



LIGO Laboratory / LIGO Scientific Collaboration

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LIGO LABORATORY Clean Room Electrical Inspection Procedure		
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**Distribution of this document:
Advanced LIGO Project**

**This is an internal working note
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Signature Sheet

Each of the undersigned has carefully reviewed the contents of this hazard analysis and believes it has adequately identified potential personnel safety hazards and risks. The safety of the personnel carrying out the procedures or using the equipment addressed by this hazard analysis is considered to be at an acceptable level.

Richard Oram, LLO Operations Manager, **date**

Calum Torrie **date**

David Nolting, LIGO Lab Safety Officer, **date**

Janeen Romie **date**

, **date**

Clean Room Electrical Inspection Procedure

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LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

Introduction

The purpose of this document is to ensure the electrical safety of the Clean Rooms utilized in the LVEA areas of LIGO by:

- Establishing a formal process of inspection of the electrical infrastructure of the Clean Room and its compliance with the National Electrical Code (NFPA 70)
- Establishing a formal process of documentation of the results of such inspection
- Providing a process to enable remedial action of any non-compliant Electrical installations found at the Clean Rooms
- ***NOTE: This document only addresses the identification of non-compliant Electrical Installations associated with a Clean Room. These inspections can and should be performed by a LIGO Lab Qualified and Authorized person as detailed on page 6 of the LIGO Laboratory Electrical Safety Policy, Qualification and Authorization document #M1200022. However, any and all Electrical Repair work that needs to be performed on devices and/or wiring following the inspection shall be performed by qualified and authorized Facilities Division or approved subcontract personnel as also directed on page 9 of the LIGO Laboratory Electrical Safety Policy, Qualification and Authorization document #M1200022.***

This document should be accompanied by

- LIGO Laboratory Clean Room Inspection Checklist - **F1600005**
- LIGO Laboratory Electrical Work Rules and Advice - [M1200365](#)

Reference Documentation

- NFPA 70E - Standard for Electrical Safety in the Workplace
- OSHA - Subpart S, 29 CFR 1910.303 to .308
- **LIGO Laboratory Electrical Safety Policy, Qualification and Authorization document #M1200022**
- LIGO Lab Lock-Out/Tag-Out Procedure - [M990190](#)
- LIGO Observatories Operations Safety and Environmental Protection Manual - [M980242](#)
- LIGO Stop Work policy - [M1200083-v1](#)
- LIGO Electrical Equipment Safety Design Rules - T1000583-v1
- Electrical Safety Training Video Presentation - <https://ligoimages.mit.edu/?c=1238>
- LIGO Laboratory Mobile Clean Room Structural Inspection List - [E1600195-v1](#)

The 'Rules and Advice', LIGO Document M1200365 and Electrical Safety Training Video Presentation - <https://ligoimages.mit.edu/?c=1238> are intended to be read/viewed and known by all at any LIGO Site (Caltech, MIT, LLO, LHO) who work with any electrical equipment.

Policy

The LIGO Lab Clean Room Electrical Inspection Procedure is based on the following notions:

1. **LIGO has a Stop Work Policy – anyone may and must call a stop to work if they have any doubts about the safety of the undertaking.** It is the responsibility of everyone to exercise this policy when observing unsafe work conditions or practices. All individuals have a responsibility to ensure they and others around them are working in a safe manner with the proper equipment and hazard controls.
2. All electrical wiring and equipment installations will comply with the NEC, OSHA regulations, and other consensus industry standards for electrical safety and engineering. All production, research, or test devices which are considered hazardous must be protected by an enclosure with secured or interlocked covers, or isolated in a manner that will prevent inadvertent contact with exposed live parts. This includes all equipment:
 - a. Operating at a voltage greater than 50 volts (V) with the ability to produce 5 milliamperes (ma) or more of current,
 - b. Which can deliver enough current to produce a burn via a short-circuit, with 10 Amps as a guideline,
 - c. With high voltage present even at low currents which can invoke an involuntary movement leading to injury,
 - d. Having capacitors with stored energy greater than 1 joule (J), or 1000 J if less than 50 V.
3. Fabrication of research and test equipment will be done following prescribed LIGO design and engineering requirements.
4. Any potentially electrically hazardous work will be performed following Lockout/Tagout (LOTO) rules.
5. Work will only be performed on live electrically hazardous electrical circuits or energy-containing components (batteries, capacitors) when it can be demonstrated that de-energizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations. Energized parts not considered electrically hazardous shall not be required to be de-energized if there will be no increased exposure to electrical burns or shocks.
6. When work on electrically hazardous electrical circuits or components is justified and approved, reasonable and sufficient controls (guards, covers, shields, insulated tools and probes, remote methods) must be used to reduce the potential for contact with energized components.
7. For live/energized work, an Energized Electrical Work Permit (EEWP) and an adequate electrical hazard analysis must be completed, and approval of the work plan by the site LIGO Electrical Safety Engineer must be obtained.

