Standard Operating Procedure
LIGO 10-W Laser for the 4k Interferometer
Operating in the LVEA (with Laser Area Enclosure)

SPONSOR
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1 PURPOSE AND SCOPE

This Document is the Standard Operating Procedure (SOP) for the LIGO 10-Watt Laser for the 4k Interferometer (4k Ifo.) when it is operating in the Laser and Vacuum Equipment Area (LVEA). It is designed to ensure the safety of all personnel and equipment in and around the area where the 4k Ifo. LIGO 10-W Laser is operating in the LVEA. Its role within the overall laser safety plan is described in LIGO-M990148, LIGO Livingston Laser Safety Plan.

This SOP contains the essential procedures required for the safe operation of the 4k Ifo. LIGO 10-W Laser in the LVEA and must be approved by both the LIGO Livingston Observatory (LLO) Laser Safety Officer and the LLO Site Safety Officer.

2 LVEA LAYOUT

There will be a single LIGO 10-W Laser in the LVEA, for the four-kilometer-long (4k) interferometer. It will be located in the LVEA as shown schematically in Figure 1. It is labeled 4k Laser. This SOP addresses the operation of the 4k Ifo. LIGO 10-W Laser in the LVEA.
The dashed lines denote the locations of the vacuum equipment in the LVEA. The laser, the ancillary optical components that comprise the Pre-stabilized Laser (PSL) and some of the Input Optics detector subsystem (IOO) components are mounted on a large (16 ft. x 5 ft. x 2 ft.) optical table. The optical table is surrounded by the IOO/PSL Optical Table Enclosures. The IOO/PSL Optical Table Enclosure for the 4k Ifo. is surrounded by the Laser Area Enclosure as shown sche-
matically in Figure 2. The Laser Area Enclosure blocks laser beams that might inadvertently exit from the I00/PSL Laser Table Enclosure when the doors are open for servicing the equipment inside the enclosure. The Laser Area Enclosure enables operating the 4k Ifo. LIGO 10-W Laser inside the LVEA in the Laser Safe Condition (see Section 5, below), with the laser beams confined within the Laser Area Enclosure.

3 LASER DESCRIPTION

The LIGO 10-W Laser is Class IV Nd3+:YAG laser. It is a model 126 MOPA laser system manufactured by Lightwave Electronics Corp. The output from this laser is in the near-infrared region of the electromagnetic spectrum and is therefore not visible to the human eye. This laser emits radiation from two apertures: the main output beam and a sample beam. The relevant operating parameters for the LIGO 10-Watt Laser are:

MAIN BEAM

- 1064 nm wavelength
- 12 W max. power output
- continuous wave output
- 6.1 kW/cm² intensity at output aperture

SAMPLE BEAM

- 1064 nm wavelength
- 70 mW max. power output
- continuous wave output
• 36 W/cm² intensity at output aperture

4 HAZARDS

A Class IV laser is a hazard to the eye or skin from the direct beam, maybe a hazard from a diffuse reflection, and may also be a fire hazard. Infrared lasers such as the LIGO 10-W Laser pose an additional hazard because the output radiation is not visible to the unaided human eye.

There are two potentially dangerous output beams from the LIGO 10-W Laser as described in Section 3, above.

After conditioning by the PSL optics, the beam propagates through the IOO optical components mounted on the IOO/PSL Optical Table, then exits through an aperture in the IOO/PSL Optical Table Enclosure. The beam then propagates through a window in the HAM chambers adjacent to the IOO/PSL Optical Table (HAM7) to the IOO optical components mounted inside the vacuum envelope. After conditioning by the IOO in-vacuum optical components, the laser radiation propagates through the Core Optics (COC) optical components, and therefore throughout the entire vacuum enclosure, including the vacuum equipment located in the Mid- and End-stations. For interferometer sensing and control, laser radiation exits the vacuum envelope through various windows in the vacuum chambers.

5 CONTROLS

For the purpose of laser safety, two conditions have been defined for the LVEA and VEAs: LASER HAZARD and LASER SAFE.

The LASER HAZARD condition shall exist any time the 4k Ifo. LIGO 10-W Laser is capable of operating and emitting a beam of laser light outside the Laser Area Enclosure in the LVEA.

The LASER SAFE condition shall exist only when a) the 4k Ifo. LIGO 10-W Laser power supply has been locked and tagged out in accordance with Lockout/Tagout Procedure (LIGO-M970144-A-M) and is therefore incapable of being energized or b) the 4k Ifo. IOO/PSL Optical Table Enclosure Output Aperture is closed and locked and tagged out and the Laser Area Enclosure laser warning sign (see Section 5.3., below) has been energized.

Individual VEAs may be in the LASER SAFE condition when the LVEA is in the LASER HAZARD condition only if a 48 inch diameter gate valve in the beam line between the VEA and the LVEA is in the closed position and locked and tagged out.

5.1. Status Controls

The procedure for transitioning to the LASER HAZARD condition is in Procedure for Transition to the LASER HAZARD Condition (LIGO-M990152-00-W). The procedure for transitioning to the LASER SAFE condition is in Procedure for Transition to the LASER SAFE Condition (LIGO-M990153-00-W).
The keyswitches that control the illumination of the laser warning signs are located on the housings of the warning signs. They are switched to the LASER HAZARD position when transitioning to the LASER HAZARD condition.

