remote alarm. The back sides of unit substations are to be installed a minimum of 36 inches away from the wall.

- 11. Transformers shall be impedance matched.

## 26 12 00 MEDIUM VOLTAGE TRANSFORMERS

Suggested procedure to establish transformer capacity:

- 1. Demand factor for receptacle loads shall be applied with consideration for the type of usage.
- 2. Total KVA demands shall be increased 25 per cent for reasonable future growth and subsidiary loads.
- 3. Review the load calculations data and transformer KVA capacities with Facilities Management before proceeding with final design layouts.

## 26 13 00 MEDIUM VOLTAGE SWITCHGEAR

- All main-tie-main disconnect arrangements shall be drawout type only, with a "kirk key interlock" system included.

## 26 13 13 CIRCUIT BREAKER SWITCHGEAR

- Fusible main secondary switch:
- 1. Switches over 601 amps shall be quick-make, quick break, bolted pressure switch(es) equal to Barkelew "Bolt-Loc" pressure contact switch complete with current limiting, time delay, hi-capacity fuses with 200,000 ampere interrupting capacity. S&C Electric is the preferred fuse manufacturer.
- 2. Switches under 601 amps shall be molded case circuit breakers or fused switches where the interrupting capacity of the device is greater than that of the transformer feed.
- • Feeder circuit breaker devices: Shall be manually or electrically (as required) operated, draw-out type or molded case, in the proper pole arrangement, and possess current ratings and interrupting capacity. Under no circumstances shall drawout breakers be fixed (bolted in). In addition, all main-tie-main breakers shall be drawout only with a "kirk-key interlock" system included.

- • All electrical equipment such as sub-stations, bus-duct, panelboards and motor control centers must be constructed to withstand the short circuit current, symmetrical and asymmetrical, for the number of cycles as required by the rating of the particular overcurrent protective device.
- • Campus lights, steam tunnel lights, pumps, outdoor tennis courts, or an adjacent building may be supplied with power from the secondary switchgear of the building. Branch circuit overcurrent device, especially for these subsidiary loads, shall be a part of the secondary switchgear in the room.

## 26 18 39 MEDIUM VOLTAGE MOTOR-CONTROLLERS

Manufacturer Qualifications: Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

- Provide products by one of the following preferred manufacturers:

1. Motor-Control Centers with Manual and Magnetic Controllers:

a. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.

b. Eaton Corp.; Cutler-Hammer Products.

c. General Electrical Distribution & Control.(d) Rockwell Automation Allen-Bradley Co.; Industrial Control Group.

d. Siemens/Furnas Controls.

e. Square D Co.

2. Motor-Control Centers with Variable-Frequency Controllers:

a. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.

b. Danfoss Inc.; Danfoss Electronic Drives Div.

c. Eaton Corp.; Cutler-Hammer Products.

d. General Electrical Distribution & Control.

e. MagneTek Drives and Systems.

f. Rockwell Automation Allen-Bradley Co.; Industrial Control Group.

g. Siemens/Furnas Controls.

h. Square D Co.

- Frame printed operating instructions for motor-control centers, including control sequences and emergency procedures. Fabricate frame of finished metal and cover instructions with clear acrylic plastic. Mount on front of motor-control centers.

## 26 24 13 SWITCHBOARDS

- Fusible Main Secondary Switch Units:
- 1. When required, shall be quick-make, quick-break, bolted pressure switch(es) (equal to Barkelew "Bolt-Loc" pressure contact switch) complete with current limiting, time delay, hi-capacity fuses with 200,000 ampere interrupting capacity.
- • Fusible Feeder Switch Devices:
- 1. Main switches larger than 600 amperes shall be quick make, quick break, bolted pressure switches with NEMA type L fuses. (Equal to Barkelew "Bolt-Loc" pressure contact switch.)
- 2. Fuses for all switches shall be U.L. listed, current limiting, time delay, silver link, fuses with 200,000 ampere interrupting capacity. Dual element fuses shall be self-protecting from extraneous heat.
- 3. After installation, the unit sub-station shall be energized for test and the secondary voltages checked for phase rotation between phases, and between each phase and neutral before the main secondary overcurrent protective device is closed. All conductors at the main secondary protective device shall be clearly identified with 1 in. high stencil letters with orange-colored paint.
- 4. Bussman is the preferred manufacturer of medium voltage fuses.
- • Feeder Circuit Breaker:
- 1. Shall be manually or electrically (as required) operated, draw-out type or molded case, in the proper pole arrangement, and possess required current ratings and interrupting capacity.
- 2. All electrical equipment such as sub-stations, bus-duct, panelboards and motor control centers must be constructed to withstand the short circuit current, symmetrical and

asymmetrical, for the number of cycles as required by the rating of the particular overcurrent protective device.

