

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
California Institute of Technology
LIGO Livingston Observatory

Document Type LIGO-M030086-A-L 5/2/03

**LLO Laser Safety Interlock
Personnel Accountability SOP**

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1 GENERAL

1.1 Purpose

This document outlines the laser safety procedures related to the Laser Safety Interlock which are implemented at the **LIGO Livingston** site.

1.2 Scope

This document contains essentials related to the overall laser safety at the observatory, and is designed to ensure the safety of all personnel, equipment and visitors, and is based on:

1. American National Standard for "Safe Use of Lasers" ANZI Z136.1-1993.
2. LIGO Laser Safety Program, LIGO-M960001-P.
3. LIGO Livingston Observatory Laser Safety Plan, M990148-L

1.3 Project Responsibility

The LIGO Project is responsible for the application of safety requirements and the operating safety of the Project's laser systems. A complete description of responsibilities are provided in the LIGO Project System Safety Plan, LIGO-M950046. Everyone attached to LIGO (staff members, employees and visitors) are personally responsible for safety and safe practices. All individuals must identify hazards and bring them to the attention of the group leaders, Safety Officer, or Project Manager. There shall be a designated **Laser Safety Officer** (LSO) for the LIGO Observatory at Livingston.

1.4 Personnel Responsibility

A. Laser Safety Officer

The LSO has the responsibility and authority to monitor and enforce the control of laser hazards at the Livingston facility. In addition, the LSO will be responsible for the following tasks:

- Maintaining an inventory of all lasers operating at the facility. Inform LIGO Livingston Safety Officer of any new laser installations.
- Maintaining an up-to-date listings of the laser system Sponsors, and those who have completed the "Basic" laser safety training. The names of the qualified Registered Laser Personnel are posted at > <http://www.ligo-la.caltech.edu/laser/>.
- Providing the necessary safety equipment for safe operation of laser systems.
- Coordinating of "baseline" and "termination" eye exams.
- Ensuring that the required Standard Operating Procedures are posted, and that proper warning equipment, signs, labels, emergency procedures, per ANSI Z 136.1 are in place.
- Providing "Basic" laser safety training seminars for workers and others that may work around, or in the vicinity of lasers.

B. Basic Trained Personnel

Basic Trained Laser Personnel have met the minimum mandatory requirements for working around lasers at LIGO Livingston Observatory. Only individuals that have received Basic Laser Training are permitted in Laser Hazard areas, i.e. the LVEA and end station VEAs. **Basic Trained personnel may not escort visitors, operate lasers or manipulate laser beams.**

- Basic Trained Laser Personnel are usually required to have an Eye Examination.
- Basic Trained Laser Personnel must have viewed and understood the two Laser Safety Videos.
- Basic Trained Laser Personnel must understand the Hazards and the Personnel Protective Equipment associated with working around the LIGO laser systems.
- Basic Laser Trained Personnel must have read and understood the LIGO Livingston Observatory Laser Safety Plan and have a copy.
- Basic Laser Trained Personnel must know the LLO Emergency Procedures.
- Basic Trained Laser Personnel must have signed of copy of the **Basic Trained Laser Personnel Registration Form** and be listed on the LLO Laser Personnel webpage at > <http://www.ligo-la.caltech.edu/laser/>.

C. Registered Laser Users

Registered Laser Personnel are persons needing to **work with lasers**.

- Registered Laser Personnel must have successfully completed the LIGO **Basic Laser Training**
- Registered Laser Safety Personnel must have read, understood and have been given a copy of the appropriate SOP governing the laser system they intend to use
- Registered Laser Personnel should assist the Laser Safety Officer in identifying any potential laser-related safety hazards.
- Registered Laser Personnel are responsible for conducting all activities in accordance with the approved **Standard Operating Procedure** and with all requirements of the **LIGO Livingston Observatory Laser Safety Plan**.
- Registered Laser Personnel are responsible for the laser safety of all personnel they escort into a Laser Control Area.(restricted access area)
- Registered Laser Personnel must be listed on the LLO Laser Personnel webpage at > <http://www.ligo-la.caltech.edu/laser/>.

D. Laser system Sponsor

Sponsors are experienced laser personnel who have a need to install a laser system.

- Sponsors should understand the LIGO Laser Safety Program, have an understanding of M990148-L, LIGO Livingston Observatory Laser Safety Plan and have completed the LIGO Livingston "Basic" Laser Safety Program.
- Sponsors prepare and obtain approval of Standard Operating Procedures (SOP) for their laser system.
- Any time one or more persons will be working on the laser system, ONE person shall be designated the "Responsible Laser Operator". This person coordinates the activities on or in the vicinity of the laser system.
- All laser systems are to have restricted access, entered only by Registered Laser

Personnel authorized by the system Sponsor or the LSO. All others must be escorted by one of the Registered Laser Personnel.

