

ELECTRICAL EQUIPMENT INSPECTION (EEI) CRITERIA GUIDE

SCOPE

To meet the Department of Energy's Electrical safety guidelines, DOE-HDK-1092-2013 (<https://www.standards.doe.gov/standards-documents/1000/1092-BHdbk-2013/@images/file>), it is strongly encouraged that all equipment (chassis, cables, etc.) containing voltages above 50 volts be approved by a Nationally Recognized Testing Lab (NRTL) certified units. (<https://www.osha.gov/dts/otpca/nrtl/nrtllist.html>) However, BNL recognizes that not every experimental installation can use solely NRTL systems in performing an experiment. This condensed guide is intended for the beam line user community on what are the minimum electrical safety concerns when low voltage (less than 50 V) designs are impossible and a "one off" custom design must be fabricated and brought to Brookhaven National Laboratory for an experiment to be performed.

Documentation is required for devices not NRTL certified. This documentation is required to ensure a proper safety review and a correct implementation of the device. For Commercial Off The Shelf (COTS) devices not NRTL certified the manufacturer's user manual can suffice as this documentation. For Built In House (BIH) custom devices the schematic, block diagram, wiring, parts list and any other documentation used to build the custom device should be made available to an inspector well in advance of planned use to avoid any delays. Any custom cabling (except mains power connection) containing over 50V outside of the chassis must be identified.

Preventing personnel from a shock and preventing a fire due to overcurrent conditions are the two primary safety concerns to any electrical design.

ALL DEVICES NOT NRTL CERTIFIED WILL REQUIRE MORE INSPECTION TIME THAN NRTL DEVICES. BIH DEVICES WILL REQUIRE MORE INSPECTION TIME THAN COTS DEVICES. DOCUMENTATION SUBMISSION WELL IN ADVANCE OF SCHEDULED OPERATION CAN EXPEDITE THE INSPECTION TIME.

PERSONNEL ISOLATION FROM SHOCKS

People are not permitted to touch an exposed conductor energized above 50 V RMS from ground potential, even accidentally. Naturally every chassis must be undamaged and not provide access to any energized conductor without the use of a tool. There are two approved methods in the electrical industry to assure personnel isolation; grounded/bonded and double insulated chassis designs.

GROUNDING/BONDED CHASSIS

This is the preferred technique for any ground referenced voltages above 50 V RMS (e.g. mains supply) in a chassis. The outer conductive chassis acts as a safety barrier between personnel and dangerous voltages by itself being bonded to ground. All mains power provides a ground connection that must be connected directly to the chassis. Painted surfaces at the point of contact must be scraped clean to provide a solid connection to ground. When the contained voltages exceed 600 V an additional external bonding point should be added to the chassis for a secondary bond path.

DOUBLE INSULATED CHASSIS

As the name implies this technique places an insulating barrier inside another insulating barrier. No grounding connection is required in this approach. However, each barrier must be able to safely isolate dangerous voltages if the inner or outer barrier fails. Due to the ease of misapplying electrical tape this insulator will never count as an acceptable barrier in any installation. Since most insulators can also become fuel in a fire, considerable care in the selection of insulators, overheating, and overcurrent devices must be considered in a double insulated design. The use of materials traceable back to a reputable manufacturer is paramount in this approach. As such this approach requires the most amount of documentation for it to be properly used in a BIH design.

EXTERNAL CABLING

The above concerns to isolate personnel from shocks also apply to external cabling. There are a few added cabling specific concerns that can only be found at installation. Cables must be kept out of apparatus pinch points. Cables must be suitably strain relieved to prevent damage at connectors. Cables bent tighter than the cable manufacturer approved bend radius will rarely immediately fail but they will eventually fail. Cables should not be stepped upon nor block any passage way where people can travel. In tight crawl spaces it is particularly important to neatly dress cables.

