



LIGO Laboratory / LIGO Scientific Collaboration

LIGO-E1200687-v3

ADVANCED LIGO

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aLIGO, SEI, HEPI
Fabrication Acceptance Documentation

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Distribution of this document:
LIGO Science Collaboration

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1. Purpose and general description

This document provides links to the hydraulic external pre-isolator (HEPI) system acceptance documentation package (as defined in M1100282-v2 per the format given in template E1300457-v3). This document focuses on the “common documentation”, which includes all the general documents (requirements, drawings, procedures...) which are common to all instances of both the HAM-ISI and BSC-ISI HEPI systems.

In contrast, the documents which are unique, or specific, to a particular unit (unit specific documentation) are typically testing reports. This document also provides links to the DCC trees used to group the “unit specific” documentation. The unit specific documentation are grouped/linked in DCC trees by module type (i.e. a DCC page containing all the testing reports related to a specific HAM or BSC chamber).

HEPI is installed on all 6 HAM vacuum chambers and all 5 BSC vacuum chambers. The design for the HAM chambers differs from the BSC chambers primarily in the mounting to the crossbeams. The function and instrumentation are identical.

2. Requirements documentation

Design Requirements Documents (DRD)

General requirements:

For the seismic isolation system over all, and displacement noise requirements for the BSC platforms are found in:

- [E990303, Seismic Isolation Subsystem Design Requirements Document](#)

Large microseism and anthropogenic disturbances local to Livingston significantly disturbed the site’s operation.. The design of HEPI originally scheduled for Advanced LIGO was accelerated and installed at Livingston before the fourth science run.

Design Requirements for this upgrade are found in:

- [T020033, Initial LIGO Seismic Isolation Upgrade Design Requirements Document](#)

Derived requirements:

HEPI Hydraulic Actuators requirements

- [E1300154-v1 HEPI Hydraulic Actuator Statement of Work](#)

Requirements for the HEPI Inductive Position Sensor

- **T080149-v1 Requirements for the HEPI HAM Displacement Sensor**

HEPI Electronics Requirements

- **T030214-01 HEPI Electronics Requirements**

HEPI Fluid Basic Requirements

- **E021116-x0 HEPI Fluid Basic Requirements**

3. Design overview and detailed design documentation

Due to the successful implementation of HEPI at LLO for Initial LIGO a decision was made to duplicate the existing system for LHO. Two fabrication readiness reviews were held to evaluate our readiness to fabricate duplicate assemblies. FRR Part 1 approved the procurements of long lead items used in the Initial LIGO upgrade. FRR Part 2 approved the design of a stiffer crossbeam for HAM chambers for better isolation performance.

Conceptual Design Review

The HEPI Conceptual Design Review was held in April 2002 during iLIGO operation due to excess ground motion at LLO. At this time a review committee reviewed several concepts and selected HEPI choosing to accelerate its implementation for use at LLO.

Pertinent documents are:

- **G020169-x0, Conceptual Design Review: Initial LIGO Seismic Isolation System Upgrade**
- **T020040-x0, External seismic pre-isolation retrofit design**
- **T020047-v1, Quiet Hydraulic Actuators for Initial LIGO**

Fabrication Readiness Review

Following the successful implementation of HEPI at LLO fabrication readiness reviews were held with the first occurring in April 2008 intended to initiate the procurement of long lead procurements. A second review held in July 2008 was then held to cover improvements in the design to improve performance.

Fabrication Readiness Review Part 1:

- **M080046-v1 HEPI Fabrication/Procurement Plan**

- **M080050-v1 HEPI Review Plan**
- **M080071-v1 Interim report to the seismic team from the HEPI fabrication readiness review panel**

Fabrication Readiness Review Part 2

- **E080359-v1 HEPI Fabrication Readiness Review**
- **E080356 HAM Crossbeam Redesign for aLIGO: Technical Justification**
- **E080328 Crossbeam Redesign for aLIGO: Impact on HAM Chamber Placement**

