LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Output Mode Cleaner Suspension Assembly and Installation Hazard Analysis

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Distribution of this document:
Advanced LIGO Project

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CHANGE LOG

Date, version, author	Summary of Changes
19 Feb 2009, v1 Michael Meyer	Initial release.
23 Jan 2013, v2 Jeff Lewis	Added Change Log Revised Related Documents Deleted hazard "Strain from lifting…" due to the use of the HAM Installation Arm. Added hazard "Working with wires…" Revised Hazard Analysis Severity Table
31 Jan 2013, v3 Jeff Lewis	Revised Approval Signature page Added second paragraph to Section 5.3 Exposure to High Vacuum
1 Feb 2013, v4 Jeff Lewis	Section 2. "…only a directorate review is necessary." deleted because the mitigated risk level of item #3 reduced from 1E to 3E. Section 4. Revised Related Documents to current references. Sections 5.1.1 and 5.3 Deleted version references from document numbers. Section 6 line 1. Unmitigated risk index changed from 2C to 3C, changed mitigated probability level from "improbable" to "occasional". Section 6 line 3. Mitigated probably level changed from 1E to 3E. Section 6 line 4. Mitigated severity level changed from "minor" to 'marginal", changed mitigated probability level from 4E to 3E.

1 Scope

This document covers safety concerns related to the assembly and installation of the Output Mode Cleaner (OMC) suspension into the HAM6 chamber for Advanced LIGO. It must be read before beginning the installation of the OMC.

2 Summary of Hazards for OMC Suspension Assembly and Installation

The major hazards to be aware of in the assembly and installation of the OMC suspension include:

1. Working with wires, including under tension. (4C)
2. Sudden release of tensioned springs (4D)
3. Exposure to high vacuum (3E)
4. Movement of HAM-ISI assembly during installation (4E)

Each hazard is described in detail in section 5.

3 Overview of Output Mode Cleaner

The OMC suspension consists of a fused silica optical bench suspended from an aluminum frame. The total weight of the assembly is ~98 lbs with the optical bench accounting for 15 lbs. During the initial assembly of the OMC suspension, the optical bench is replaced with a metal dummy mass to prevent damage to the silica bench. Once the suspension has been assembled and checked, the metal bench is removed and the silica bench is installed. The complete assembly is then moved from its assembly table and installed on the HAM-ISI table inside the HAM6 chamber. The HAM Installation Arm will be used to place the OMC suspension into the HAM6 chamber. A separate Hazard Analysis for the HAM Installation Arm is found at E1000252.

During the assembly and installation of the OMC, it is important that a task leader be assigned to supervise all activities. The task leader needs to be someone experienced with suspensions and their accompanying hardware (OSEMs, blade springs, etc). It is also important that someone with a working knowledge of the OMC optical bench and its attached optics and hardware be involved to supervise any activities related to the bench. The task leader could fill this role as well if they possess the required knowledge.

This assembly and installation requires overall common sense and good lab practices. Personnel must have good working knowledge of how to safely use the tools associated with the build. This work also involves working in the same area as the vacuum system and lasers. All personnel must have appropriate safety training to work at a LIGO facility.

