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C-A OPERATIONS PROCEDURES MANUAL

1.5.2 Engineering / Design Guidance
Grounding / Bonding Methods for
Tray, Raceway, Beam Components, Equipment, and Safety Devices

Text Pages 2 through 7

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Collider-Accelerator Department Chairman Date

J. Sandberg

1.5.2 Engineering / Design Guidance
Grounding / Bonding Methods for Tray, Raceway, Beam Components, Equipment, and Safety Devices

1. Purpose

1.1 This guide recommends grounding and bonding methods to minimize the chance of personnel injury, to assure the operation of protection relays, and to meet the minimum requirements of the National Electrical Code (NEC), and the BNL Electrical Safety Committee (LESC).

1.2 Conductive materials enclosing electrical conductors or equipment shall be grounded to limit the voltage to ground of these materials and to facilitate the operation of over voltage devices under ground fault conditions.

1.3 The grounding of electrical systems, circuits conductors and conductive non current-carrying equipment shall be installed and arranged in a manner that will prevent an objectionable flow of current over the grounding conductors or ground path.

1.4 Definitions

1.4.1 Bonding – The permanent joining of metallic parts to form an electrically conductive path that ensures electrical continuity and the capacity to conduct safely the current likely to be imposed.

1.4.2 Ground – A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth or to some conducting body that serves in place of the earth.

2. Responsibilities

None

3. Prerequisites

None

4. Precautions

As described in section 5 of this OPM.

5. Procedure

5.1 Tray, raceways, enclosures, etc. bonding and grounding

5.1.1 All trays, raceways and metallic enclosures carrying conductors rated 50 volts or more shall be bonded to ground.

5.1.2 Exposed non current-carrying metal parts of fixed equipment which could become energized shall be grounded if within 8 feet vertically or 5 feet horizontally of ground or grounded metal objects if subject to contact by personnel or where any terminal is operated at 150 Volts or greater.

5.1.3 Where cable spills out of trays, conduit, etc. into racks, cabinets, or other raceways, a green #6 AWG wire (minimum) shall bond the tray or raceway to the rack, cabinets, raceways, etc. Bond needs to be connected to both the a/c and d/c trays if they are separate.

5.1.3.1 Exception: When enclosures/racks are to be isolated, the bond to the local tray shall be omitted if the rack exterior needs to be isolated. An insulated ground conductor shall be brought with the a/c electrical feed. Ground wire shall be sized to minimize the touch potential to less than 20 volts under a fault condition. Isolated enclosures/racks shall be labeled, "Isolated Equipment – Do Not Touch or Connect Unapproved Equipment"

5.1.4 All A/C trays shall have a 250 kcmil ground wire run the length of the tray.

5.1.4.1 Exception: When the tray carries a circuit with over current protection greater than 1200 amperes, additional grounding may be required.

5.1.4.2 Exception: When A/C trays run parallel, 1 – 250 kcmil can be used as long as a jumpers to the additional trays, sized 250 kcmil, are provided at the beginning, end, and with intermediate jumpers not to be spaced greater than 24'.

5.1.5 All D/C trays shall have a 250 kcmil ground wire run the length of the tray.

5.1.5.1 Exception: When power supply has ground fault protection on the output, the tray shall be bonded to building ground at the beginning and end with #6 AWG minimum.

5.1.5.2 Exception: When power supply has ground fault protection on the output and the tray runs parallel to an A/C tray, #6 AWG bonds can be installed between the A/C and D/C tray at the beginning, end, and with intermediate jumpers not to be spaced greater than 24'.

5.1.6 In general, no credit is given to the tray acting as a ground path other than local grounding.

5.1.7 The path to ground from metal enclosures shall, 1) be permanent and electrically continuous, 2) have capacity to conduct safely any fault current likely to be imposed on it, and 3) have sufficiently low impedance to limit the voltage to ground and to the facilitate the operation of the circuit protection devices.

5.1.8 Grounding conductors shall be run with the circuit conductors and can be bare, covered, or insulated. Individually covered or insulated grounding conductors shall have a continuous outer finish that is either green or green with one or more yellow strips.

5.1.9 The structural metal frame of a building shall not be used as the required equipment grounding conductor.

5.1.10 Any nonconductive paint, enamel, or similar coating, shall be removed from the point of contact of the grounding connection unless the connection fitting is so designed as to make such removal unnecessary.

5.2 Grounding Sticks

5.2.1 Grounding hooks bent in the shape of a shepherd's staff may be used on conductors to drain absorption and capacitive currents to ground. When used, it shall not be subject to power supply fault currents in excess of its rated current.

5.2.2 Ground hooks may not be used to establish long-term grounds on equipment or for the purpose of making equipment safe to work on. In such cases permanently installed bolted or clamped grounding connections are required.