Additional background information can be found on the HEPI Fabrication Readiness Review wiki page:

https://awiki.ligo-wa.caltech.edu/aLIGO/Advanced_LIGO_HEPI?highlight=%28HEPI%29

Response to Phase 1 and Phase 2 Fabrication Readiness Review:

- **M080113 Phase 1 and Phase 2 report from the HEPI fabrication readiness review panel**

SolidWorks Model

The HEPI top assembly Solidworks Model is checked in the LIGO Caltech PDM vault, in the SEI folder:

[SEISMIC/HEPI aLIGO/D1000513 HEPI, BSC, CHAMBER Level Assem,Aligo SEI.SLDASM](#)

[SEISMIC/HEPI aLIGO/D1000514 HEPI, HAM, CHAMBER Level Assem,aLIGO SEI.SLDASM](#)

Drawings package

The top level assembly, sub-assembly and parts drawings are all posted in the DCC in the pdf formats. All subassemblies and part drawings are linked from these top assemblies.

The top level assembly drawings are

- **D1000513 HEPI Assembly, BSC aLIGO**
- **D040001 HEPI-BSC Top Level Assy aLIGO BSC**
- **D1000514 HEPI Assembly, HAM aLIGO**
- **D040002 HEPI-HAM Housing Hydraulic Assy, aLIGO**

- **D020284 HEPI Hydraulic Actuator Assembly, aLIGO**

Bills of Materials (BOM)

- **E1100016 Bills of Materials for HEPI , Advanced LIGO**

The drawings for all SEI electronics modules including system level schematics (wiring diagrams) are listed in the following document:

- **T1300173-v1 SEI Electronics Drawing Hub aLIGO**
- **D080521 HEPI Pier Interface Schematic and PCB**
- **D0901559 aLIGO HEPI Pump Servo Schematic**

The top level assembly drawings for the pump station and fluid distribution lines are found in the following documents:

- **D040299 LLO Vertex Reservoir Assembly Detail**
- **D030453 LLO Pump Station Assembly**
- **D030097 Pump Station Layout**
- **D020214 Hydraulic External Pre-Isolation (HEPI) Piping and Instrumentation Diagram.**
- **D020214 Hydraulic External Pre-Isolation (HEPI): Piping and Instrumentation Diagram**

All of the seismic isolation system software is configuration controlled and resides in the SVN repository:

- <https://svn.ligo.caltech.edu/svn/seismic/HEPI>

4. Materials and Fabrication specifications:

HEPI is external to the vacuum and does not require special in-vacuum handling requirements. The following documents apply:

- **LIGO-E0900047: LIGO Contamination Control Plan**

- [LIGO-T1100066: Torque values](#)

5. Parts and in-process spares inventoried

In general, the critical parts and sub-assemblies for HEPI, are all recorded in the ICS under ASSY-D1000514

- [E1200847-v2 aLIGO Seismic Isolation Spare Parts List](#)

The expected number of in-process spares to survive the project and be delivered to operations is listed in:

- [T1300832, SEI Sparing Analysis](#)

6. Assembly procedures:

All assembly procedures must be in the DCC and annotated or updated for lessons learned. Storage, if used, should be described here along with procedures to maintain the equipment in good condition (e.g., purge frequency). Transportation procedures and cautions must be noted.

The assembly documentation is posted in the DCC under the document page:

- [E040011-v1 Installation Specification – HEPI Assembly and Installation Procedures.](#)
- [T0900066 Procedure for Assembling Advanced LIGO HAM HEPI](#)
- [D1100568 HAM HEPI Assembly Flow Chart](#)
- [E0900025-v1 aLIGO BSC HEPI Pre-Storage Assembly Procedure](#)
- [E030068 Welded HEPI Actuator Assembly Procedure](#)

7. Installation procedures

All installation procedures must be in the DCC and annotated or updated for lessons learned.