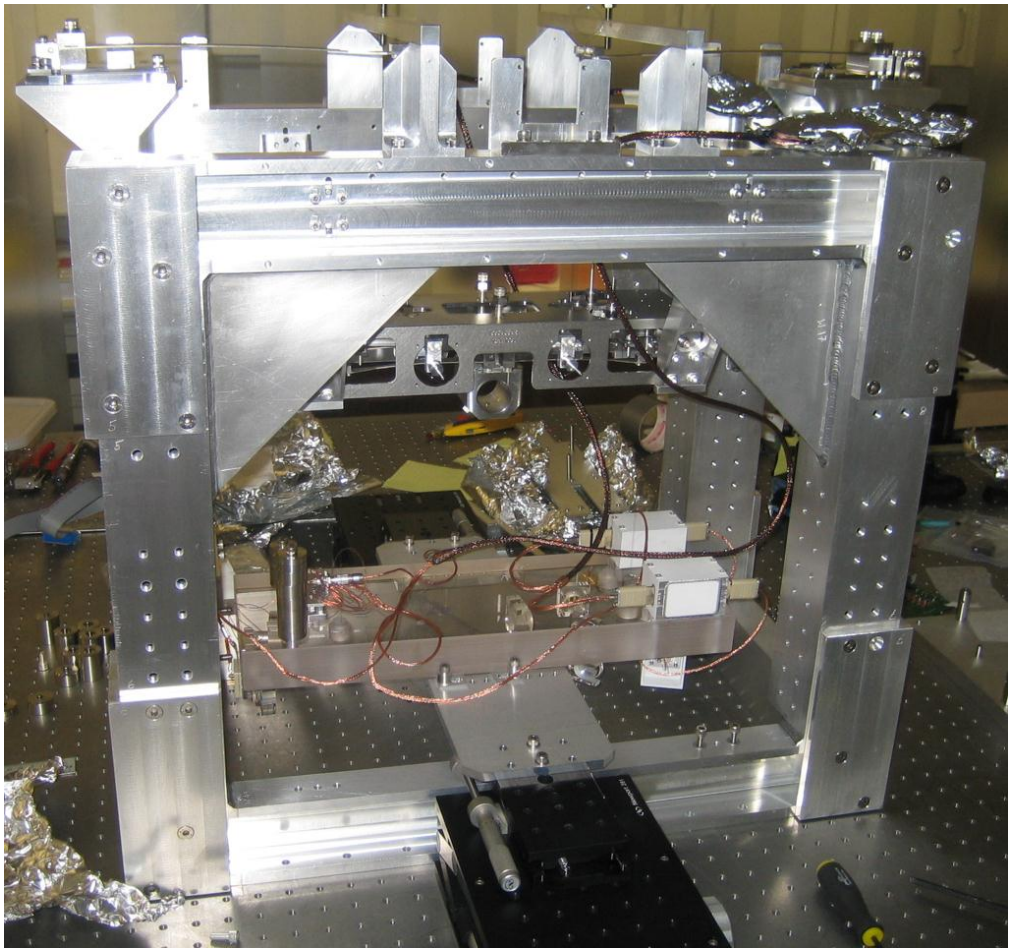

Figure 1. Output Mode Cleaner Assembly

4 Related Documents

Output Mode Cleaner Installation Procedures (LIGO-E070271)

Advanced LIGO Safety: Processes and Guidelines (LIGO-M070360)

LIGO Project System Safety Plan (LIGO-M950046)

LIGO Contamination Control Plan (LIGO-E0900047)

LIGO Vacuum Compatibility, Cleaning Methods, and Qualification Procedures (LIGO-E960022)

Advanced LIGO Chamber Entry / Cleaning / Exit Checklist (LIGO-E1201035)

LIGO Hanford Observatory Laser Safety Plan (LIGO-M020131)

LLO Laser Safety Plan (LIGO-M1000228)

BSC Installation Repair Arm and HAM Installation arm Hazard Analysis (E1000252)

5 Hazard Analysis

5.1 Working with wires, including under tension

The wire used in all of our suspensions is made of spring steel which has stored energy such that it can curl back on itself. It therefore needs careful handling to avoid injury to personnel. In particular, safety glasses must be worn at all times when working with this wire.

5.1.1 Wire Sub-Assembly Hazard

Wire segments are cut to desired length, cleaned and then assembled into clamp-wire-clamp assemblies before they are attached to the full OMC assembly. For cutting lengths and cleaning, the detailed procedure given in T1000674, to be included in the assembly documentation, should be followed. This procedure minimizes the chance of a wire end puncturing skin. The key safety points are wearing safety glasses, wearing glove liners as a protective layer, and following a process for cleaning the wire while it is coiled rather than stretching it taut.

The wire segments (called clamp-wire-clamp assemblies) are assembled before they are attached to the full OMC assembly. The wire assembly process requires that they are built under tension in a wire jig assembly. This process provides the possibility that wires could break and spring out of the wire fixture. In addition wire ends might be pointing up during the creation of the wire assemblies. We reiterate that safety glasses must be worn throughout the assembly process.

5.1.2 Wire Hazard in full OMC assembly

The fully assembled OMC will have several sets of wires under tension. Safety glasses must be worn at all times when the wires are under tension to prevent injury in the unlikely event that a wire breaks or a wire clamp slips, resulting in the release of a fast moving wire end or shrapnel.

