



SPECIFICATION

Qualifying Parts for LIGO UHV Service

AUTHOR(S)	DATE	Document Change Notice, Release or Approval
Dennis Coyne	19-Mar-2010	see LIGO DCC record Status

1 Introduction

Each part or component intended for service within the LIGO Ultra-High Vacuum (UHV) system shall

- be comprised of acceptable materials or components,
- be manufactured in accordance with appropriate specifications,
- be prepared (cleaned and baked) in accordance with the LIGO specifications, and
- be tested to confirm that the surface cleanliness meets requirements.

This document calls out the appropriate specifications to comply with LIGO UHV requirements.

2 Scope

This specification covers requirements for all parts, components, materials, assemblies that are to be used in the LIGO Ultra-High Vacuum (UHV) system.

This specification does not cover elements of the vacuum envelope, which have additional leak rate and vacuum load requirements.

This specification does not cover hermetically sealed elements which are placed within the UHV system; these sealed elements have additional leak rate requirements.

If the part is not in the vacuum system, then this specification does not apply.

3 Abbreviations and Acronyms

FTIR Fourier Transform Infrared Transmission

LIGO Laser Interferometer Gravitational-wave Observatory

RGA Residual Gas Analyzer or Assay

UHV Ultra-High Vacuum

4 Exceptions, Deviations, Clarifications

Exceptions, additions or clarifications should be obtained, by the LIGO subsystem Designer or Cognizant Engineer, from Systems Engineering by contacting Dennis Coyne coyne@ligo.caltech.edu or Calum Torrie ctorrie@ligo.caltech.edu.



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5 Materials

5.1 Approved Materials

Only materials listed in the "LIGO Vacuum Compatible Materials List" ([LIGO-E960050](#)) may be used. The Vacuum Compatible Materials List also defines related requirements and restrictions, including, but not limited to the following:

- Material certifications are required in every case.
- Only the specific material grades called out are acceptable
- Only the material grades and sources called out for the polymers may be used (unless otherwise noted).
- All polymers (including adhesives) are restricted (even if approved). The use of an approved polymer in a new application must be approved. Despite the fact that some polymer materials are approved for use, these materials should be avoided if possible and used sparingly, especially if used in proximity to LIGO optics.
- No metal castings are permitted, including no aluminum tooling plate.

5.2 Qualifying Materials

Only the LIGO laboratory may qualify materials for use in the LIGO UHV system. The procedure requires extensive testing in accordance with section 9.1, "Initial Qualification & Screening", of the document "LIGO Vacuum Compatibility, Cleaning Methods and Procedures", LIGO-[E960022](#). The basic procedure is to evaluate outgassing with an RGA after cleaning and vacuum baking a sample of the material/component. If the outgassing is acceptable, then the material/component is placed into a high irradiance optical cavity for long duration exposure testing. (See Reference 3 for more information).

6 Part Fabrication

Restrictions are defined in the following specifications:

[E010613](#) Sections 6 & 7 of Generic Requirements & Standards for Detector Subsystems

[E0900364](#) "Metal components intended for use in the Adv LIGO Vacuum System"

[E0900048](#) "Welding Specification for Weldments used within the Adv. LIGO Vacuum System"

7 Assembly

All assembly and subsequent packaging is to be performed a Class 100 Clean Room (per FED-STD-209).

In addition one must comply with [E0900047](#), "LIGO Contamination Control Plan", for assembly and installation work at the LIGO Observatories. In particular, this document defined the requirements for clean tooling (Class B) which contacts parts which are installed into the vacuum system (Class A).



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8 Packaging

The clean parts or assemblies are to be packaged (wrapped, bagged and tagged) per [LIGO-E960022](#).

9 UHV Preparation

All parts are to be cleaned before assembly. All parts, components be prepared (cleaned and baked) in accordance with the “LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures” ([LIGO-E960022](#)).

10 Cleanliness Testing

10.1 Cleanliness Requirements

Cleanliness Requirements are defined in section 6.1 of LIGO-[E010613](#), and are repeated here for convenience:

- Achieve a Non-Volatile Residue (NVR) level of A/50 or better (per MIL-STD-1246C or IEST-STD-CC1246D) on piece parts before clean assembly
- Achieve a Particulate Cleanliness Level of 50 or better (per MIL-STD -1246C or IEST-STD-CC1246D) on piece parts before clean assembly

10.2 RGA Testing

The preferred method of verifying non-volatile residue (NVR) cleanliness is Residual Gas Assay (RGA) testing with a mass spectrometer since it directly measures the outgassing from the component. All parts which can fit into our vacuum bake ovens ($<10^{-6}$ torr) undergo RGA testing. The method and criteria for qualifying cleanliness via RGA testing is defined in [E080177-v1](#).

10.3 FTIR Testing

Those parts which are too large for the vacuum bake ovens are Fourier Transform InfraRed (FTIR) tested and then air baked. FTIR provides chemical functional group information for quantitative analysis and qualitative identification of contaminants. Specification [E0900480](#), “FTIR Testing to Qualify Parts for LIGO UHV Service”, defines the requirements for FTIR testing to meet LIGO UHV requirements. See also [E0900479](#), “Instructions for taking Low Volatility Residue (LVR) Wipe Samples” and Reference 13.

N.B.: All quantitative FTIR analyses done to date by LIGO Lab have been performed by JPL; We are not aware of any quantitative commercial FTIR capability.

11 References

1. LIGO-[E960050](#) LIGO Vacuum Compatible Materials List
2. LIGO-[E960022](#) LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures



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3. Li, D., Coyne, D., and Camp, J., "Optical Contamination Screening of Materials with a High-finesse Fabry-Perot Cavity Resonated Continuously at 1.06-um Wavelength in Vacuum, Appl. Optics, 38, 5378-5383 (1999)
4. LIGO-[E010613](#) Generic Requirements & Standards for Detector Subsystems
5. [E0900364](#) Metal components intended for use in the Adv LIGO Vacuum System
6. [E0900048](#) Welding Specification for Weldments used within the Adv. LIGO Vacuum System
7. FED-STD-209
8. [E0900047](#) LIGO Contamination Control Plan
9. IEST-CC1246D Product Cleanliness Levels and Contamination Control Program (replaces MIL-STD-1246C)
10. LIGO-[E080177](#) Specification: RGA Test Qualification
11. LIGO-[E0900480](#) FTIR Testing to Qualify Parts for LIGO UHV Service
12. LIGO-[E0900479](#) Instructions for taking Low Volatility Residue (LVR) Wipe Samples
13. J.J. Herrick, et. al., "Analysis of Semi-Volatile Residues Using Diffuse Reflectance Infrared Fourier Transform Spectroscopy" in Optical System Contamination: Effects, Measurements, and Control VII; July 2002, edited by Phillip T. C. Chen and O. Manuel Lee; Proceedings of the SPIE, Vol. 4774, pp. 251-261, (2002).