



LIGO Laboratory / LIGO Scientific Collaboration

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PSL Laser Area Enclosure Cleanrooms
Specifications, Requirements, and Design Considerations

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LIGO Scientific Collaboration

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1 Introduction

Three Laser Area Enclosures (LAE) will be constructed inside the high-bay, Class 50,000, Laser and Vacuum Equipment Areas (LVEA), two at the LIGO Hanford Observatory (LHO) in Richland, WA and one at the LIGO Livingston Observatory (LLO) in Livingston, LA. Each LAE will have two principal components – the Laser Room composed of the Acoustic Shell and the Laser Cleanroom and the Ante-room with an Air Shower for personnel access. The sizes and configuration of the components are shown in the architectural drawings for the LAEs. Note that the layouts of the H1 and L1 LAEs are identical, but the H2 LAE layout is different because of space constraints in the LVEA.

Construction of each LAE will be divided into two main phases each the subject of separate contracts. They are the Laser Room Acoustic Shell and the Laser Area Enclosure Cleanrooms. The Laser Room Acoustic Shell is a gypsum-board-based structure that serves primarily to attenuate acoustic noise. The Acoustic Shell includes HVAC for the Laser Room and the Make-up air supply system that provides air ducted from a remotely-located fan unit. The Laser Area Enclosure Cleanrooms consist of a Class 1000 cleanroom constructed inside the Laser Room Acoustic Shell and a Class 1000 Ante-room with an Air Shower at the entrance to the Ante-room. The Cleanroom vendor will also supply the doors that separate the Laser Room from the Ante-room.

Note that during all construction phases the Laser Table with dimensions of 59” x 16’ x 24” and positioned with a surface height of 40” above the floor will be located inside the Laser Room as shown in LIGO-D1000735-v3. The table location will be fixed and the table will be covered to protect it from contamination during construction. Welded, sheet vinyl flooring will be installed over the whole footprint of the LAEs prior to construction of either the Acoustic Shell or the Cleanrooms. It will have to be protected from damage and contamination by the contractors during construction of both the Acoustic Shell and the Cleanrooms.

1.1 Scope of Acoustic Shell phase

During the Acoustic Shell phase, a gypsum-board-based, double-wall structure, will be constructed. This structure, along with the double-doors that are part of the Cleanrooms phase, will provide the acoustic attenuation required inside the Laser Room. It will also provide the HVAC for the Laser Room and the Make-up air supply for the Laser Room. **Construction of the Acoustic Shell which includes the HVAC and Make-up air system is not part of this contract.**

1.2 Scope of Cleanrooms phase

1.2.1 Laser Room cleanroom

During the Cleanrooms phase, a Class 1000 cleanroom will be constructed inside the LAE Acoustic Shell. We envision that this will involve installation of a drop ceiling that supports Fan Filter Units and LED lighting and construction of cleanroom walls separated by about 8 inches from the walls of the LAE Acoustic Shell as shown schematically in the architectural drawings. The interstitial space serves as a return air plenum. We also envision that all walls will be “skinned” with cleanroom compatible surfaces. The double doors, chosen to provide superior acoustic attenuation, will be provided by the Cleanrooms contractor. The Make-up air duct

provided by the Acoustic Shell contractor will be ported to a HEPA filter unit mounted in the drop ceiling. The HEPA filter unit and connection to and control of the remotely-located fan unit is part of this Cleanrooms contract.

1.2.2 Ante-room cleanroom with AirShower

The Ante-room, also a Class 1000 cleanroom, will be provided by the Cleanrooms contractor. We envision that this cleanroom will be free-standing other than its attachment along one wall to the Laser Room. We envision that it will draw air from the temperature-controlled LVEA high-bay space and exhaust back into that space. Except for the slight increase in air temperature across the HEPA FFUs, we expect that the temperature in this room will follow that of the LVEA. Make-up air from the Laser Room will exhaust into the Ante-room via a damper in the common wall. This damper and its control are within the scope of the Cleanrooms contract. An Air Shower will be provided for personnel access to the LAE from the LVEA.

2 Range of air flows

We expect that the LAEs will operate over a wide range of air flows, from the full flow required to maintain Class 1000 conditions when work inside the LAE is ongoing to the no-flow condition when the room is unoccupied and all the Fan Filter Units (FFU) have been shut down to minimize acoustic noise and vibrations when we are searching for gravitational waves. In the no-flow condition, a small amount of Make-up air may still flow in order to maintain overpressure and some degree of thermal control.