5.2.3 When large discharge currents are expected, appropriately sized discharge resistors shall be connected between the grounding electrode and the ground connections.

5.2.4 Temporary grounding devices to short and ground power circuits shall have a minimum withstand rating equal to the maximum short-circuit and ground fault current available at the intended point of connection to the system as determined by the cognizant personnel.

5.2.5 Temporary grounding devices shall have components that comply with the requirements of NEC Article 250-8 and shall be furnished with clear, insulated, extra-flexible, stranded-copper, grounding conductors, except

when the grounding cable is required to be No. 2 AWG or larger; then the components of the device shall comply with ASTM Specification F855

5.2.6 Insulated collars shall be used on grounding sticks to indicate the handling limit. The collars shall be made of rubber or equivalent shatter resistant plastic.

5.2.7 The grounding cable shall be continuous throughout its length. The conductor shall be extra flexible uncoated, stranded copper having a transparent thermoplastic, 600 V rated covering to provide mechanical protection for the cable and to permit inspection for possible strand breakage. Grounding cable shall be terminated in listed compression fittings and connected together with other grounding conductors using approved clamps.

5.2.8 Only qualified and authorized personnel trained in the application of temporary grounding devices shall be permitted to install or use them.

5.2.9 Before installing temporary grounding devices, perform the following:

5.2.9.1 Visually check the entire length of the grounding conductor for continuity and for adequate mechanical bonding to the nearest equipment-grounding conductor of sufficient capacity.

5.2.9.2 Visually check the insulating handle for signs of cracking, voltage breakdown, dirt, or other deterioration. Do no use the equipment if it appears damaged in any way

5.2.9.3 The user shall use appropriate PPE, which shall include as a minimum, protective insulating gloves and safety glasses.

5.2.9.4 Check the integrity of the insulating gloves before use by performing both an air-leakage test and a visual inspection. Check the test date stamped on the gloves and make sure it is current.

5.2.9.5 When applying the stick keep clear of the grounding cable, since its covering is provided to protect the conductors from mechanical damage and has no appreciable voltage rating.

5.2.9.6 Before applying grounds, use an appropriate voltage detector to verify that each ungrounded conductor is de-energized, verify that the voltage detector is operational before each use.

5.2.9.7 All sticks shall be visually inspected before use and as a minimum every two years as required by 29CFR 1910.269(J)

5.2.9.8 All sticks shall have an in service test per ASTM F-711

5.2.9.9 See Table 1 for hot stick length requirements

Table 1. Grounding Stick Lengths

Max Voltage kV	Max Voltage kV	Collar to Head (ft-in)	Handle to Collar (ft-in)	Overall (ft-in)
AC RMS	DC			
2.0	3	1-10	0-8	2-6
15.0	21	2-0	1-0	3-0
35	50	2-4	1-8	4-0
46	65	2-6	2-0	4-6
72	103	3-0	2-2	5-0
121	171	3-4	2-6	5-6

5.3 Transformers in Storage

5.3.1 Oil filled transformers with exposed terminals shall have their terminals, both primary and secondary, bonded together and bonded to the transformer tank with #12 AWG bare or green wire. Where possible, this bond shall be brought to a local area ground.

5.4 Beam line components

5.4.1 Component stands supporting equipment powered at greater than 50 V shall be bonded to local ground.

5.4.1.1 Exception – Stands supporting magnets with their own ground need not be bonded again.

5.4.2 Component stands supporting beam tube on either side of an insulated flange shall be bonded to local ground.

5.5 Machine Grounding Philosophy

5.5.1 AGS Ring Ground. –later-
5.5.2 Booster Ground –later-
5.5.3 RHIC Ground –later-

5.6 Grounding of Wire Shields

5.6.1 Conventional high voltage, a/c cables shall have drain wires grounded at every joint or termination.

5.6.2 High voltage cables feeding beam components shall be grounded at the power supply end only.

5.7 Capacitors out of service or in storage

5.7.1 Terminals shall be shorted with appropriate size wire if the capacitor's accumulated energy could be ≥10 Joules.

5.8 Isolated Racks

5.8.1 In general, isolated rack enclosures shall not be used. When isolation is required, this should be accomplished within the devices installed in the racks. When this is not possible, the Chief Electrical Engineer shall be notified.

5.8.2 Isolated rack enclosures are grounded through their power feed only. No local bonds are provided to trays, adjacent grounded racks. The ground provided with the power feed shall be sized to limit touch potential to less than 50V during a ground fault.