OVERCURRENT PROTECTION

Due to the fault current capacity from mains power, all mains connections in a chassis must have an overcurrent protection device (fuse, circuit breaker) between the mains “hot” power connector lead and any possible load. There are many power entry devices available on the market that integrate fuse, power indicator, chassis grounding and power switch in one package. These devices are encouraged to be used but are not mandatory. Mains power above 120 V AC requires a fuse or breaker on each hot conductor. Many chassis power supply suppliers provide a recommended current rating for the overcurrent device. When the overcurrent device is a replaceable fuse the current rating of the fuse must be permanently marked on the outside of a chassis.

FOREIGN POWER SUPPLIES

With sufficient planning, time and funding any power requirements can be met for foreign power supplies. The nominal mains power connections available are single phase, 60 HZ 120 VAC provided via connections of NEMA 1-15 and 1-20 outlets. Other common US power voltages (e.g. 208, 480) are also available contingent on location. Many foreign power supplies designed today can accept a wide enough voltage and frequency range that only a suitable adapting cable between mains NEMA power output connector and supply input connector is required.

CONCLUSION

The inspectors selected for the EEI program have decades of experience in the safe use of electricity. One short pamphlet cannot contain all of the scenarios observed or all of the electrical safety concerns encountered in the future. As such this guideline is not an exhaustive list of everything that can be used; it is just the most common design approach that meets the DOE safety mandate. It is also not the only things an inspector will examine or question a visitor. For a more complete list of these concerns please visit the above cited DOE web site.

For questions or guidance please contact EEI Program Manager; Eugene Santiago, (631)344-8326, esantiago@bnl.gov

See appendix A for an electrical equipment inspection check list used at Brookhaven National Laboratory for Non-NRTL equipment:

APPENDIX A

Before any equipment is to be allowed within Brookhaven National Laboratory for use, it must meet specific safety standards. This checklist is required for all non NRTL equipment so that we can be assured that it meets the BNL safety requirements. The use of NRTL certified equipment is preferred in order to reduce the amount of labor required by this list.

Enclosure:

1. No evidence of hazard to operator
2. No evidence of damage
3. Appropriate material
4. Protects contents from operating environment

Power Source – Cords and Plugs:

1. Proper voltage and current rating for plug and cord
2. Grounding conductor included if required
3. Not frayed or damaged
4. Proper wiring of plug (Visual inspection required on field installed plugs.)
5. Strain relief on cord

Power Source – Direct wired into facility covered

1. Proper voltage and current rating for wiring method
2. Suitable for permanent installation by a qualified person
3. Proper loading and overcurrent protection in branch circuit

Grounding

1. Equipment grounding conductor included in the circuit.
2. Equipment grounding conductor properly terminated.
3. All non-current carrying exposed metal surfaces properly bonded.

Foreign power supplies and equipment

1. The connection to facility power is made with appropriate adapters
2. Correct wire ampacity for use in the United States
3. Is the voltage, frequency, and phasing correct for application

Marking Requirements

1. Equipment marked with potential hazards (stored energy, open buss, etc.)
2. The voltage, current, and frequency properly marked on equipment.
3. The make, model, and drawing number properly marked on equipment.
4. Supporting document supplied for inspection.

Internal Wiring

1. The Polarity correct such that the hot conductor(s) is interrupted by the breaker or fuse.
 - a. Mains higher than 120 VAC require a breaker or fuse on each hot conductor.
2. Multi-phase equipment has the phasing correct.
3. The equipment grounding conductor properly attached to a paint free surface using correct fasteners.
4. For different voltages that are being used the separation is adequate for the application.
5. The wiring terminals the correct size for the conductors.
6. Is the wire sized adequately for the load
7. Clearance/Creep distances for high voltage equipment adequate.
8. All conductors being used listed by an NRTL.
9. All cables installed in neat workman-like manner.
10. All conductors protected from sharp edges, and are wire bends gentle.
11. Equipment that generates heat has to have sufficient room for air circulation and/or cooling.
12. Equipment that has any stored energy (capacitor) needs an automatic discharge for any stored energy.

Test performed

1. Actual ohm's readings are required and documented for all continuity checks and verifications.
2. Field installed mains AC power plug will be tested to ensure wires properly phased and connections tightened.