- 3. Campus lights, steam tunnel lights, pumps, outdoor tennis courts, or an adjacent building may be supplied with power from the secondary switchgear of the building. Branch circuit overcurrent device, especially for these subsidiary loads, shall be a part of the secondary switchgear in the room.

## 26 24 19 MOTOR CONTROL CENTERS

- Starters for motors shall be of the magnetic type as required for the respective motor service, complete with overload protection, in all three phases. Motor control center shall be used where economically possible. Combination starter-fuse disconnect units shall be installed in either motor control centers or individual enclosures provided at each motor installation not in sight of the motor controller.

- • Starter selection shall be based on the following table for particular installations. If the motors are fed from the same transformer that supplies the building lighting and receptacle loads, then the inrush KVA shall not exceed 20% of the transformer KVA rating. Inrush KVA shall be computed using the mid-range value of the code letter designation of the motor. A table showing the maximum horsepower permitted for different size transformers based on motors with a code letter "G" has been supplied as a sample.

- • Code "G" has a mid-range value of 6 KVA per horsepower.

| KVA of | Maximum Across-the-Line HP |
|---|---|
| 100 | 5 |
| 200 | 7.5 |
| 300 | 10 |
| 500 | 15 |
| 750 | 25 |
| 1000 | 30 |

Pr Project electrical designers shall direct special attention to power quality issues relating to power line disturbances caused by starting or operating large electrical loads. The final electrical design shall address power quality by the use of reduced voltage starters, electronic "soft start" solid state starters, or any other necessary means.

.

- All devices, switches, receptacles, and cover plates shall be specification grade.
- • Switches shall be composition body, flush tumbler, quiet type.
- • Interior cover plates in finished offices, classrooms, and other general purpose occupancies shall be #430 brushed stainless steel. Interior cover plates in laboratories and other potentially corrosive occupancies shall be #302/304 brushed stainless steel.
- • Interior cover plates in unfinished areas shall be stamped galvanized for sheet metal boxes and cast for cast boxes.
- • Outdoor cover plates shall be gasketed, weatherproof, spring loaded lid, and suitable to protect the receptacle during use.
- • Lighting switches shall be located six inches horizontally from door jambs.
- • Where switches are together at one location they shall be ganged.
- • Switches controlling or disconnecting motor loads shall be horsepower (HP) rated.
- • Install all wall switches with OFF position down.
- • Install receptacles with grounding pole on bottom for vertically mounted receptacles, and on the right for horizontally mounted receptacles.
- • Cover plates shall be installed flush and level.
- • Receptacle cover plates shall be labeled with the panelboard and circuit designation when requested by the department occupying the finished space. This requirement shall be defined during the project's design phase.
- • High quality, high sensitivity, surge arrestor receptacles shall be required in areas that serve personal computers or other sensitive electronic equipment when requested by the department occupying the finished space. This requirement shall be defined during the project's design phase.
- • Methods of Wiring:
- • All of the conductors shall be run in grounded metallic conduits. Equipment and devices

installed and not constructed with enclosures suited for mounting or enclosing all live parts shall be installed in grounded metal cabinets.

- • All conduits shall be run to the distribution cabinets in a neat, accurate manner and shall be installed concealed in ceiling and wall construction where possible or exposed at right angles at roof purlin and beam locations as required.
- • All conduit shall be swabbed until all moisture and grit is removed before any wires are pulled or installed.
- • Wire pulling compound may be used to ease the pulling of wire or cable. Excess compound must be removed.
- • Installing fluorescent light fixtures with rubber cord, receptacle and plug is not acceptable.
- • Use high efficiency light fixtures.
- •
- Raceways and Conduits:
- 1. General
- a. All wires shall be installed in conduit or raceway except as noted elsewhere in specification.
- b. All conduit shall be sized according to the National Electric Code except that minimum allowable size shall be 3/4" .
- c. All conduit bends shall be long radius.
- d. Coordinate all conduit locations with other trades before roughing-in.
- e. Three (3) 1" conduits, for future use, shall be installed from each flush mounted panel and turned into the joist space above the panel.
- 2. Electrical Metallic Tubing (EMT)
- a. EMT shall be:
- i. Galvanized zinc exterior coating.

