16060
Grounding and Bonding

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A. Summary

This section contains design criteria for the grounding of building services and separately-derived systems under 600 volts. “Building service” can refer to utility services or services originating in other Yale University buildings. This section also contains design criteria for grounding and bonding electrical equipment.

B. System Design and Performance Requirements

1. Ground all equipment with insulated ground wires run in conduit with circuit conductors. Construct metal raceway systems to create an independent and redundant ground path bonded to the ground wire at all boxes and enclosures. Provide another redundant ground where nonmetallic conduits are used (for example, ground rods at site lighting fixtures).

2. For all circuits of systems over 50 volts to ground, include an insulated equipment grounding wire sized according to NEC requirements. In addition, design metal raceway systems to serve as a redundant grounding conductor, and bond the insulated grounding wire to the metal raceway system at all terminations.

3. Where isolated grounding systems are provided, provide an additional insulated grounding wire to serve isolated ground terminals. Isolated ground wire conductor shall be green with yellow tracer.

4. Provide all building services with a minimum of two grounding electrodes described by the NEC and bonded together to form a grounding electrode system.
5. Ensure that all grounding electrode system bonding conductors are the same size and type as the grounding electrode conductor from the system neutral connection and are run within a separate and independent conduit system.
   a. Make connections to metal underground water piping within five feet of the point at which the pipe enters the building. Also, all water meters in piping shall have ground conductor jumper across the meter.
   b. Effectively ground metal building frames by using connections to concrete-encased electrodes within the foundation, a ground ring encircling the building, or driven ground rods, but no less than six feet apart.
   c. Provide concrete-encased electrodes and ground rings for all new buildings.
   d. Where ground rods are provided, install a minimum of three ¾” by 10 feet long copper clad ground rods, and bond them together to form a grounding electrode. The three grounding electrodes shall be spaced in a triad arrangement six feet apart or at a minimum distance equal to the depth of the rods.

6. Do not bond neutral conductors to grounding conductors at locations other than those specifically allowed by the NEC. Connect generators to wiring systems by transfer switches employing solid neutrals. Do not bond grounding conductors to neutral conductors at generators.

7. Where a special grounding system (for example, an isolated ground or ground grid) is provided for sensitive electronic equipment, bond the grounding system to the equipment grounding conductor only at the grounding system's point of connection to the system neutral conductor. Special grounding systems that are completely isolated from the building's normal equipment grounding system are never acceptable. Where shielded isolation transformers are provided, bond the electrostatic shield to the primary circuit equipment grounding conductor.

8. On construction drawings, indicate all required methods of service grounding and separately derived system grounding by specific details or notes. References to NEC requirements without such details or notes is not acceptable.

9. All new building modifications shall provide and install a building ground loop which will contain ground rods at 100’ apart. This ground loop shall be connected to electrical service ground and main water pipe. Grounding cable shall be independent of all other conduit systems.
10. Ensure that all building main service transformers are wired to the main electrical room individually. Wire the ground bus to the water main. The size of the conductor is determined by the NEC 250.30 and NEC 250.104. Duplex switchgears, double-ended substations, 300 kVA or larger transformers, motor control centers, and other major electrical equipment shall be grounded in two locations on that equipment with 4/0 size of conductor tying to the building ground. Major pieces of mechanical equipment such as chillers, air compressors, mechanical skid package frames have to be grounded with 4/0 conductor to building ground.

C. Product Standards

Ensure that all products conform to the requirements contained in UL 467, Electrical Grounding and Bonding Equipment.

D. Manufacturers

Any products that meet the materials requirements are acceptable.

E. Materials

1. Use copper-clad steel ground rods with a minimum diameter of 3/4 inches and a minimum length of 10 feet. Where longer rods are required, use 1-inch diameter sectional rods.

