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**SCOPE**

This document lays out the test plan and acceptance criteria for the Advanced LIGO Faraday Isolator.

**APPLICABLE DOCUMENTS**

[T060269-01-D](https://dcc.ligo.org/LIGO-T060269-x0) Input Optics Preliminary Design

[G070591-00-D](https://dcc.ligo.org/LIGO-G070591-x0) Input Optics Preliminary Design Review

[T060267-00-D](https://dcc.ligo.org/LIGO-T060267-x0) Upgrading the Input Optics for High Power Operation

[E0900301-v6](https://dcc.ligo.org/LIGO-E0900301-v6) IOO Faraday Isolator Assembly and Certification Procedures

[T020020-02-D](https://dcc.ligo.org/LIGO-T020020-v2) Input Optics Subsystem Design Requirements Document

**APPLICABLE SPECIFICATIONS[[1]](#footnote--1)**

[LIGO-E080125:](https://dcc.ligo.org/LIGO-E080125-v3) aLIGO TGG crystals for Input Optics Faraday isolator

[LIGO-E0900330](https://dcc.ligo.org/LIGO-E0900330-v1): ALIGO IO CALCITE WEDGE POLARIZER

[LIGO-E1100122](https://dcc.ligo.org/LIGO-E1100122-v2): Quartz Rotators for aLIGO Input Optics Faraday isolators

[LIGO-E1100222](https://dcc.ligo.org/LIGO-E1100222-v1): aLIGO HWP for IO PSL and HAM2 Tables