If a laser hazard is present, laser safety glasses may be worn in lieu of regular safety glasses for the purpose of shielding the eyes from wire ends.

5.2 Sudden release of tensioned springs

The OMC utilizes several blade springs which are placed under tension during its assembly. The two top springs are each loaded with approximately 11 lbs by the suspended components. In the event that the tension in the springs should suddenly be released, the blade guards on top of the OMC structure, shown in Figure 3, will prevent the springs from traveling upward. The four lower springs have less tension, approximately 4 lbs each, and are similarly guarded from springing upward if a wire breaks. Safety glasses must be worn at all times when the springs are under tension to prevent injury in the unlikely event that a wire breaks or a wire clamp slips, resulting in the release of a fast moving wire end or shrapnel. Laser safety glasses may be worn in lieu of regular safety glasses when a laser hazard is present.

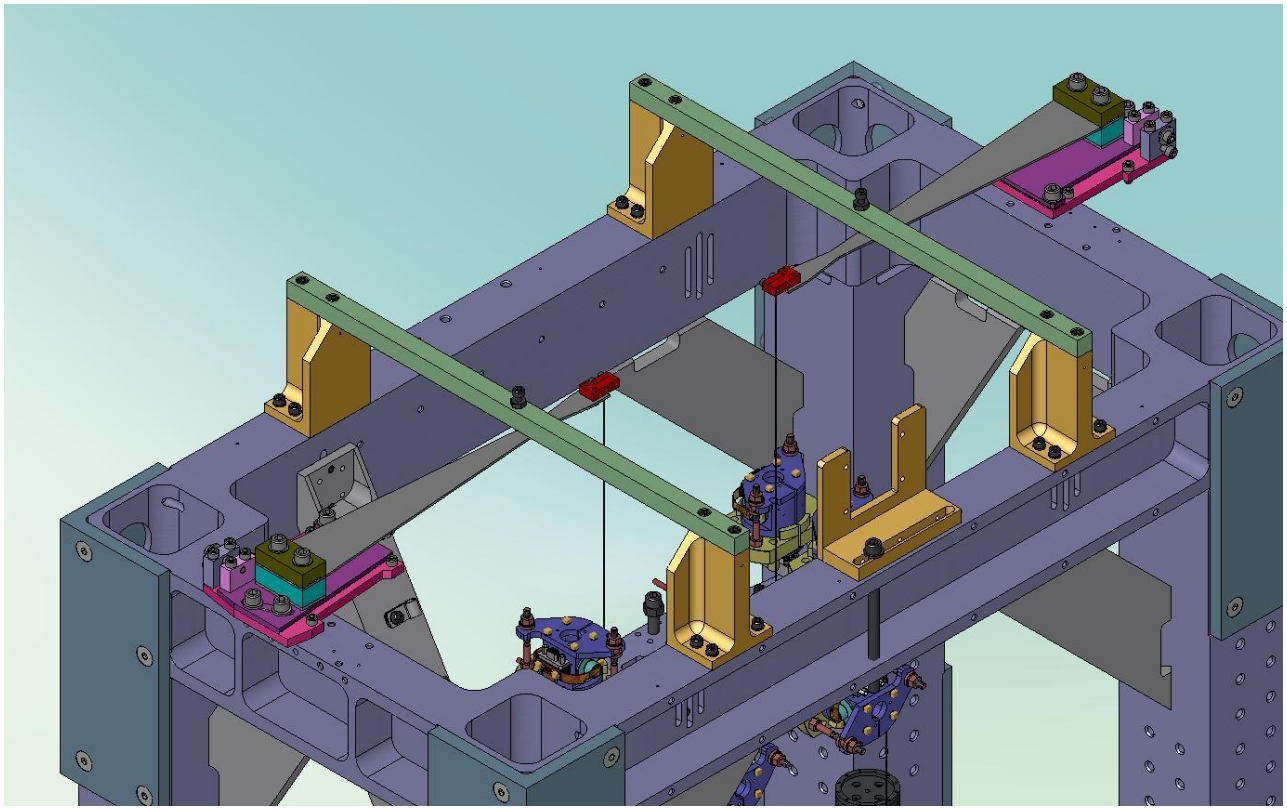

Figure 2. Blade guards over tensioned springs

5.3 Exposure to high vacuum

The installation of the OMC will take place in relatively close proximity to the septum plate viewport in the HAM6 chamber. Since the opposite side of the septum plate may be under vacuum, extreme care must be taken to avoid contacting or damaging the viewport during the installation. Care must also be taken to avoid damaging the coating on the viewport, which might impair its function. A viewport cover (LIGO-D080103) must be in place before starting the installation. All vacuum safety procedures must be followed and all personnel must use extreme care when working to prevent damage to the vacuum equipment.