2. For grounding conductors, use green insulated building wire, as described in Section 16120: Conductors and Cables.

3. Connectors used for grounding must meet the following requirements:

   a. Mechanical connectors shall be cast bronze. Connectors used in branch circuits with #14 to #10 AWG solid conductors may be spring wire connectors with a green plastic shell, designed for grounding.

   b. Compression connectors must be copper.

   c. Welded connections must be exothermic-type and copper.
F. Preparation

1. Where new feeders terminate in existing switchboards that do not contain grounding busses, specify new copper grounding busses sized at 20 percent of the phase busses, located at the bottom of the enclosures, and extending the full width of the enclosures.

2. Where new circuits terminate in existing panelboards and the ground bar is full or does not exist, specify a new ground bar.
G. Installation Guidelines

1. Where ground grids are required under raised floors, specify #2 AWG bare copper conductors in each direction on 24-inch centers with cross-type compression connectors where grid conductors cross. Bond each item of equipment in room individually to the grid and to the isolated grounding conductor. Bond the grid directly to the isolated grounding conductor. Where necessary, bond the grid to each floor pedestal.

2. For buildings with metal siding that does not have an electrical connection to a metal building structure, bond the siding to equipment grounding conductors in panelboards at a minimum two, diametrically opposite locations.

3. Provide ground busses in all access holes and vaults containing circuits operating over 600 volts.

4. Specify new insulated or isolated ground bar for all panelboards through which isolated grounding conductors are run.

5. Do not bond isolated grounding conductors to equipment grounding conductors at locations other than at the point where system neutral is bonded to grounding electrodes. In small projects where new wiring does not extend beyond a local panelboard, insulated or isolated ground bar may be bonded to equipment ground bar in the panelboard.

6. At isolated grounding receptacles, bond the equipment grounding conductor to the box.

7. A ground ring encircling a building shall be buried at a depth of not less than 30” below the earth’s surface.

H. Quality Control

Test the resistance to ground of all grounding electrodes under any of the following conditions, and submit the test results to Yale University.

- Where new low voltage building services are installed.
- Where existing low voltage building services are upgraded.
- Where new or replacement grounding electrodes are installed or newly connected.
End of Section
16072
Electrical Supports and Seismic Restraints

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A. Summary

This section contains design criteria for supporting devices, including anchors and fasteners for raceways and equipment.

B. System Design and Performance Requirements

1. When located in the following facilities, design the electrical system components listed in paragraph 2 to withstand the effects of seismic forces. Comply with the requirements of the Connecticut State Building Code.
   - Buildings occupied by University police
   - Power plants
   - Telecommunications equipment centers
   - Buildings containing hazardous materials in excess of exempt amounts allowed by code
   - Health care facilities
   - Assembly occupancies
   - Residential colleges, dormitories, and similar buildings that house students
   - Laboratories and classroom buildings exceeding 50,000 square feet gross area
2. When located in the occupancies listed in paragraph 1, design supports for the following types of equipment to withstand the effects of seismic forces.
   - Conduits supported by individual hangers more than 12 inches in length from the top of the conduit to the bottom of the supporting structure
   - Conduits 2-1/2 inches trade size and larger
   - Transformers
   - Switchgear and switchboards
   - Bus ducts
   - Panelboards
   - Motor control centers
   - Motor controllers
   - Motors
   - Lighting fixtures  * If over 12”, then flexible fitting is required for raceway.

3. Design supports for the following types of equipment, including associated raceways, to withstand the effects of seismic forces in all buildings, regardless of occupancy.
   - All components of systems operating over 600 volts, including manholes and duct banks.
   - Substations.
   - Emergency electrical systems, legally required standby systems, and optional standby systems, including all wiring on line sides of transfer switches.
   - Fire alarm systems.
   - Telecommunications systems from plant to telephone cabinets and backboards.

4. Design all raceway and equipment supports for easy installation and removal or disassembly with as little damage as possible to the underlying structure. System shall use fastening systems, such as screws, bolts, and beam clamps, unless specific design conditions require alternate supporting methods. Nails, power-driven studs, welds, and similar methods are not acceptable.

C. Manufacturers
   Any product that meets the materials requirements is acceptable.
D. Materials

1. Use galvanized steel, aluminum or malleable iron supports, treated for rust resistance. Any cuts for support shall be treated with a rust inhibitor.

