PART 1: GENERAL

1.01 SUMMARY

A. This section contains design criteria for the grounding of building services and separately derived systems under 600 volts as well as equipment grounding and bonding requirements.

B. This design standard is not intended to be used as a construction specification. It provides general guidance concerning specific preferences for Grounding and Bonding at Cornell University.

C. Cornell University recognizes that project conditions and requirements vary, thus precluding the absolute adherence to the items identified herein in all cases. However, unless there is adequate written justification, it is expected that these guidelines will govern the design and specifications for projects at Cornell University.

1. Electrical System Grounding:
   a. Electrical systems shall be grounded to:
      1) Limit voltages due to lightning, line surges, or intentional contact with higher voltage lines.
      2) Stabilize the voltage to ground during normal operations.
      3) To facilitate the operation of overcurrent devices in case of ground faults.

2. Definitions:
   a. Bonded – connected to establish electrical continuity and conductivity.
   b. Effective Ground Fault Current Path – electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a low impedance circuit facilitating the operation of the overcurrent device or ground detection for high impedance grounded systems. It shall be capable of safely carrying the maximum ground fault current likely to be imposed on it from any point on the wiring system where a ground fault may occur to the electrical supply source. The earth shall not be considered as an effective ground fault current path.
c. Equipment Grounding Conductor – the conductive path installed to connect normally non-current carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both.
d. Equipotential Bonding Plane - an area where wire mesh or other conductive elements are embedded in or placed under concrete, bonded to all metal structures and fixed nonelectrical equipment that may become energized, and connected to the electrical grounding system to prevent a difference in voltage from developing within the plane.
e. Ground – the earth
f. Grounded (Solidly) – connected to earth without inserting any resistor or impedance device.
g. Grounded Conductor - a system or circuit conductor that is intentionally grounded.
h. Interrupting Rating - the highest current at rated voltage that a device is identified to interrupt under standard test conditions.
i. Main Bonding Jumper – the connection between the grounded conductor and the equipment grounding conductor at the service.
j. Separately Derived System - a premise wiring system whose power is derived from a source of electrical energy or equipment other than a service. Such systems shall have no connection from the circuit conductors of one system to circuit conductors of another system, other than connections through the earth, metal enclosures, metallic raceways, or equipment grounding conductors.
k. Service Point - the point of connection between the facility of the serving utility and the premise wiring.
l. System Bonding Jumper - the connection between the grounded conductor and the supply side bonding jumper, or the equipment grounding conductor, or both at a separately derived system. This connection can be at the separately derived system source (Detail #3) or at the first system overcurrent device enclosure. (Detail #4)

PART 2: PRODUCTS

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

A. Material
   1. Copper, aluminum, or copper clad aluminum conductor
   2. Rigid metal conduit
   3. Electrical metallic tubing
   4. AC cable
   5. MC cable, where approved
   6. MI cable
7. Cable tray  
8. Cable bus  
9. Listed metallic raceways and gutters  
10. Listed surface metal raceways

PART 3: EXECUTION

3.01 GROUNDING CONDUCTORS

A. Purpose:
   1. Provide a path that connects the equipment to ground.  
   2. Bonding.  
   3. Serves as an effective ground fault path during abnormal events such as ground faults.

B. Equipment grounding conductors, grounding electrodes conductors and bonding jumpers shall be connected by one of the following means:
   1. Listed pressure connectors  
   2. Terminal bars  
   3. Pressure connectors  
   4. Exothermal welding process  
   5. Machine screw type fasteners that engage not less than two threads or are secured with a nut.  
   6. Thread forming machine screws that engage not less than two threads in the enclosure.  
   7. Connectors that are part of a listed assembly.  
   8. Other listed means

C. Terminations must be torqued to manufacturer’s recommendations.

D. Generally sized in accordance with NEC 250.122.

E. In no case is the equipment grounding conductor required to be larger than the ungrounded phase conductors.

F. For multi-conductor cables the equipment grounding conductor within the assembly is permitted to be sectioned as long as the combined circular mil area of the sectioned equipment grounding conductor meets the size requirement in 250.122.

G. Verify that cable assemblies used for large capacity parallel installations have equipment grounding conductors sized in accordance with 250.122.
H. Equipment grounding conductors are required to be increased in size proportionate to any increase of associated ungrounded conductors for considerations like voltage drop.

I. Where multiple circuits are installed in a single raceway, cable or cable tray, a single equipment grounding conductor is permitted.

J. For parallel feeders or branch circuits the equipment grounding conductors in each raceway are required to be sized based on the size of the overcurrent protective device rating in accordance with 250.122.

K. When conductors are run in parallel in separate raceways or cables, any wire type equipment grounding conductors are also required to be run in parallel in their respective raceway or cable.