Specifically, prior to entering HAM6 and installing the viewport covers on the septum plate between HAM5 and HAM6, the neighboring volume (ie HAM5) shall either be at one atm pressure OR GV1 and GV2 shall be closed so as to limit damage to the vacuum system in case of a catastrophic failure of the viewport. Alternately, the two gate valves isolating the beam tube from the vertex shall be soft or hard closed. In LLO these are designated GV3 and GV5. In LHO these are designated GV5 and GV7. This closure should be confirmed by a member of the vacuum group. Once the OMC is set in place gate valves can be reopened provided the viewport covers are in place when work is being performed in the HAM6 chamber.

5.4 Movement of HAM ISI table

The OMC assembly will be mounted to the HAM ISI optical table. Before the OMC is moved onto the table, personnel need to verify that the HAM ISI has been properly locked down and is not

capable of moving. This will prevent any injury to personnel or damage to equipment due to unexpected movement while installing the OMC on the table.

6 Output Mode Cleaner Hazard Analysis Severity Table

ITEM #	Hazard	Cause	Effect	Unmitigated Severity	Unmitigated Probability Level	Unmitigated Risk Index	Comment	Mitigation	Mitigation Severity	Mitigated Probability Level	Mitigated Risk Index
1	Working with wires, including under tension	catastrophic failure of wire, wire releasing from wire clamps, wire end pointing outwards	injury to personnel	marginal	occasional	3C		Wear safety glasses. Follow detailed procedures. When cleaning use glove liners and do not hold wire taut.	minor	occaisonal	4C
2	Sudden release of tensioned springs	catastrophic failure of wire, wire releasing from wire clamps	injury to personnel, damage to equipment	critical	remote	2D	top springs are loaded with 11 lbs of tension each, lower springs with 4 lbs each	Guards installeld above springs limit their movement when not under tension; safety glasses will prevent eye injury in the case of a fast moving wire end or shrapnel.	minor	remote	4D
3	Exposure to high vacuum	Damage to septum viewport	severe injury/death to personnel, damage to equipment	catastrophic	remote	1D		Install viewport cover, personnel must use extreme care when working around viewport	catastrophic	improbable	3E
4	Movement of HAM ISI assembly	HAM ISI assembly not locked down	injury to personnel, damage to equipment	marginal	occasional	3C		Verify that ISI assembly is properly locked down prior to starting installation	marginal	improbable	3E

Hazard Severity	Category	Definition
Catastrophic	1	Death or permanent total disability, system loss, major property damage or severe environmental damage.
Critical	2	Severe injury, severe occupational illness, major system or environmental damage.
Marginal	3	Minor injury, lost workday accident, minor occupational illness, or minor system or environmental dam
Minor or Negligible	4	Less than minor injury, first aid or minor supportive medical treatment type of occupational illness, or less than minor system or environmental damage.

Probability	Level	Individual Item
Frequent	A	Likely to occur frequently or continuously experienced.
Probable	B	Will occur several times in the life of an item.
Occasional	C	Likely to occur some time in the life of an item.
Remote	D	Unlikely but possible to occur in the life of an item.
Improbable	E	So unlikely, it can be assumed occurrence may not be experienced.

	PROBABILITY				
SEVERITY OF CONSEQUENCE	E Improbable	D Remote	C Occasional	B Probable	A Frequent
1 Catastrophic					
2 Critical					
3 Marginal					
4 Negligible					

Hazard Risk Index	Risk Code Criteria
1A, 1B, 1C, 2A, 2B, 3A	**Unacceptable**
1D, 2C, 2D, 3B, 3C	**Undesirable (Directorate decision required)**
1E, 2E, 3D, 3E, 4A, 4B	**Acceptable with review by Directorate**
4C, 4D, 4E	**Acceptable without review**