- Sponsors must supply any additional specific precautions and a copy of the SOP to each "Registered Laser Personnel" that they authorize.

D. Visitors

- If a visitor is to enter a Laser Control Area (restricted access area) governed by an SOP, they must be escorted by a **Registered Laser User ONLY**. Visitors require the proper safety eyewear when required, and their acknowledgment that laser hazards exist.

2. EYE PROTECTION

The required protective eyewear for work with lasers is a pair of **LASER SAFETY GLASSES**, which must have an optical density (OD) of greater than 5.0 for 1064 nm wavelength radiation. Particular care must be taken to ensure that the **sideshields of the laser glasses are properly fitted to your face**.

Plastic protective eyewear is designed for protection from diffuse scattered radiation, and does not provide sufficient protection to direct exposure of infrared beams.

The output beams of the LIGO 10-W laser exit the vacuum envelope into the interior IOT/ISC table enclosures at **eye level** and extreme caution must be exercised by Registered Laser Users working in the table enclosures.



These types provide protection from a direct beam



These types provide protection from a direct beam



These do not

3. ENGINEERING CONTROLS

3.1 Emergency OFF Switches

Emergency OFF switches are located as follows: one in the control room, one at the entrance to the 4k Ifo. Laser Safety Enclosure, and one near the laser warning sign at the entrance of the LVEA. Activation of any Emergency OFF switch shuts down the laser. Emergency shutdown from the End-stations require communication with the control room via telephone or radio.

3.2 Laser Safety Interlock Description

The goal of the laser interlock is to provide a system of positive access controls that positively prevents exposure to harmful laser beams. It must also accommodate our required operations without unnecessarily impeding them.

The plan is to:

- Exercise full control over Laser Hazard areas, LVEA and VEAs.
- Permit or deny entry to Laser Hazard areas with the use of access cards.
- Restrict entry to PSL, ISC tables and End Transmission Monitors only to Registered Laser Users.
- Use Activity logs to generate Time and Activity sheets.
- Monitor alarms triggered by predefined events.
- Track and record the activities of all Basic Laser Trained personnel in the Laser Hazard Areas.
- Monitor every activity, every card transaction and maintain logs with complete statistics.

This will be accomplished by using the encoded information of an access card read by a reader. Information is transmitted from the readers through the system wiring to an electronic control unit for evaluation. Access is then granted or denied after the electronic control unit has confirmed the information as valid and checked it against its authorization profile. Authorization profiles actually define the ability of the encoded card number to gain access throughout the Laser Hazard Areas based on one or more of the following criteria:

- Access level
- Door
- Time of day
- Day of week
- Time schedule
- Previous events (i.e., a table enclosure left open)
- Alarm conditions

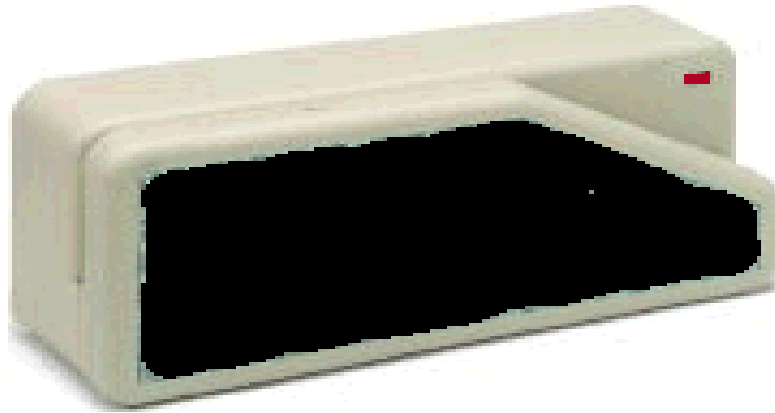
If the information has passed these checks, then access is granted by means of a signal or contact closure that allows passage through the entry way or access to a laser enclosure. If the information is not valid, the system response can be adjusted to range from denial of entry to dispatching guards.