- ii. Lacquer coated interior.
- iii. Installed in masonry walls.
- iv. Installed above ceilings in joist spaces.
- b. EMT shall:
- i. Not be used for exterior installations.
- 3. Rigid Heavy Wall Conduit (Rigid)
- a. Rigid shall be:
- i. Galvanized steel.
- ii. Installed in concrete slabs and walls. (1" minimum concrete covering).
- iii. Installed in exposed exterior locations above grade.
- iv. Reamed after cutting threads.
- v. 3/4" minimum allowable size.
- vi. Coupled with a 3-piece coupling in lieu of running threads.
- vii. Installed with joints sealed with copper coat conductive, anti-corrosive surface treatment.
- 4. Flexible Conduits
- a. Flexible conduit shall be:
- i. Greenfield type in all dry locations with compression type connectors.
- ii. Liquid-tight type in all wet locations (including all exterior locations) with ferrule and sleeve type connections.
- iii. Used for the final connection to all motors and vibrating equipment.
- iv. Used for the final connection to all recessed fixtures.
- b. General
- i. All straps and clamps shall be galvanized steel.

- ii. Support every 6 ft. min. for conduits 1" and smaller.
- iii. Support every 5 ft. min. for conduits over 1".
- iv. Supports for suspended conduits shall be threaded steel rods.
- v. Anchor rods to inserts in concrete.
- vi. Anchor rods to beam clamps on steel structure.
- 5. Surface mounted conduits
- a. Use one hole straps.
- b. For EMT use stamped steel straps.
- c. For rigid conduit use malleable iron straps and pipe spacers.
- 6. Suspended conduits
- a. Individual conduits: Use Minerallac galvanized conduit clamps with proper threaded rod.
- b. Two or more conduits adjacent to each other:
- i. Use painted channel 1-5/8" x 1-5/8" constructed from 12 gauge steel hung from at least two rods.
- ii. Use suitable galvanized split pipe clamps for rigid and EMT conduit.
- • Individual lighting controls must be installed in 90% of the building. In multipurpose areas provide separate lighting controls for different areas

## 26 29 23 VARIABLE FREQUENCY MOTOR CONTROLLERS (VFMC)

- • Variable Frequency Drives (VFD) shall be used in mechanical systems to conserve energy. Typical applications include motors for pumps, air handling unit fans, or chillers. The VFMC shall be coordinated for the specific system application by the VFMC, motor, and driven equipment manufacturers. VFMC units installed in existing systems must maintain all existing safety devices in both VFMC and bypassed modes. Typical safety devices include high and low pressure controls, low temperature freeze protection and high temperature fire protection.

- • All VFD enclosures shall be NEMA 3 type.
- • The VFMC shall be subject to the following parameters and tests:
- 1. All integrated circuits (TTL) and all components used for circuit board construction shall be tested to an acceptance criteria of 0.5% AQL (Accepted Quality Level).
- 2. In-circuit testing of all printed circuit boards shall be conducted to insure proper mounting and correct value of all components.
- 3. Final printed circuit board assemblies shall be functionally tested via computerized test equipment where all tests and acceptance criteria are pre-programmed and test results are stored as detailed quality assurance data.
- 4. All fully assembled controls shall be combined-tested for performance and functionality at the manufacturer's factory with fully loaded VFMC rated induction motors. The combined test data shall then be analyzed to insure adherence to quality assurance specifications.
- • Power components shall undergo 168 hours factory burn in, circuit boards shall be tested under thermal cycling and the complete unit shall be tested under full load conditions to insure maximum product reliability.
- 1. The VFMC radio frequency interference/electro-magnetic interference emission (radio noise) will be below limits as set forth by the Federal Communication Commission Rules and Regulations Class A Computing Devices, Subpart J. The VFMC manufacturer will furnish laboratory test results showing that noise levels above 10 KHz as well as SCR's firing angle, GTO's or transistors that produce high frequency noise to be conducted back on the power lines must meet FCC standards.
- 2. To insure compatibility with future equipment, the manufacturer shall have one design to cover the range of 1 to 1 50 Hp.
- 3. The VFMC manufacturer shall have a minimum of 5 years experience in VFMC manufacturing.
- 4. The VFMC shall be designed to meet the power line transient condition defined with IEEE-587; protected against line transients as great as 6 KV without failure (Excluding fuses).
- • The system and components shall be supplied by one manufacturer of established

reputation and experience who shall have produced similar apparatus for a period of at least three years and who shall be able to refer to similar installations rendering satisfactory service.

- • All VFMC's shall be guaranteed for two calendar years from the date of owner acceptance. The vendor, at his expense and without extra charge to the University, and within a reasonable period of time after being contacted by the University shall provide labor and material to repair or replace any defects in materials and workmanship on the VFMC which may develop or appear during the two year period. This guarantee also includes any damage to other work caused by such defects or the repairing of same.
- • Preferred manufacturers and their series:
- 1. B & G Series
- 2. ABB - ACS500 Series
- 3. Toshiba - VT130 H2 Series
- 4. Danfoss - VLT Series
- 5. Square D - Altivar 16 Series
- 6. Allen-Bradley - 1336 Plus Series
- • All VFMC's shall be a pulse width modulated (PWM) design that has a carrier frequency of 8 KHz or higher so no acoustic noise will be produced onto the motor. The VFMC shall generate a sine-coded, adjustable voltage/frequency three phase output for complete speed control of any NEMA B VFMC duty squirrel cage induction motor. The VFMC shall maintain a 120% current overload capability for 60 seconds with automatic stall prevention and voltage boost to prevent nuisance tripping during load or line side transient conditions. The VFMC shall maintain a power factor of not less than 0.95 throughout its speed range. The VFMC shall be 95% efficient of 100% rated output power at 60 Hz.
- • Service: VFMC manufacturer shall have the following available:
- 1. Service engineer.
- 2. Training/service schools.
- 3. 24-hour phone service.