L. All conductors including the equipment grounding conductors are to be installed in the same raceway, cable or trench.

M. An equipment grounding conductor shall not be used as a grounding electrode conductor.

N. An equipment grounding terminal bar must be installed in panelboard enclosures where there are wire type equipment grounding conductors in the circuits entering the enclosures.

O. For agricultural installations, equipment grounding conductors of underground wiring systems must be insulated copper.

P. In agricultural installations, an equipotential bonding plane must be created in concrete slabs of animal confinement areas.

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

R. The earth shall not be used as the sole equipment grounding conductor or effective ground fault current path. A ground rod driven at a light pole base is permissible but must not be used without an equipment grounding conductor installed with the circuit ungrounded conductors.

S. Grounded conductor size relative to nonlinear loads:

1. The grounded conductor shall be permitted to be increased in size due to nonlinear loading.
T. Temporary currents:
   1. Temporary currents that develop from accidental short circuits and ground faults and flow over grounding conductors shall not be considered objectionable currents.
   2. Currents generated from electronic equipment shall not be considered objectionable currents where such currents introduce noise or data errors.

U. Protection of Ground Clamps and Fittings: Unless approved for general use without protection, ground clamps and fittings shall:
   1. Be located so they will not be subjected to physical damage.
   2. Be enclosed in metal, wood or equivalent protective covering.

V. When exothermic welding is used, the connection shall be checked with an appropriate meter.

3.02 SEPARATELY DERIVED SYSTEMS

A. When a generator is used as an alternative source of power and is provided with transfer equipment that includes switching the grounded (neutral) conductor, the generator shall be classified as a separately derived system and grounded in accordance with Cornell Standard Detail 2.3.3. A 4-pole transfer switch on a three phase, four wire system is Cornell’s preference for automatic transfer switches.

B. When a generator is used as an alternative power source and is provided with transfer equipment that does not include switching the grounded (neutral) conductor, the generator shall not be classified as a separately derived system and shall be grounded in accordance with Cornell Standard Detail 2.3.4. The use of a 3-pole transfer switch on a three phase, four wire system needs to be specifically approved by Cornell University Facilities Engineering.

C. The system bonding jumper can be located at any point from the source enclosure up to the first system overcurrent device or disconnecting means (refer to Cornell Standard Details 2.3.1 & 2.3.2). The system bonding jumper shall be in the same enclosure as the grounding electrode conductor connection.

D. The system bonding jumper shall remain in its original enclosure.

E. The grounding electrode shall be:
   1. As near as practicable and preferably in the same area as the grounding electrode conductor connection to the system.
   2. The nearest of either a metal water pipe electrode or a structural metal grounding electrode.
3. If there is no grounding electrode available, then a grounding electrode must be established.

F. Metal water piping and structural steel that are in the same area served by the separately derived system shall be bonded.

G. Where the separately derived source is outside the building or structure it serves, a grounding electrode connection to the source is required at the source location outside building or structure.

H. The supply side bonding jumper shall be routed to the first system overcurrent device and sized in accordance with 250.102(C). It shall not be required to be larger than the derived phase conductors supplied by the system.

3.03 GROUNDING ELECTRODES

A. All grounding electrodes at a building or structure must be bonded together and used as the grounding electrode system (see Cornell Standard Detail 2.3.5).

B. Provide concrete encased electrodes and ground rings for all new buildings.

C. Do not bury wire, ground ring, pipes or plates in soils with cinders or other corrosive material.

D. Water pipe and a single rod, pipe or plate electrode shall be supplemented by at least one additional electrode.

E. Metal building frames can serve as grounding electrodes. The building frame electrode must be in direct contact with the earth for 10 or more feet, with or without concrete encasement.

F. Concrete encased electrodes must be included in the grounding electrode system for building or structures with concrete footings or foundations that provide not less than 20 feet of reinforcing steel or bare copper wire.

G. Ground ring electrodes must circle the entire building or structure, be a minimum 2 AWG copper, and be buried a minimum of 30 inches below grade.

H. Rod type electrodes must be at least 8’ in length and a minimum of 5/8” in diameter.

I. Plate electrodes must be buried a minimum of 30 inches deep.

J. Where metal water pipe electrodes are used, the continuity of the grounding path or bonding connection to the piping must not depend on water meters, filters or similar equipment.
K. Test the resistance to ground of all grounding electrodes under any of all the following conditions and submit the results to Cornell Facilities Engineering:

1. Where new low voltage building services are installed
2. Where existing low voltage building services are upgraded
3. Where new or replacement grounding electrodes are installed or newly connected.

L. Metal gas piping is not permitted to be used as a grounding electrode, but those systems are required to be bonded.

M. The electrode system for the electrical supply to the building has to be bonded to the ground network of a lightning protection system.