The system provides a central point of control using the monitoring computer in the Control Room, and will monitor all card reader transactions and alarm inputs. It incorporates an Anti-Passback feature, which prevents successive use of one card to pass through any door in the same direction. Anti-Passback is the term describing the act of passing a card back to another person for the purpose of unauthorized access. To attain this type of protection, a separate reader is located at each entry and exit point. The doors which personnel pass through are those entering our three VEAs (LVEA, X and Y end-stations) as well as the PSL enclosure in the vertex. Operationally, the system will view the laser table enclosures as passage doors. The logic of the system is straightforward. To enter a VEA, an authorized person will swipe their passcard through the cardreader located on the wall adjacent to the entrance/exit door. The LED indication will change from red to green, signaling that the person may enter the VEA without triggering an alarm. Imagine now that the same person intends to work on one of the ISC tables. Before opening the table enclosure's door, he will need to swipe his passcard through the cardreader at the table. If the authorization profile is met, the system will respond with a green LED and the table enclosure contacts will be disarmed permitting the doors to be opened without generating an alarm. Here is where the Anti-Passback feature comes into play. Suppose our user completes his task, and attempts to leave the LVEA without rearming the table enclosure by swiping their passcard through the exit reader

At the LVEA exit door the system will **NOT** yield a green LED when the passcard is offered. This is a reminder that one must retrace their steps and rearm the laser table. Likewise, assume the user wants open the PSL table for a moment to change the laser power. If he has not rearmed the first enclosure, he will **NOT** receive a green LED when he attempts to open the second. Neither of these sequences will generate an alarm, unless the user ignores the lighted indication and exits the LVEA or opens a second enclosure.

The system does not prevent a second user from independently opening another table enclosure, but it will prevent a single user from opening multiple enclosures simultaneously. If an individual operator needs to open multiple laser table enclosures simultaneously, he will need to coordinate this through the Laser, or Site Safety Officer and the monitoring computer in the Control Room will be used to permit the required activities.

The cards are also known as embedded wire (Wiegand Effect) cards. They use a pulse generating phenomenon in a special alloy wire which is processed in such a way as to create two distinct magnetic regions in the same homogeneous piece of wire. When embedded into a card in distinct patterns, these wires are read as codes by the reader. Codes for these cards are unique, permanent, and unalterable.



3.2.1 Weigand Reader Usage

- Swipe card from right to left
- Access is authorized when **RED** LED changes to **GREEN**
- The **green** indication will remain for 10s, but the door may be opened anytime within the following 20 seconds.
- One exception to the 20s interval is the key safe, which disarms after 10s.
- If you change you mind and do not open the door, the system will reset after 20s and you must swipe again to enter.
- If you open the door, you must enter, allow the door to close and exit using the exit reader.
- If you swipe, open the door but do not enter, the system ‘thinks’ you did and notes you ‘inside’ the area.
- Now if you swipe and try to enter, the LED will blink alternately **GREEN** and **RED**.
- This is a warning that you are in a bad passback location.
- If you are outside the area, this must be corrected by a manual override of the computer in the Control Room.
- You can also receive a bad passback if you forgot to close a laser table before exiting a VEA.
- This you can remedy by retracing your steps and properly closing the area.