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1. **Qualified Persons:** The Clean Room Electrical inspection procedure shall be performed by a LIGO Qualified Electrical Worker or Licensed Electrician
2. **Major Areas of Consideration:**
 1. Proper Physical Installation of Devices/Components
 2. Any signs of Physical Damage
 3. National Electrical Code Compliance
 4. Voltage Ratings
 5. Amperage Ratings
 6. Proper Conduit/Wiring Installation and supports
3. **Definitions:**
 1. **Floor Level Device:** Any Electrical Device accessible for proper inspection from standing height
 2. **Roof Level Device:** Any Electrical Device accessible only by use of ladder or scissors lift
 3. **Control Station:** Switching device to provide power to Clean Room Devices (Lights and HEPA Filters)
 4. **Design Document:** A Drawing/Descriptive document, to include manufacturer submittals, listing all electrical devices and components (Type of Devices, Quantity, and any other description as required) and total Electrical Load (Voltage and Amps)
 5. **NEC:** National Electrical Code (NFPA 70) 2014 Edition
4. **Clean Room Configuration:**
 1. Clean Room shall have a unique identifier (tag number) in a clearly visible location
 2. Clean Rooms shall be equipped with Cable Hangers as needed for the sole purpose of coiling and hanging any Electrical Power Cords or Cables that are part of the Clean Room
 3. Each Clean Room shall have a Design Document describing the Electrical Devices installed on its structure. This design document shall be laminated and locally attached in an easily accessible location on one of the Clean Room Legs or Risers
 4. Any changes to the Clean Room Electrical Devices, whether in quantity or type, shall be noted on the Design Document for the Clean Room
5. **Specific Devices at the Clean Rooms**

Clean Room shall be inspected at the Floor Level, as well as the Roof Level, for any of the below referenced issues:

 1. Power sources for the Clean Room shall be made available in the form of permanently installed receptacles of proper Voltage and Amp Rating in close physical proximity to the Clean Room location
 2. Electrical Power to Clean Rooms shall have:
 - a. A dedicated Power Cord (not an extension cord)
 - b. Power Cord shall be of the proper cable type/size, and equipped with the correct plug type of proper rating to the adjacently located receptacle(s)
 - c. Power Cord shall be free of abrasion or damage to the insulation

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- d. Power Cord shall be without any in-line receptacles (that are accessible from the Floor Level)
 - e. Power Cord shall be equipped with a properly rated and permanently installed On/Off switch
 - f. Power Cord shall be clearly tagged with its corresponding switch's tag information
3. Permanently installed dedicated Power Strips on the Roof Level are permitted to supply power to the HEPA Filters and Light Fixtures that are part of the Clean Room Structure.
 - a. Each Power Strip shall be tagged properly and clearly with a unique identifier which corresponds to its switch
 - b. "Daisy Chaining" of Power Strips is not allowed
 - c. Care shall be taken to not overload Receptacles or Power Strips
 - d. Receptacles and/or Power Strips shall not be loaded to more than 80% of their rated capacity (ie: 15A rated receptacle shall not have a combined load greater than 12A connected)
 - e. Power Strips shall be installed so as to be easily seen from the Ground
4. Panelboard feeding the Receptacle(s) to the Clean Room shall have its door schedule properly noted with the Receptacle(s) information, as well as having the Panelboard Schedule drawing on file updated with this information
5. Light Fixtures
 - a. Confirm quantity of lights fixtures to Clean Room Design Document
 - b. Proper operation (turns on quickly, no flickering)
 - c. Missing, Dimmed, or Burned out bulbs/lamps. This may indicate a ballast issue and/or a lamp issue.
 - d. Cracked or missing lens/diffuser
6. HEPA Filters
 - a. Confirm quantity of HEPA Filters to Clean Room Design Document
 - b. Proper operation
 - c. Cracked or missing parts
7. Other Electrical Components
 - a. Confirm quantity of Other Electrical Components to Clean Room Design Document
 - b. Proper operation
 - c. Cracked or missing parts
 - d. Proper Grounding of components as applicable
8. Switches/Control Stations
 - a. Confirm quantity of Switches/Control Stations to Clean Room Design Document
 - b. Switches/Control Stations shall be properly tagged with the Clean Room and or devices they service
 - c. Proper cable routing to/from Switches/Control Station (Pinched, pulled tight, excessive bending). Cables shall be dressed so as not to create a safety hazard (Yellow Trip Strips may possibly be employed as required)
 - d. Proper Strain Relief of cable at Switches/Control Station
 - e. Proper operation of pushbuttons or switches

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- f. Missing or broken covers on pushbuttons or switches as applicable
 - g. Each Switch/Control Station shall be tagged properly and clearly with its correct tag (unique identifier) and source information.
9. Disconnects and/or Breakers (as part of the Clean Room Structure)
- a. Confirm quantity of Disconnects and/or Breakers to Clean Room Design Document.
 - b. Proper cable routing (Pinched, pulled tight, excessive bending)
 - c. Disconnect/Switch/Breaker Box shall not be used as a pull box for cables to route through per NEC 2014 Article 404.3(B) "Enclosure/Used as a Raceway" unless the enclosure meet the requirements of NEC 2014 Article 312.8 "Switch and Overcurrent Device Enclosures with Splices, Taps, and Feed-Through Conductors"
 - d. Enclosures shall be properly Grounded with a permanent Green Ground conductor as applicable per NEC Article 250
10. Conduit & Cable Systems
- a. Conduit shall be properly routed (plumb, Horizontal and/or Vertical) and supported every 10 feet
 - b. Cable shall be free of abrasion or damage to the insulation. Cable shall be properly routed (not pinched, pulled tight, or excessively bent) and supported every 3 feet.
 - c. Conduit Fill shall comply with NEC Article 314
 - d. All conduit fittings shall have covers with neoprene gaskets installed
 - e. All Vertical runs of conduits shall have drains installed at bottom of the vertical run
 - f. Flexible Conduit shall have a Green Ground Wire between the fittings at both ends