LIGO Laboratory / LIGO Scientific Collaboration

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OFI Assembly & Installation Hazard Analysis

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Table of Contents

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CHANGE LOG

Date, version	Summary of Changes
2012-09-25	• Added Change Log • Changed title • Incorporated changes from Final Design Review committee • Added hazard: Damage to TGG crystal

Abstract

This document covers safety concerns related to the assembly and installation of the Output Faraday Isolator (OFI) assembly into the HAM5 chamber for Advanced LIGO. It must be read before beginning the assembly and installation of the OFI, and used in conjunction with the SLC and Viewports Installation plan Document, document number LIGO-E1000099-v1.

1 Scope

This document covers safety concerns related to the assembly and installation of the Output Faraday Isolator (OFI) assembly into the HAM5 chamber for Advanced LIGO. It must be read before beginning the assembly and installation of the OFI, and used in conjunction with the SLC and Viewports Installation plan Document, document number LIGO-E1000099-v1.

2 Summary of Hazards for Output Faraday Isolator (OFI) Assembly and Installation

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

1) Moving a heavy, delicate and valuable assembly with various types of lifting and moving equipment, with potential for shock/impact if dropped or bumped, leading to the following potential failures/hazards:

a) personnel injury (crushing, pinching)
b) damage to equipment (impact), such as:
c) failure/stretching of wires
d) mis-alignment of suspension elements
e) mis-alignment of optical elements

2) Strain from lifting the assembly
3) Sudden release of tensioned springs
4) Laser hazard
5) Damage to TGG crystal

Each hazard is described in detail later in the document.

3 Overview of OFI

A Solid Works model of the Faraday Isolator suspension is shown in Figure **1**. The optical components on an optical table are isolated by a two-wire pendulum and by vertical blade springs. The suspended table is damped by an eddy current damping plate that mounts to the frame below the Faraday Isolator optical table. The total weight of the assembly is approximately 55 lbs.

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.

This procedure requires one person outside the HAM, one person inside, and one person to operate a lifting mechanism. The access door is removed from the HAM chamber side closest to the SR3 mirror. The Output Faraday Isolator is inserted through the chamber door using the HAM Installation Arm. The Output Faraday Isolator is mounted to the HAM optical table and aligned with the signal recycling cavity optical centerline.

During the assembly and installation of the OFI, a task leader should be assigned to supervise all activities. The task leader needs to be experienced with suspensions and their accompanying

hardware, and have a working knowledge of the OFI optical bench and its attached optics and hardware.

Once the installation is complete, the alignment of the OFI will be performed. Final optical alignment of the OFI requires that the PSL laser be flashed through the SRM. The OFI input and output apertures will be aligned with the IFO output beam by moving the suspension frame of the OFI and by adjusting the lengths of the suspension wires.