The power supply for the laser is locked and tagged out in the “off” position or the 4k Ifo. IOO/PSL Optics Table Enclosure Output Aperture Shutter is locked and tagged out in the “closed” position when transitioning to the LASER SAFE condition. This is described in more detail in the procedures referenced above.

5.2. 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.

5.3. Access Controls

The designated Nominal Hazard Zone (NHZ) includes all of the LVEA and the VEAs at both End-stations, the Cleaning Areas in the OSB and End-stations, and the Vacuum Support Equipment areas of the End-stations.

Laser safety warning signs with the message, “DANGER VISIBLE AND/OR INVISIBLE LASER RADIATION - AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION. EYE PROTECTION REQUIRED” are mounted on the Change Area side of the doors leading from the Change Area to the LVEA and near the doors leading into the Change Areas of the End-stations.

A laser warning sign is mounted at the entrance to the Laser Area Enclosure and is energized when the LASER SAFE condition exists and the 4k Ifo. LIGO 10-W Laser is operating within the Laser Area Enclosure.

All other outside access doors to the LVEA and VEAs and the doors accessing the LVEA from the Large Item Access Area (including the roll-up door) are for emergency egress only and are equipped with signs bearing the message “DANGER VISIBLE AND/OR INVISIBLE LASER RADIATION - AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION.”

Additional signs are mounted near the laser safety warning signs with the message “LASER HAZARD - AUTHORIZED LASER PERSONNEL ONLY EXCEPT WHEN GREEN LIGHT ILLUMINATED.”

Access to the LVEA and VEAs is strictly controlled when the LASER HAZARD condition exists. Only Registered Laser Personnel are authorized to enter the LVEA or VEAs without an escort. The names of all Registered Laser Personnel are posted near the illuminated warning signs at the entrance of the LVEA, and at the entrance to the LASER AREA ENCLOSURE. Names can be added to the list only by the sponsor of this SOP or by the LLO Laser Safety Officer and only after training which satisfies the requirements detailed in LIGOM990148, LIGO Livingston Laser Safety Plan.
5.4. Electrical Controls

All control and monitoring functions for the LIGO 10-Watt Laser are accessed via the laser power supply (labeled 126 MOP A) located in the rack next to the optics table. Most Control and monitoring functions can be remotely activated via the PSL CDS interface.

5.5. Beam Controls

A rocker switch on the front panel of the laser power supply activates a solenoid which opens and closes a shutter inside the laser head. These functions can be remotely controlled via the PSL CDS interface. From the standpoint of laser safety, the laser is considered to be activated even when the shutter is closed and/or the laser is in the standby mode.

5.6. Eye Protection

Required protective eyewear for the LIGO 10-W Laser must have an optical density (OD) of greater than 5.0 for 1064 nm wavelength radiation.

6. OPERATING PROCEDURES

1. The procedure described in Procedure for Transition to the LASER HAZARD Condition (LIGO-M990152) must have been executed before the 4k Ifo. LIGO 10-W Laser is operated in the LVEA unless the the 4k Ifo. IOO/PSL Optical Table Enclosure Output Aperture is closed and locked and tagged out and the Laser Area Enclosure laser warning sign has been energized. In this case, the LASER SAFE condition must have been established by execution of the procedure detailed in Procedure for Transition to the LASER SAFE Condition (LIGO-M990153).

2. When the LIGO 10-W Laser is operating within the Laser Area Enclosure, the Laser Area Enclosure laser warning sign must be energized and all persons entering the Laser Area Enclosure are required to wear eye protection as described in Section 5.6., above, before entering and at all times while working within the Laser Area Enclosure(NHZ).

3. Before entering the Laser Area Enclosure, each person must announce his or her intent to enter and await a reply from anyone already within the enclosure.

4. When the LASER HAZARD condition exist, all persons entering the LVEA or VEA(NHZ) are required to wear eye protection, as described in Section 5.6., above, before entering and at all times while working within the NHZ.

5. Any time one or more people will be working within the Laser Area Enclosure or the laser will be running unattended, ONE person shall be designated the “Responsible Laser Operator.” The name of the Responsible Laser Operator shall be posted near the Laser Area Enclosure laser warning sign.

6. The Responsible Laser Operator shall coordinate activities on or in the vicinity of the laser optical table. Multiple independent activities involving manipulation of the laser beams shall not occur simultaneously. Any time the laser beams will be manipulated, e.g. by inserting, removing, or adjusting optical components, persons not directly participating in the beam manipulation activity will move to a safe location until the activity is completed.

7. Before and during insertion or removal of any optical component, the power of all affected
laser beams shall be reduced to less than 100 mW.

8. All persons manipulating the laser beams, e.g., by placing objects such as mirrors, lenses, power meters, or beam dumps, into or near the laser beam paths, must remove all jewelry such as wrist watches and rings.

9. Immediately after inserting, removing, or making significant adjustments to any optical component, the vicinity of the optical table shall be scanned an infrared viewer or other suitable beam-finding device to ensure that all stray beams are dumped.

10. Scattering of laser light shall be kept to a minimum at all times by maintaining proper alignment of optics, utilization of beam dumps, and ensuring that optics are securely fastened.

11. Each time the laser will be left running unattended, the vicinity of the optical table shall be scanned for stray beams immediately prior to vacating the Laser Area Enclosure. The “unattended” status of the laser shall be posted near the name of the Responsible Laser Operator at the entrance to the Laser Area Enclosure.

It is the responsibility of each person working within the LVEA and VEAs (NHZ) to ensure that LIGO standards for safe laser operation are being followed at all times