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Viton Spring Seat

Vacuum Bake Qualification

D. Coyne

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Detector

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California Institute of Technology
LIGO Project - MS 51-33
Pasadena CA 91125
Phone (818) 395-2129
Fax (818) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project - MS 20B-145
Cambridge, MA 01239
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

WWW: http://www.ligo.caltech.edu/

Abstract

The fluorel spring seats, used with the constrained layer damped coil springs in the Seismic Isolation (SEI) system, have been provisionally qualified for use in the LIGO vacuum system. The vacuum bake requirements are defined (temperature, time and pressure). The outgassing levels measured via an RGA are reported. The viton demonstrated exceptional dimensional stability through the bake and a low outgassing rate.

Keywords: seismic isolation system, viton, vacuum bake, vacuum qualification

1 INTRODUCTION

Fluorel (viton) seats are used with the constrained layer damped coil springs in the Seismic Isolation (SEI) system. The purpose of the seats are:

(a) to mate the helicoil geometry of the springs to the flat surfaces of the SEI support table and isolation stack leg elements
(b) to provide acoustic isolation, and
(c) to accommodate and dissipate shearing stresses at the interface with the springs as they are compressed (so that the residual stresses at this interface are low and the rate of non-Gaussian strain relief events, due to this stress, is low).

Molded viton is used in the prototype interferometers (the 40m system and the Phase Noise Interferometer (PNI)) in the form of solid conical fustrums used as spring/damper elements between the mass elements of the passive isolation system. This particular grade of viton was problematic to clean up for use in the vacuum system. It required 10 days of vacuum baking at 200 C and considerable clean up of crystal deposits from the vacuum system used for the bake.

The fluorel seats are composed of a different formulation than LIGO has used in the past. It's formulation is as follows:

- 100 parts, Flourel FC2180 (or FE5641)
- 20 parts, MT Black (N990)
- 3 parts, Maglite (MgO)
- 6 parts, $Ca(OH)_2$
- 3 parts, CaO

Unlike previous Fluorel formulations used in LIGO, this has no mold release agents which reduces the amount of material which is baked out of the parts. The fluorel spring seats are governed by a process specification.[1]

2 BAKE PROCESS SPECIFICATION

The vacuum bake should be performed as follows and in accordance with the LIGO vacuum qualification procedures[2]:

1. E. Ponslet, T. Thompson, "Material, Process, Handling and Shipping Specification for Fluorel Parts", Hytec-TS-LIGO-05b, LIGO-E970130-00-D, 8/20/97.
2. W. Young, LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures, LIGO-E960022-03-E, 12/20/96.

1) Ramp up from room temperature to 182 C (360 F) at a rate ≤ 2.5 C/min (4.5 F/min)

2) Maintain 182 C (360 F) ± 1 C (2 F), a vacuum pressure of ≤ 1 microtorr, for 48 hrs.

3) Cool down in vacuum at a rate ≤ 3 C/min (5 F/min)

4) After cool down, perform a RGA (residual gas assay) and compare to a TBD outgassing rate criteria. If necessary based on the RGA results, rebake for another 24 hrs. and re-measure the outgassing rate with the RGA.

3 DIMENSIONAL STABILITY

Two of the four viton seats which were vacuum baked were measured before baking and then within 15 to 45 minutes after being exposed to atmosphere after the bake. The results are indicated in Table 1. The measurement of the dimensions is difficult due to the compliant nature of the material. However, clearly the vacuum bake causes very little dimensional change. The maximum change is about ±0.009 in. which is less than the dimensional tolerances of the part, ±0.03 inches[1].

Table 1. Viton seat dimensions before and after vacuum baking.

unit	*dimension*	*pre-bake (in)*	*post-bake (in)*	*difference (in)*
1	Outer Diameter	2.8005	2.8090	+0.0085
	Inner Diameter	1.8760	1.8870	+0.0010
	Minimum Height	0.2345	0.2350	+0.0005
	Maximum Height	0.6485	0.6480	-0.0005
2	Outer Diameter	2.8100 2.8210	2.8140 2.8005	~ -0.0083
	Inner Diameter	1.8625 1.8770	1.8675 1.8735	~ +0.0007
	Minimum Height	0.2345	0.2345	0.0000
	Maximum Height	0.6460	0.6465	+0.0005

4 OUTGASSING

The chamber was baked at 200 C for 48 hours and then cooled for an RGA scan to verify that the background level was low enough. Four unbaked viton seats were then put into the chamber and baked at low temperature (100 C) at about 1 microtorr fro 24 hours to drive water off in order to perform an initial, unbaked outgassing measurement. The initial viton outgassing rate was found to be 9×10^{-13} torr-l/s/cm^2, which is quite good. Baking the viton for 48 hrs. at 182 C (360 F)

1. LIGO Isolation System, Coil Spring Seat, D972219-00.

reduced the outgassing rate by over a factor of 2. Baking for an additional 24 hrs. (72 hrs. total) at 182 C reduced the outgassing rate to 3 x 10^{-13} torr-l/s/cm^2. The viton outgassing rate, measured after an additional 24 hrs. in vacuum at room temperature and subsequent to the bake, was found to be 2 x 10^{-13} torr-l/s/cm^2.

The surface area of each viton seat was calculated from the nominal drawing dimensions to be 99.5 cm^2. This area was used to calculate the outgassing rate per unit area in Table 2. It was also used to calculate the expected pressure (for AMU components 41, 43, 53, 55 and 57 per the procedure in LIGO-E960022) based upon the vertex isolated volume with seismic isolation systems for 4 HAM chambers and 1 BSC chamber. This amounts to 928 viton seats. The assumed pumping speed (for AMU components 41, 43, 53, 55 and 57) is 3000 l/s (based on E960022). Of course this does not account for other loads on the pumps (an outgassing budget is in preparation). If these viton seats were the only loads on the pumps, then (as shown in the last column of Table 2) we can easily meet the LIGO requirement of < 5 x 10^{-10} torr for these gas species.

Table 2. Viton outgassing rates.

State	$\Gamma = \sum(p_{41}, p_{43}, p_{53}, p_{55}, p_{57})$ *(torr)*	*Outgassing Rate (torr l/s/cm^2)*	*Projected[a] LIGO Pressure (torr)*
background	2.2 x 10^{-12}	--	--
un-baked[b] viton	14.0 x 10^{-12}	8.8 x 10^{-13}	27.1 x 10^{-12}
baked for 48 hrs., 182C	6.5 x 10^{-12}	4.1 x 10^{-13}	12.6 x 10^{-12}
baked for 72 hrs., 182C	4.8 x 10^{-12}	3.0 x 10^{-13}	9.2 x 10^{-12}
24 hrs. additional pumping	3.1 x 10^{-12}	1.9 x 10^{-13}	5.8 x 10^{-12}

a. Based upon the vertex isolated volume with 928 viton seats and a nominal 3000 l/s pump speed. The LIGO Vacuum Compatibility Document (LIGO-E960022-03) states a LIGO pumping speed of 3000 l/s. PSI design calculations use from 2500 to 3000 l/s depending on species.

b. baked at 100C for 24 hrs. to drive water off of the seats and get an outgassing rate for the viton prior to vacuum baking.