2. Use stainless steel fasteners in damp and wet locations and where they are exposed to view in finished areas.

3. Use expansion shield or expansion bolt anchors in concrete or masonry structures that are rated to support, at a minimum, four times the anticipated load. Anchors attached to concrete ceilings must be vibration- and shock-resistant.

4. Use 3/4-inch thick exterior grade plywood backboards, primed and painted prior to mounting.

E. Installation Guidelines

1. Use beam clamps when mounting to structural steel construction. Do not drill structural steel.

2. For surface-mounted panelboards and equipment cabinets installed against walls, provide support channels to create a minimum one-inch ventilation air space behind the enclosure.
16075
Electrical Identification

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Change History

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<th>Pages / Sections Modified</th>
<th>Change Approver Initials</th>
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A. Summary

This section contains design criteria for electrical and wiring identification systems.

B. System Design and Performance Requirements

1. Ensure that identification systems are compatible with existing systems, provide for future additions to system, and are consistent throughout the project.

2. On construction documents, indicate identification systems and designations for all equipment and wiring.

3. On identifying plates, indicate unit designation or load served, as applicable, and other information not readily apparent, which might be required by service personnel, particularly with regard to emergency conditions.

4. Ensure that color-coding for power and lighting circuits is in accordance with Section 16120: Conductors and Cables.
5. For systems such as fire alarm, intrusion detection, access control, intercom, public address, television, and audio/visual, ensure that the color-coding of wiring is in accordance with Yale University and industry or manufacturers' standards. In instances where these standards conflict, Yale University standards take precedence.

6. In accordance with Section 16442: Panelboards, follow a specific methodology for panelboard designations. Show the designation on every panel schedule on the panel door and in the construction document.

C. Manufacturers

Any product that meets the materials requirements is acceptable.

D. Materials

1. For equipment identification plates, use:
   • Laminated phenolic resin
   • Black with a white core (unless specific design conditions require an alternate color scheme)
   • Engraved lettering
   • Plates shall be screwed on with stainless steel screws. Adhesive tape is not acceptable.

2. For branch circuit wiring and circuit cable identification markers for systems such as fire alarm and intrusion detection, use:
   • Pre-printed plastic
   • Black-on-white background
   • Pressure-sensitive adhesive

3. For identification markers for such components as feeders, switchboard buses, and transformer terminals, use:
   • Pre-printed vinyl cloth
   • Black-on-yellow background
   • One-inch lettering (minimum)
   • Pressure-sensitive adhesive
4. For all cables in manholes and feeding main services into buildings, all phase conductors shall be tagged with the feeder identification. The tags shall be as follows:
   - 1-1/2” Tech Products tags
   - Black lettering with yellow background
   - Identify all phase conductors in manholes and sub feeders to buildings
   - Each phase conductor shall be tagged with the feeder designation, its source and designation, and its phase. (example: C1-A -for phase A of feeder C-1)

5. Control panels for sump pumps and other control systems use:
   - Vinyl sleeves with typed indelible ink for all control wires
   - All devices in panel to have identification plates for components using laminated phenolic resin nameplates (see #1 above)

6. Building Automation Systems shall have identification in panel for the followings:
   - All controller numbers, I/O tag, address
   - All control and signal cable contain the controller number I/O tag number including the address
   - The control and signal cables shall be tagged at both ends per Section 15900 HVAC Instrumentation and Controls
E. Installation Guidelines

1. Provide all equipment, including switchboards, panelboards, transformers, safety switches, and motor controllers with identification plates secured with stainless steel screws.

2. Neatly type directories for equipment controlling multiple circuits (panelboards, fire alarm control panels, intrusion detection control panels), and mount them on the inside of the panel front cover. Ensure that circuit numbers marked in the field match the circuit numbering contained in the construction documents, so that future references to system wiring can be obtained easily.

3. Identify branch circuit numbering at the panelboard. Identify wiring for other systems, such as fire alarm and intrusion detection, at all terminations and connections.

4. When required by individual standards, such as fire alarm systems and energy management and control systems standards, paint conduit and boxes to identify the system contained within. Painting is described in Division 9, Finishes standards.

End of Section