



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

*LIGO Laboratory / LIGO Scientific Collaboration*

LIGO-E1300769-v4

*LIGO*

2 March 2015

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Core Optics Fabrication Acceptance Documentation

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GariLynn Billingsley, Bill Kells and Hiro Yamamoto

Distribution of this document:  
LIGO Scientific Collaboration

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## 1 Requirements documentation

*The design requirements document must be brought up to date, and pointers to background material, analyses, etc. added to the Requirements document. Pointers to prototyping endeavors including testing results if they are not superseded by subsequent testing should be included here.*

a. *Design Requirements Document (DRD)*

The Design Requirements Document for the Core Optics is in [T000127](#).

The Review Committee Reports on the Design Requirements are in [L080031](#) and [T040009](#).

b. *Supporting documents (models, analyses, ...)*

## 2 Design overview and detailed design documentation

a) *Final Design Document (FDD): must bring the FDD up to date.*

The Core Optics Final Design Document is in [E080494](#).

b) *Review reports:*

- *cite the final design review committee's report*

A summary of all Final Design Documents and Reports can be found at

<https://dcc.ligo.org/LIGO-L1300216>

- *cite the design team's response to the final design review (note that any resulting changes to the design should have been incorporated into the FDD).*

c) *Supporting design documents: models, analyses, specifications, etc. If not applicable, then state so.*

Supporting documents include the CSIRO Pathfinder Final Report [C070179](#), Tinsley Pathfinder Metrology Review [C080135](#), Tinsley Pathfinder Metrology Review-ASML presentation [C080136](#), LASTI LMA test data [C070150](#), CIT Test report [T070233](#).

Additional modeling results can be found in [T1300873](#).

d) *Drawings: cite the top level assembly drawing for each major assembly or subsystem. In the DCC, all subsidiary drawings (sub-assemblies and part drawings) must be linked in a drawing tree manner.*

Drawings are linked from <https://dcc.ligo.org/LIGO-E1400259>

e) *Bill(s) of Materials (BOM): cite any collected BOMs. If the BOMs are only to be found on the Assembly and Sub-Assembly drawing sheets, then state so.*

The only BOM associated with COC are for the optic containers and are found on the assembly drawings

f) *Interface control: cite any documents (such as RODAs) with interface definition/control and/or cite the relevant sections of the DRD and FDD.*

- LIGO-M040006: [Record of Decision/Agreement \(RODA\) - Same Size FM and BS Optics](#)
- LIGO-M040020: [Record of Decision/Agreement \(RODA\) - Sapphire/fused silica downselect date](#)
- LIGO-M040135: [Record of Decision/Agreement \(RODA\) - Detailed Scope of Work on Advanced LIGO by the UK AdL Team](#)
- LIGO-M040387: [Record of Decision/Agreement \(RODA\) - Recycling Mirror size for Advanced LIGO](#)
- LIGO-M050175: [Initial Alignment Requirements for COC](#)
- LIGO-M050397: [Record of Decision/Agreement \(RODA\) - Core Optic sizes, including TMs, BS, FM and RM](#)
- LIGO-M060032: [Elimination of the Photon Drive from the AL baseline](#)
- LIGO-M060305: [Record of Decision/Agreement \(RODA\) - Compensation Plate dimensions](#)
- LIGO-M060315: [Record of Decision/Agreement \(RODA\) - No Flats on Input Mode Cleaner Optic & Recycling Mirror for Advanced LIGO](#)
- LIGO-M070055: [Dimensions of the Large MMT Mirror \(MMT3\) and the Recycling Mirrors \(PRM & SRM\) for the Marginally Stable Recycling Cavities](#)
- LIGO-M070120: [Record of Decision/Agreement \(RODA\) - Beamplitter Optic Size, Geometry, Wedge Orientation and Suspension Wire Material](#)
- LIGO-M080022: [Record of Decision/Agreement \(RODA\) - ETM reaction mass has same mass as Thermal Compensator Plate](#)
- LIGO-M080042: [Record of Decision/Agreement \(RODA\) - Transmission Requirements for ETM and ERM](#)
- LIGO-M080041: [Thickness of PR3 and SR3 and wedge information](#)
- LIGO-M080371: [RODA: Arm Length Stabilization system to use end-station injection of a 532 nm beam, and PDH cavity sensing.](#)
- LIGO-M0900025: [RODA: Decision to reduce the beam size on the ITMs to 5.3 cm](#)
- LIGO-T1000175: [Thinner Compensation Plates for reduced Squeeze film damping](#)
- LIGO-T080277: [BS, CP, RM, ITM and ETM Wedge Angle Tolerance](#)
- LIGO-L1200291: [TRB Report: Recommendation related to the discrepancy between single version of the quad ITM suspensions and the optical layout which calls for left and right handed versions](#)

*g) Software: cite any software design description documentation. If not applicable, or not available, then state so.*

There is no software for the Core Optics.

*h) Design source data:*

- *Confirm that all mechanical design CAD models are in the SolidWorks/PDMWorks vault, or explain what is not and why.*

Solid works models exist for the core optics and containers. There is an assembly drawing for the Ergo arm at D1002605. The Ergo arm was manufactured by Central Engineering at Caltech with the final item being the deliverable. We did not require a full set of detailed drawings. Drawings of the optic interface plates do exist.

- *Confirm that all electronics design CAD models (schematics and PWB layouts) are backed up and available on LIGO Lab archives, or explain what is not and why.*

All Design Documents are filed in the DCC.

### **3 Materials and fabrication specification**

*Any special materials, or treatment of materials including preparation for in-vacuum use; this may be integrated into the Design documentation.*

- *Cleaning in preparation for installation is described in LIGO-E1100439: [General Optics Cleaning Procedure](#)*

Parts and in-process spares inventoried

*All elements of aLIGO must be recorded in the ICS or in the DCC using the S-number scheme. As-built modifications for parts or assemblies should be found here.*

All currently delivered Core Optics recorded in the Inventory Control System.

An inventory of the Core Optics is also summarized conveniently at:  
<https://galaxy.ligo.caltech.edu/optics/>.

### **4 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 Core Optics Component long term storage for the 3<sup>rd</sup> aLIGO interferometer [T1300016](#).

### **5 Installation procedures**

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

All Core Optics installation is accomplished by the Suspensions group.

### **6 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.*

LIGO-E1000763: [aLIGO COC Testing and Commissioning Documentation](#)

The test results for the Core Optics is also summarized conveniently at:  
<https://galaxy.ligo.caltech.edu/optics/>.

## 7 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.*

There is no user interface software.

## 8 Operation Manual

*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.*

The Core Optics long term storage plan for the 3<sup>rd</sup> aLIGO interferometer is in [T1300016](#).

The aLIGO optic container shipping and storage procedure [E0900394](#)

QA Test Procedure for aLIGO COC Reflection, Transmission, Scatter and Absorption. [E1000863](#)

Figure Metrology measurement procedure for Core Optics [E1101064](#)

## 9 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.*

[T080231](#) Ergo arm Hazard Analysis

[T1000425](#) Hazard analysis for use of First Contact(TM) Optical Cleaner