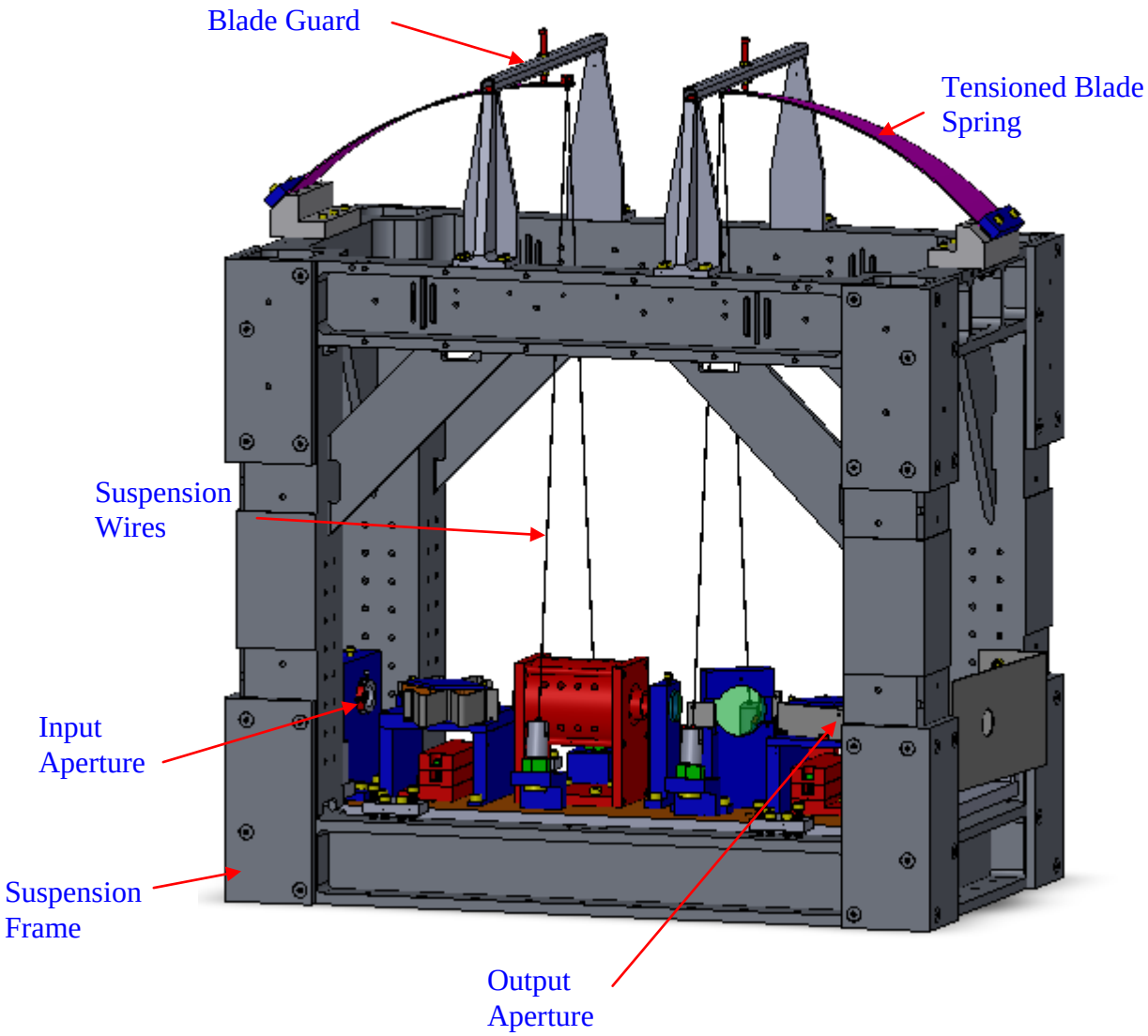

Figure 1: Suspended Output Faraday Isolator Assembly

4 Related Documents

SLC and Viewports Installation Plan (LIGO- LIGO-E1000099-v1)

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

LIGO Project System Safety Plan (LIGO-M950046)

LIGO Hanford Observatory Contamination Control Plan (LIGO-M990034)

Chamber Entry/Exit Checklist (LIGO-E000065)

LIGO Hanford Observatory Laser Safety Plan (LIGO-M020131)

LIGO Safety Procedure documents: https://safety.ligo.caltech.edu/

HAM Installation Arm User Guide (LIGO-E1100831)
BSC Installation Repair arm and HAM Installation arm Hazard Analysis (E1000252)

LIGO T000083 COS Faraday Isolator Pre-alignment Procedure

IAS Initial Alignment Procedure LHAM4 and LHAM5 E1100784
LIGO-M080108 NPRO Laser Operating in the OSB Optics Lab

5 Hazard Analysis

5.1 Impact/Shock Hazards to Personnel and Equipment during Transport

The complete OFI assembly, including the frame, the suspension, and the optical bench weighs approximately 55lbs; it will be lifted from an optics table where it has been assembled and pre-aligned and hand-carried by two people to a suitable material handling device (e.g. a Genie Lift), which will be used to transport the OFI to within reach of the HAM Installation Arm; this procedure may cause a strained back. Safety Hazards when using the HAM Installation Arm are addressed in E1000252, which must be read before installing the OFI. In particular the user should take care to minimize the risk of pinching or crushing fingers.

In order to prevent injury to personnel while using the HAM Installation Arm it is also important that the Arm only be moved using the handles provided.

During transport there is a risk that the OFI might be bumped or dropped, particularly if transported in haste, or without following proper procedures for use of the material handling equipment.

5.2 Strain from lifting assembly

See section 5.1.

5.3 Sudden release of tensioned springs

The OFI utilizes two blade springs that are placed under tension during its assembly. The two springs are each loaded with approximately 12 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 OFI, shown in

Figure 1, will prevent the springs from traveling upward by more than a fraction of an inch. However, 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.

5.4 Stray Laser beams

5.4.1 Pre-alignment

The OFI optical table with its installed components will be pre-aligned in a clean optics lab at the IFO site, as described in T000083 COS Faraday Isolator Pre-alignment Procedure. The alignment will require the use of an alignment laser and various steering mirrors and other optical devices for positioning and detecting the reflected and transmitted laser beam through the Faraday Isolator. The alignment laser presents a laser eye hazard, and an appropriate laser safe operating procedure must be followed.

5.4.2 Installation Alignment

The OFI suspension frame will be roughly located on the HAM optical table by the use of positioning templates. The OFI optical table will be aligned in situ in the IFO by using the PSL beam to provide an aligned output beam through the SRM. The signal beam presents a laser eye hazard. The laser hazard is addressed in the IAS procedures, D1002649 IAS Layout for H1 SR3, SR2, SRM; IAS Initial Alignment Procedure LHAM4 and LHAM5 E1100784.

5.5 TGG Crystal Damage

Steel tools, and potentially steel fasteners and steel suspension wires, represent a continuing hazard when in proximity to the OFI, and must not be used in the vicinity of the Faraday Rotator magnet housing because the intense magnetic field may attract the tool through the opening of the housing and damage the TGG crystal. Titanium allen wrenches must be used for attaching all items to the OFI optical bench.

Likewise, avoid inserting any object through the opening of the magnet housing because that may damage the TGG crystal.

6 Output Faraday Isolator 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	Strain from lifting heavy assembly	Lifting heavy assembly without support	Injury to personnel, damage to equipment	marginal	occasional	3C	Total assembly weighs 96 lbs, CA OSHA one man lift value is 40 lbs	At least three people must lift assembly	minor	improbable	4E
2	Failure of HAM Installation Arm	Failure to inspect equipment	Injury to personnel, damage to equipment	critical	occasional	2D		Inspect equipment prior to use	minor	remote	4D
3	Sudden release of tensioned springs	spontaneous failure of wire, wire releasing from wire clamps	Injury to personnel, damage to equipment	critical	remote	2D	Blade springs are loaded with 12 lbs of tension each	Guards installed above springs limit their movement when not under tension, safety glasses will prevent eye injury in the case of fast moving wire end or shrapnel	minor	remote	4D
5	Laser hazard	Direct or reflected laser beam entering eye	Retinal damage	critical	occasional	2C		Follow standard LIGO laser safety procedures	minor	remote	4E
6	Damage to TGG crystal	Magnet attracting magnetic tools	Damage to TGG crystal	critical	occasional	2C		Use Titanium allen wrench	minor	remote	4E

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