**APPLICABLE DRAWINGS**

[LIGO-D1000332](https://dcc.ligo.org/LIGO-D1000332-v1): ALIGO IO L1 FI ASSEMBLY

[LIGO-D1000333](https://dcc.ligo.org/LIGO-D1000333-x0): ALIGO IO H1 FI ASSEMBLY

LIGO-D1002987: ALIGO IO FI L1 H1 BREADBOARD

LIGO-D1000877: ALIGO IO FI CALCITE MOUNT ASSEMBLY

LIGO-D0902253: ALIGO IO FI CALCITE WEDGE POLARIZER

LIGO-D1000874: ALIGO IO FI CALCITE MOUNT

LIGO-D0901488: ALIGO HAM TABLE FORK

LIGO-D1101505: ALIGO IO IN VACUUM POST

LIGO-D1101677: ALIGO IO L1 INDIUM ROD

LIGO-D1101667: ALIGO IO FI DKDP ASSEMBLY

LIGO-D1101569: ALIGO IO HWP MOUNT

LIGO-D1101668: ALIGO IO HWP RETAINING RING

LIGO-D0901488: ALIGO HAM TABLE FORK

LIGO-D1101505: ALIGO IO IN VACUUM POST

LIGO-D1101566: ALIGO IO FI RHWP ASSEMBLY

LIGO-D1101567: ALIGO IO FI RHWP ROTATIONAL ADAPTER

LIGO-D1200982: ALIGO IO FI RHWP H1 HEIGHT ADAPTER

LIGO-D1101568: ALIGO IO FI RHWP BASE

LIGO-D1101569: ALIGO IO HWP MOUNT

LIGO-D1101570: ALIGO IO FI RHWP UPPER SPRING MOUNT

LIGO-D1101572: ALIGO IO FI RHWP LOWER SHORT SPRING MOUNT

LIGO-D1101574: ALIGO IO FI RHWP LOWER TALL SPRING MOUNT

LIGO-D1101579: ALIGO IO FI RHWP BEARING BLOCK

LIGO-D1101581: ALIGO IO FI RHWP PICOMOTOR MOUNT

LIGO-D1101582: ALIGO IO FI RHWP PICOMOTOR CLAMP

LIGO-D1101592: ALIGO IO FI RHWP RISER

LIGO-D1101593: ALIGO IO FI RHWP BEARING COVER

LIGO-D1101594: ALIGO IO FI RHWP BEARING STOP

LIGO-D1101668: ALIGO IO HWP RETAINING RING

LIGO-D1101660: ALIGO IO L1 FR ASSEMBLY

LIGO-D1101661: ALIGO IO FI FR QUARTZ CAP

LIGO-D1101662: ALIGO IO FI FR QUARTZ HOLDER

LIGO-D1101663: ALIGO IO FI FR TGG CAP

LIGO-D1101666: ALIGO IO FI FR TGG HOLDER

LIGO-D070466: ELIGO IO FI FR LLO DUST SHIELD

LIGO-D1101664: ALIGO IO FI FR POSITIONING SCREW

LIGO-D1101665: ALIGO IO FI FR SLEEVE LOCK

LIGO-D1101211: ALIGO IO L1 FI FR SPACER

LIGO-D1200981: ALIGO IO H1 FI FR SPACER

LIGO-D070469: ELIGO IO FI FR STAND

LIGO-D080176: ELIGO IO FI FR THIN CLAMP

LIGO-D1101682: ALIGO IO L1 FR TGG

LIGO-D1101683: ALIGO IO L1 FR QUARTZ

LIGO-D1101753: ALIGO IO FI FR L1 HEAT SINK

LIGO-D1200983: ALIGO IO FI FR H1 HEAT SINK

LIGO-D1101888: ALIGO IO FI FR SINK CLAMP

LIGO-D1003033: ALIGO IO L1 FR MAGNET ASSEMBLY

LIGO-D0902391: ALIGO IO STRAIGHT HA4 BAFFLE ASSEMBLY

LIGO-D0902390: ALIGO IO STRAIGHT HA4 BAFFLE PLATE

LIGO-D1003011: ALIGO IO HARD APERTURE TABLE BRACKET

LIGO-D0902393: ALIGO IO STRAIGHT HA5 BAFFLE ASSEMBLY

LIGO-D0902392: ALIGO IO STRAIGHT HA5 BAFFLE PLATE

LIGO-D1003011: ALIGO IO HARD APERTURE TABLE BRACKET

LIGO-D0902395: ALIGO IO STRAIGHT HA6 BAFFLE ASSEMBLY

LIGO-D0902394: ALIGO IO STRAIGHT HA6 BAFFLE PLATE

**A FARADAY ISOLATOR COMPONENTS – PRELIMINARY INSPECTION**

As the material for the Faraday isolator assembly is received, the following procedures apply.

1. Optical Components (TGG crystals, quartz rotator, waveplate, DKDP, polarizers)

a. Test Method

i. Visual inspection of all components for chips, inhomogeneities, surface scratches; follow up by microscope if needed

ii. Measurement of anti-reflection coating performance – low angle reflectance measurements

b. Acceptance Criteria

i. No evidence of chips, scratches, inhomogeneities, surface damage

ii. AR performance measures within required specification.

2. Mechanical Components (custom fabricated and purchased parts)

a. Test method

i. Visual inspection of all parts

ii. Form and fit tests – building up subassemblies

b. Acceptance Criteria

i. No evidence of damage or obvious deviations from design

ii. Successful assembly of all components

3. Picomotors

a. Test method

i. Verify that the picomotor can be powered up and functions properly

b. Acceptance Criterion

i. Proper function – unit works and performs five calibrated rotations successfully

4. Magnets

a. Test Method

i. Visual Inspection of magnet surfaces for chips, foreign materials

ii. Measurement of the magnetic field strength

b. Acceptance Criteria

i. No evidence of damage

ii. Magnetic field meets specification

NOTE: The mechanical components and magnets must be re-inspected after baking. In particular, the magnetic field should be remeasured to verify that it has not degraded.

**B FARADAY ISOLATOR ASSEMBLY – BENCH PERFORMANCE**

These tests should be performed when assembling the Faraday isolator in air in the PSL enclosure. Assembly procedures can be found in [E0900301-v6](https://dcc.ligo.org/LIGO-E0900301-v6) “IOO Faraday Isolator Assembly and Certification Procedures”.

 1. Optical throughput

a. Test method

i. Measurement of the input power and the power transmitted through the Faraday isolator assembly

b. Acceptance criterion

i. The total power throughput exceeds 95%

2. Isolation ratio

a. Test method

i. Measurement of the power leaking through the upstream polarizer

(retroreflector slightly misaligned to allow for pick-off )

b. Acceptance criterion

i. The isolation ratio exceeds 40 dB, optimized at 20 W

3. Thermal Lensing

a. Test method

i. Measurement of transmitted mode size at low (1 W) and high (100 W or

greater) power using a Z-scan measurement

b. Acceptance criterion

i. The change in mode matching is less than 5%, ie, does not degrade

the interferometer mode matching to below that specified in [T020020-02-D](https://dcc.ligo.org/LIGO-T020020-v2) “Input Optics Subsystem Design Requirements Document”

4. Thermal beam steering

a. Test method

i. QPD measurement of the angular displacement of the forward going beam

(into the interferometer) and the rejected beam as the power is changed

impulsively from 1 W to 100 W.

b. Acceptance criterion

i. The in-air change for both forward going beam and isolated beam used for the REFL signal should be less than 1/10 the beam diameter at about 1 m away (400 urad) at all powers.

**C FARADAY ISOLATOR ASSEMBLY – INSTALLATION**

These tests should be performed once the Faraday isolator has been installed in the vacuum

1. In vacuum isolation ratio

a. Test method

i. Measurement of the power leaking back to the PSL table

b. Acceptance criterion

i. The isolation ratio is greater than 30 dB, the IOO requirement in T020020,

“Input Optics Subsystem Design Requirements Document”

2. Thermal Lensing

a. Test method

i. Measurement of the interferometer visibility at low and high power.

ii. One arm cavity scan at 1 W and 100 W.

b. Acceptance criterion

i. The mode matching is better than 95% at all powers (max 125 W out of IO) for the nominal interferometer mode.

3. Thermal beam steering

a. Test method

i. QPD measurement of the angular displacement of the forward going beam

(into the interferometer) and the REFL beam as the power is changed stepwise from 1 W to full power

b. Acceptance criterion

i. The change for both the forward going beam and the REFL beam should be

accommodated by the REFL beam steering (RBS) system.

1. *We discussed with many vendors to provide coatings for the crystals of the Faraday isoalator, and in the end no vendor agreed to 100 ppm reflectance for any of these crystals, although earlier discussions were more optimistic. The specifications were revised prior to ordering to take into account vendor capabilities.* [↑](#footnote-ref--1)