3.04 GROUNDING ELECTRODE CONDUCTORS

A. Generally sized based on the size of the ungrounded service entrance conductors.

B. Where connected to rod type electrodes, the minimum size for the grounding electrode conductor is 4 AWG copper based on the National Electrical Safety Code requirement.

C. The grounding electrode conductor connection to the water pipe must be made within 5’ of where the water pipe enters the building.

D. Connection of grounding electrode conductors or bonding jumpers of the grounding electrode system can be made using:

   1. Listed lugs
   2. Exothermic welding processes
   3. Listed pressure connectors
   4. Listed clamps
   5. Other listed means.

E. Where enclosed in a ferrous metal enclosure, both ends of the enclosure must be bonded.

3.05 BONDING REQUIREMENTS

A. Bonding of Electrical Equipment: Noncurrent carrying conductive materials that enclose electrical conductors or equipment, or forming parts of such equipment shall be connected together and to the supply system grounded equipment in such a manner so as to create permanent low impedance path for ground fault current that is capable of carrying the maximum fault current likely to be imposed.
B. Methods acceptable for grounding and bonding requirement are:
   1. Listed pressure connectors
   2. Terminal bars
   3. Exothermal welding processes
   4. Machine screw fasteners engaging not less than two threads or secured with a nut.
   5. Thread forming machine screws engaging not less than two threads in the enclosure.
   6. Connections that are part of a listed assembly
   7. Other listed means.

C. Supply side bonding jumpers are installed in accordance with 250.102(C) and generally based on the size of the ungrounded conductors.

D. Load side bonding jumpers are installed in accordance with 250.102(D) and generally based on the size of the overcurrent protective device.

E. Make connections to metal underground water piping within five feet of the point at which the pipe enters the building. Also, all water meters shall have bonding conductor jumper across the meter.

F. Bond fences that are within six feet of main service equipment, switchboards or switchgear.

G. Bonding jumpers are required to be used with expansion fittings.

H. Metal water piping systems are required to be bonded.

I. Gas piping systems are required to be bonded, but never used as a grounding electrode.

J. Structural steel metal building frames likely to be energized are required to be bonded.

K. Do not bond neutral conductors to grounding conductors at locations other than those specifically allowed by the NEC.

L. Ground terminals of a lightning protection system shall be bonded to the building or structure grounding electrode system.

M. An intersystem bonding termination for connecting intersystem bonding conductors required for other systems shall be provided external to enclosures at the service equipment for metering equipment enclosure and at the disconnection means for any additional buildings or structures (refer to Cornell Standard Detail 2.3.6). The intersystem bonding termination shall:
   1. Be accessible for connection and inspection.
   2. Consist of a set of terminals with the capacity for connection of not less than three intersystem bonding conductors.
3. Not interfere with opening the enclosure for a service, building or structure disconnecting means, or metering equipment.
4. At the service equipment, be securely mounted and electrically connected to an enclosure for the service equipment to the meter enclosure or to an exposed nonflexible metallic service raceway, or be mounted at one of these enclosures and be connected to the enclosure or to the grounding electrode conductor with a minimum 6 AWG copper conductor.
5. At the disconnecting means for a building or structure, be securely mounted and electrically connected to the metallic enclosure for the building or structure disconnecting means, or be mounted at the disconnecting means and be connected to the metallic enclosure or to the grounding electrode conductor with a minimum 6 AWG copper conductor.
6. The terminal shall be listed as grounding and bonding equipment.

3.06 COMMUNICATION SYSTEMS

A. All communication systems equipment must be effectively bonded together and connected to ground.

B. The grounding electrode conductor shall be connected to the same grounding electrode connected to the building electrical system.

3.07 Ungrounded systems should be legibly marked “Ungrounded Systems” at the source of first disconnecting means of the system. The marking should be of sufficient durability to withstand the environment involved.

3.08 Assured Equipment Grounding Conductor Program for personnel protection using temporary power is not permitted in place of Ground Fault Circuit Protection.

3.09 BUILDINGS OR STRUCTURES SUPPLIED BY FEEDER(S) OR BRANCH CIRCUIT(S)

A. An equipment grounding conductor shall be installed with the supply conductors and be connected to the building or structure disconnecting means, and to the grounding electrode(s).

3.10 LIGHTNING PROTECTION

A. When a lightning protection system is required, it shall be manufactured and installed in complete accordance with Underwriter’s Laboratories Pamphlet No. UL96A Master Labeled “Lightning Protection Systems,” NFPA 780 and LPI-175.

B. The contractor shall be listed with UL for lightning protection installation.

C. Upon completion, the contractor shall furnish the Owner with the Master Label Certificate.