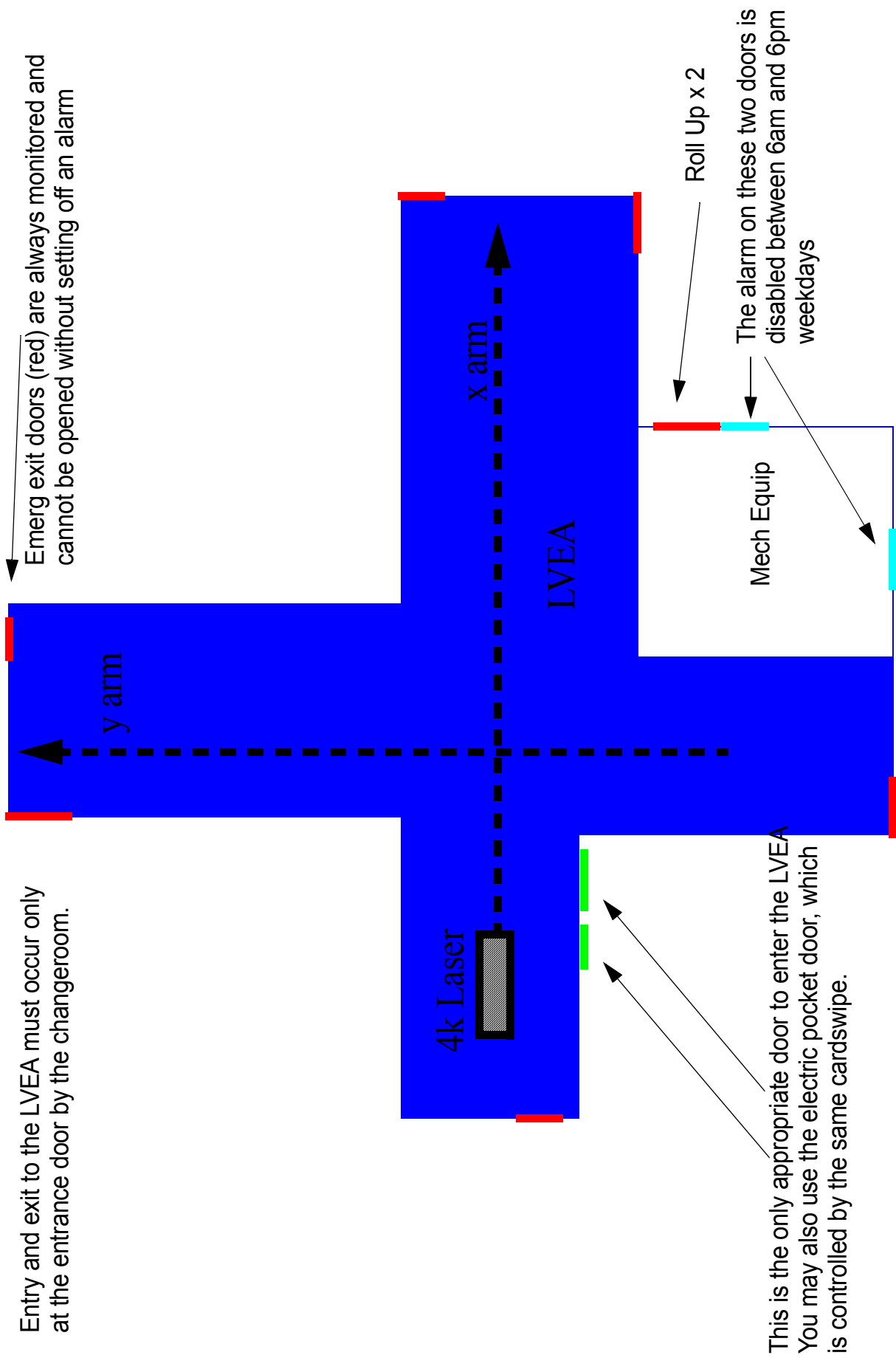
3.2.1 Access Cards

- Cards are issued individually to all staff and long term visitors
- Cards are for your individual use and are not to be loaned or borrowed.
- Emergency cards with Registered User privileges are stored in the Control Room key safe and may be used by appropriately qualified users.
- Registered Users borrowing an emergency card must make a notation in the i-log when they borrow the card, and they must return it before leaving the site.
- Individuals may have multiple cards.

3.2.2 Laser Safety Interlock Alarm Conditions

1. When one of the Emergency OFF Switches is depressed manually, Laser Safety Officer and Site Safety Officer will determine why and report to Gary Sanders. Gary must approve restarting the system
2. Alarm sounds at the Operator's control station announcing a 'forced door' event into a VEA. Operator investigates and silences the alarm.
3. Alarm is caused by a forced door event upon an IOT, ISC table or ETM cabinet. Alarm sounds and Laser Safety Interlock closes the mechanical shutter on the PSL table preventing laser from entering vacuum system. Mode Cleaner and IFO are lost. Laser remains on table, in PMC and Ref Cavity. If the Operator determines the cause is the inadvertent opening of an ISC table door before a user swipes their card, the Operator will make an i-log entry describing the circumstances and restart the system. Table will be scanned for errant beams and if any are found system will be shutdown and reported to Gary Sanders by Laser Safety Officer and Site Safety Officer. Gary authorizes restart.
4. Alarm is caused by a forced door event on the PSL table. Alarm sounds and Laser Safety Interlock closes the mechanical shutter in the laser, preventing laser from exiting the PSL housing. PMC, Ref Cavity, Mode Cleaner and IFO are lost. If the Operator determines the cause is the inadvertent opening of the PSL table door before a user swipes their card, the Operator will make an i-log entry describing the circumstances and restart the system. Table will be scanned for errant beams and if any are found system will be shutdown and reported to Gary Sanders by Laser Safety Officer and Site Safety Officer. Gary authorizes restart.
5. Any errant beam triggers a shutdown and immediate report to Gary Sanders. Only Gary authorizes a restart.

3.2.3 WEIGAND READER LOCATIONS



LVEA