- [E040011-v1 Installation Specification – HEPI Assembly and Installation Procedures](#)
- [E1100075-v5 Removing iLIGO HAM-HEPI/ Installing aLIGO HAM-HEPI](#)

8. Test documents

Test rationale, plans, and data for each unit must be documented as described in M1000211. That tree structure should be pointed to by the overall tree structure laid out in this Acceptance prescription. The top-level objective is to make clear how the measurements performed, which often will not directly measure a required performance parameter, give confidence that the subsystem will fulfill the requirements.

The SEI testing documentation is posted in the DCC at:

- **[E1000304: aLIGO SEI Testing and Commissioning Documentation](#)**

This document describes how the SEI test documentation is organized. The DCC entry page for this document contains the links to the Seismic Group testing and commissioning documentation of the Advanced LIGO SEI installation. In particular, the testing page of sub-assemblies used on the HEPI are collected at:

- **[E1100276, aLIGO HEPI Testing Documentation](#)**

This DCC page HEPI Testing Documentation, E1100276, contains the links to the primary testing procedures:

- **[LIGO-E1300824: aLIGO HEPI Assembly Validation Procedure](#)**
- **[LIGO-E1300825: aLIGO HEPI Control Implementation Procedure](#)**
- **[LIGO-E1300454: aLIGO HEPI Individual Testing Reports](#)**

In particular, the HEPI Individual test reports are in the DCC at:

- **[E1300454: aLIGO HEPI Individual Testing Reports](#)**

The testing page for HEPI sub-assemblies are in the DCC at:

- **[E1100786: aLIGO SEI Instruments Testing Reports and Tracking Lists](#)**

9. User's manual:

A manual appropriate for operators, covering alignment/adjustments and normal operations, must be available (and in the DCC). It must describe what not to do as well, and give clear guidance and cross-pointers to activities which require safety considerations. It must be accessible from standard user screens.

- **E1200762: User interfaces Overview and restart procedure of the Seismic systems**
- **E040419 LLO HEPI Shutdown and Recovery Procedure**
- **E1300825 aLIGO HEPI Control Implementation Procedure**
- **E040339 HEPI Pump Station Maintenance Manual**

10. User interface software

User interface software, and the test routines indicating proper functioning of the software, must be described in words and have code under configuration control (SVN). Watchdog and Guardian routines must also be treated in this way.

All of the seismic isolation system software is configuration controlled and resides in the SVN repository:

<https://svn.ligo.caltech.edu/svn/seismic/>

The following documents focus on user interface software:

- **G1301210 Software Watchdogs for SUS + ISI + HEPI**

11. Operation Manuals

A manual appropriate for operators, written in accordance with M1200366, covering setup/initialization, check-out, operating instructions, calibration, maintenance, operations spares plan, storage/transport and troubleshooting. It must be accessible from standard user screens.

- **E1500146 aLIGO, SEI, Operation Guides/Manuals/Tutorials**
- **E1200762, User interfaces Overview and restart procedure of the Seismic systems**
- **G1300618, ISI Watch Dog (WD) Plots - Operator Training**

- **T0900362 LLO HEPI Actuator Control Valve Test Stand Manual**
- **T0900580 LLO HEPI Actuator Test Stand Manual**
- **E1400298 HEPI DIT-5200 Position Sensor Manual**
- **D040454 HEPI Accumulator Manual**

Some overview and tutorial documents regarding the SEI system (including the HAM-ISI):

- **G1400093, SEI and SUS subsystem tutorial**
- **G1400089, aLIGO SEI overview for Detector Group**
- **G1100431, aLIGO Active Seismic Isolation**

12. Safety

Safety documentation must be in the DCC for all phases of the subsystem development, including any needed for normal use or foreseen maintenance/repair scenarios.

The following documents cover hazard analyses associated with the assembly and installation of the HAM-ISI system:

- **T1000629 aLIGO General Safety Rules for De-Install/Installation Activities**
- **E1100090 HEPI Actuator Test Hazard Analysis**
- **E1100994 aLIGO HAM-HEPI Switch/Install Hazard Analysis**
- **T0900296 LLO HEPI Assembly Job Hazard Analysis**

13. Acronyms

For a list of LIGO abbreviations and acronyms, see M080375.