Based on our past experience, we expect that, for a properly constructed facility, particulate counts will remain below detectable levels in the Laser Room even after the HEPA FFUs have been shut down, and only make-up air enters the Laser Room. Minimizing particulate contamination inside the Laser Room is the highest priority for the Cleanrooms phase.

3 Features

- 1) Laser Room Cleanroom interior dimensions: 23 ft x 15 ft with minimum ceiling height of 9 ft for H1 and L1 and 24 ft x 15 ft x 9 ft for H2.
- 2) Ante-room Cleanroom interior dimensions: 11 ft. 6 in. x 18 ft. 4 in. with minimum ceiling height of 9 ft.

High-velocity, filtered and re-circulated air shower with minimum interior dimensions of approximately 3 ft. x 4 ft.

- 3) Cleanroom-grade double door access to Ante-room with two 3 ft. wide leaves. Viewed from inside the Ante-room, the left leaf is normally active and the right leaf is normally inactive. The doors swing out from the Ante-room to the LVEA
- 4) Cleanroom-grade and acoustically superior double door access between Ante-room and Laser Room with two 3 ft. wide leaves. Viewed from inside the Laser Room, the right leaf is normally active and the left leaf normally inactive. The doors open into the Ante-room.
- 5) Windows in each of the leaves of the double doors between the Ante-room and the Laser Room.

- 6) Lever-style door handles for each leaf of the double doors (four total per LAE). Locksets for double doors between Ante-room and LVEA – key entry from LVEA side.
- 7) 1000 lux LED lighting in both the Laser Room and Ante-room with capability to vary light levels either by dimmers or multiple switchable circuits or both. Lights wired to junction box located on the roof or one of the walls of the LAE. AC power connection to be provided by LIGO.
- 8) Switches for Laser Room lights on both sides of the plan-west wall of the Laser Room, just to the left of the double doors when viewed from the Laser Room side, i.e. the Laser Room lights can be controlled from the Ante-room or the Laser Room. Rocker-style light switches or dimmers in all locations.
- 9) Through-wall cable and hose ducts, consisting of short sections of 4 inch diameter PVC pipes passing through oversize circular openings in the Acoustic Shell and Cleanroom walls and caulked in place, are located as shown in the architectural drawings. The pipes extend approx. 1” inch beyond both the inner and outer surfaces of the walls. Openings through the Acoustic Shell will be provided by the Acoustic Shell supplier, the PVC pipes and their installation will be the responsibility of the Cleanrooms supplier.
- 10) 120V duplex electrical outlets (general purpose spec. grade 20A) located approx. 18 inches above floor level and at approx. 6 foot intervals along the interior Laser Room walls and all walls of the Ante-room except the wall that contains the Air Shower access.
- 11) Variable-flow HEPA fan units capable of control from both the Ante-room and a remote location (the observatory control room). Control room control to be installed by LIGO. Air flow to be adjustable in step-wise or continuous fashion from no-flow to full-flow levels.
- 12) All electrical equipment to be UL-rated.

4 Performance

1. Class 1000 (Fed Std 209e or ISO Class 6, ISO Std 14644-1) working conditions in both Laser Room and Ante-room when in Service Mode. Maintaining low particulate levels is most critical inside the Laser Room. This might dictate that it maintain overpressure with respect to the Ante-room.

5 Design considerations

1. It may be desirable to concentrate the flow of HEPA filtered air over the laser table in the Laser Room. Maintaining cleanliness of the optical components on and above the table surface is the principal goal of the LAE. The surface of the 5 ft. x 16 ft. x 2 ft. thick optical table will be 40 inches above the floor of the Laser Room.
2. Pre-fabrication of as much of the Cleanrooms as possible may be desirable for control of particulate contamination during construction inside the LVEA and to minimize construction time inside the LVEA. The LVEA can be accessed via a roll-up door approximately 15 ft. wide and 25 ft. high. Overhead bridge cranes with 5 ton capacities and hook heights of 26 ft. service the LVEA and could be used to transport pre-fabricated sections.

3. To maintain cleanliness, significant construction activities carried out inside the LVEA, will likely require installation of temporary barriers of plastic sheeting and working with vacuum cleaners with exhausts ducted to the outside or clean room vacuum cleaners.
4. It is preferable that HEPA fan units operate on 277 V mains power.

6 Interfaces with Acoustic Shell phase

The Cleanrooms supplier shall provide the following information:

1. exact finished dimensions for the opening for the double doors that separate the Laser Room from the Ante-room.
2. locations and dimensions for the vent/damper(s) in the wall that separates the Laser Room from the Ante-room.