5.8.3 Isolated racks shall be labeled, " Isolated rack - Do not touch".

5.9 Grounding Office Trailers and Outdoor Structures

5.9.1 Follow the requirements in Attachment 8.2, as provided by the BNL LESC.

5.10 Discussion

Where possible, bond/ground wiring shall follow the path of the normal current.

5.11 Calculations

To be supplied.

6. Documentation

None

7. References

7.1 NEC

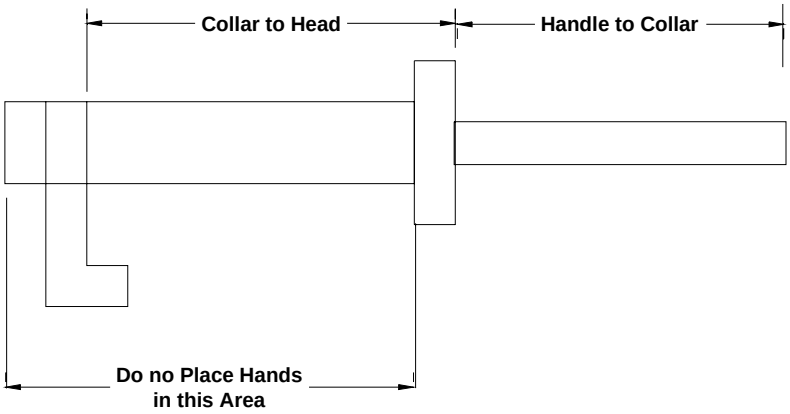
8. Attachments

8.1 Grounding Stick Diagram.

8.2 Grounding Office Trailers and Other Outdoor Structures

Attachment 8.1

Grounding Stick Diagram



Attachment 8.2

Grounding Office Trailers and Other Outdoor Structures

An electric shock can occur at outdoor electrical installations through a person becoming in contact with a structure normally isolated from ground which has become accidentally energized, while also being in contact with the ground or while in contact with a solidly-grounded structure like a metal fence.

The National Electrical Code (Article 250.24) requires that local grounding (with ground rods) is required when electrical power is extended to buildings or structures. This requirement will maintain voltages in relative balance if the neutral conductor should open. Such grounding also assures that the local ground and the structure remain at the same potential, so that a person standing in solid contact with local ground cannot be shocked while also in contact with the structure.

If a metal device on a trailer with rubber tires is powered through a very long cord, then an electrical fault may result in the enclosure of the device becoming energized. Even if the enclosure is connected to the grounding wire in the cord, it would be energized up to one-half line voltage through the voltage divider formed by the power conductor to the enclosure and the ground conductor returning from the enclosure. Without local grounding of the enclosure, a person standing in solid contact with ground would be exposed to the energized enclosure during a fault. Adequate local grounding would result in the ground potential being raised to the same potential as the enclosure, eliminating the voltage difference and thus protecting personnel. A step potential would also exist in this situation, between the fault location and general ground some distance away. While this effect is significant on high voltage power systems, it is not a concern for systems operating below 600 volts, which are more likely to be encountered at BNL.

The above paragraph describes how a person in good contact with ground is at risk if they should touch equipment while it is energized but lacking local grounding. A person would still be at risk, even if they were wearing rubber insulating boots, if they should touch the equipment and simultaneously touch a good local ground, such as a chain-link fence constructed around the equipment.

Requirements

Local grounding receives adequate attention during design of larger installations. Uniform application of local grounding for smaller jobs like office trailers, outbuildings, or equipment shacks, is problematic. To address the concerns described above, the following guidelines should be used at BNL to determining the need for local grounding and bonding:

1. A grounding conductor must be run along with the power supply conductors, and the grounding conductor should be at least equal in size to any power conductor. The grounding conductor must be connected to the frame of the trailer or metal enclosure, and all metal parts must be bonded together.

2. No local ground rods are required if the distance to the source of power is fifty feet and the area is a finished surface (asphalt, concrete). If the surface is a well-drained finished surface, or well-drained gravel, then the local Authority Having Jurisdiction may allow the distance to be extended an additional twenty-five percent, to sixty-three feet. If the surface is bare ground, or grassy, or has similar open field conditions, then the distance must be decreased by fifty percent, to twenty-five feet.

3. Effectiveness of local grounding is assumed to be fifty feet. If electrical service to a 50-ft trailer is at one end, then an additional ground rod shall be installed at the diagonally opposite end. If electrical service to the trailer is at the center, then only the service entrance ground rod is required. For larger structures, at least one other ground rod is required and it must be placed diagonally opposite the point of the power entrance and associated ground rod.

4. The structure must be bonded to any metal fence, or other significantly grounded structures, that exists within six feet (arm's reach).

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For the Laboratory Electrical Safety Committee,

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Laboratory Electrical Safety Officer