- • Testing: The VFMC manufacturer shall make an inspection of the equipment including those components necessary to the direct operation of the system. All test and report costs shall be borne by the supplier. The inspection technician shall prepare a checkout report and the original submitted to Facilities Management and a copy shall be registered with the equipment manufacturer. The report shall include, but not be limited to:
- 1. A complete list of equipment installed and wired.
- 2. Indication that all equipment is properly installed and functions and conforms with these specifications.
- 3. Physical tests of each individual device.
- 4. Serial numbers, locations by device and model number for each installed device.
- 5. That the wiring connections to all equipment components show that the installer undertook to have observed the National Electrical Code.
- 6. That the equipment of the manufacturer has been installed in accordance with the manufacturer's recommendations, and that all signaling devices of whatever manufacture have been operated or tested to verify their operation.
- 7. That the supervisory wiring of those items of equipment connected to a supervised circuit is operating and have been met to the satisfaction of inspecting officials.
- 8. Technicians name, certificate number and date.
- 9. The manufacturer shall supply all technical assistance with respect to any changes necessary to ensure a complete, workable system. During the period of inspection by the manufacturer, the electrical contractor shall make available electricians for whatever changes deemed necessary by the manufacturer at the contractor's cost.
- • Labeling:
- 1. All user connection points shall be labeled with self adhesive labels that clearly identify the terminal as it is shown on the shop drawings.
- 2. If the readout is digitally coded for faults and other VFMC information, a decoding legend must be affixed to the front of the VFMC indicating what these codes mean.
- • User Agency Training: The system manufacturer or authorized distributor shall provide

training for users, with the initial session to occur when the system is accepted by the Operation and Maintenance Division.

- 1. On Site Training Personnel:
- a. Four (4) hours of instruction including an overview of the system and its capabilities, what to do in case of alarm or trouble.
- b. Eight (8) hours of instruction as in both items above in addition to maintenance instruction on each type of device connected to the system, all modules involved in the control panel and all aspects of user-accessible programming
- c. Training is to be at the expense of the manufacturer. Lodging, meals and transportation are a Facilities Management expense.

## 26 32 00 FACILITY ELECTRICAL POWER GENERATING AND STORING EQUIPMENT

1. Manufacturer must maintain a service center capable of emergency maintenance and repairs at the Project with eight hours' maximum response time.
2. • Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace packaged engine generator and auxiliary components that fail in materials or workmanship within specified warranty period of five (5) years from date of Substantial Completion.
3. • At Substantial Completion, begin 12 months full maintenance by skilled employees of the manufacturer's designated service organization. Include quarterly exercising to check for proper, starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Maintenance agreements shall include parts and supplies as used in the manufacture and installation of original equipment.
4. • Provide products by one of the following preferred manufacturers:
5. 1. Caterpillar, Inc.; Engine Div.
6. 2. Generac Corp.
7. 3. Kohler Co; Generator Division.
8. 4. MagneTek, Inc.

9. 5. Onan Corp; Industrial Business Group.

10. 6. Penn Detroit Allison.

11. 7. Spectrum Detroit Diesel.

12. 8. Stewart & Stevenson Services, Inc.

13. 9. Western Diesel Service.

14. • Fuel: Natural Gas

15. Functional Description: When the mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic-transfer switches initiate starting and stopping of the generator set. When the mode-selector switch is switched to the on position, the generator set manually starts. The off position of the same switch initiates generator-set shutdown. When the generator set is running, specified system or equipment failures or derangements automatically shut down the generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down the generator set.

16. • Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators as specified below:

17. 1. Coordinate this training with that for transfer switches.

18. 2. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.

19. 3. Review data in maintenance manuals. Refer to Division 1, Section 01 77 00 (Closeout Procedures).

20. 4. Review data in maintenance manuals. Refer to Division 1, Section 01 78 23 (Operation and Maintenance Data).

21. 5. Schedule training with Owner, through Architect, with at least seven days advance notice.

22. 6. Minimum Instruction Period: Eight hours.

.

- Zenith transfer switches are preferred.

This section of the Building Standards establishes minimum requirements only.
It should not be used as a complete specification