RGA Test Qualification of components for the LIGO UHV

1 Scope

This specification is for the NVR cleanliness qualification by RGA testing of components (parts, assemblies) which are to be installed into the LIGO UHV system. This specification does not address particulate contamination requirements or qualification.

2 Abbreviations and Acronyms

FTIR Fourier Transform Infrared Transmission
ITM Input Test Mass
NVR Non-Volatile Residue
RGA Residual Gas Analyzer
UHV Ultra-High Vacuum

3 Applicable Documents

Section 4, “Contamination Control” of E1400371, “aLIGO System Acceptance Document/ Data Package” gives a good overview of LIGO contamination control practices
E0900047: LIGO Contamination Control Plan
E960022: LIGO Clean and Bake Methods and Procedures
E960050: LIGO Vacuum Compatible Materials List
E1000088: Qualifying Parts for LIGO UHV Service

4 Cleaning and Bake-out

See the relevant sections of E960022 for cleaning, vacuum baking and RGA testing. There are several acceptable cleaning methods/procedures and other proposed approaches can be evaluated and approved if/as needed.

Air baking is mentioned in document E960022 as an alternative to vacuum baking. It should be noted that the cleanliness in this case must be verified by an FTIR test per E0900480; see also E1000088.

5 Outgassing Measurement

After cleaning the parts, baking them in vacuum, and allowing the parts to cool to room temperature, an RGA is taken (with a mass spectrometer) to measure the outgassing rate. A suggested equipment arrangement for this measurement is given E960022. A large turbo-pump is used to pump off outgassed contaminants during the bake. Once the chamber and parts have cooled down, a smaller turbo-pump is used in order to raise the background pressure due, to outgassing from the parts, so that the outgassing rate can be measured. A calibrated leak is used to calibrate the RGA scan.

The base pressure of the chamber when making the RGA measurement should be no higher than 10^{-6} torr.

The chamber should not be significantly larger (in area or volume) than required to fit the parts under test (otherwise deposition to the chamber walls may dominate the effective pumping rate and mask a measurement of the outgassing of the parts).

6 RGA Scan Requirements

Our principal concern is high molecular weight hydrocarbons due to inadequate cleaning, and not the total pressure due to adsorbed water and volatile gasses. (However for some materials which absorb/adsorb significant quantities of water and gases, measurement of the outgassing rates of these species is also required.) When reviewing an RGA scan for approval:

a) Verify that the amplitude of the 43 AMU peak is ≤ 1/10 of the 44 AMU peak
b) Verify that the amplitude of all peaks > 44 AMU are no higher than 1/100 of the 44 AMU peak
c) Check that the calibrated outgassing rate (torr-liter/sec) of the cracked hydrocarbon signature[1] (sum of AMUs 41, 43, 53, 55, 57) is ≤ 4E-10 torr-liter/sec for a single suspension structure.
d) If a small quantity of material occupies the oven, then it should be background limited at ~2E-12 torr-liter/sec for the hydrocarbon signature
e) Check that there are no "significant" high AMU components above the background or instrument noise floor (even if < 1/100'th of AMU 44) up to AMU 100.

Subtraction of an empty chamber mass spectrum is not permitted when meeting the above requirements.

Every RGA scan should have an associated, and recently taken, empty chamber scan (prior to loading the chamber with the parts being evaluated) and a calibrated RGA scan. The empty chamber scan should not have any peaks above the background (instrument noise floor) for AMUs 41, 43 and AMUs > 44. The RGA calibration should be accomplished with a multi-component calibrated leak which includes argon (AMU 40) and krypton (AMUs 85, 86, 87).

[1] High molecular weight hydrocarbons crack into lower AMU components when measured by a mass spectrometer. AMUs 41, 43, 53, 55 and 57 were found to be indicative of all high molecular weight hydrocarbons.