LIGO Undamped Coil Spring on Fluorel - Comparison of Mechanical Behavior of Two Compound Formulations

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Abstract

This document compares test results for dynamic axial and shear stiffness and damping of LIGO coil springs on viscoelastic seats made from two different Fluorel formulations. Although differences are small, there appears to be a performance enhancement in terms of loss factor with the new UHV formulation.

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LIGO PROJECT

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1. Summary

The purpose of this work is to compare different rubber formulations for Fluorel seats made by two different vendors in terms of stiffness and loss factor. An undamped coil was placed between the respective seats to measure free vibration decay responses in both axial and shear directions. The new (2180) formulation shows a slight increase in loss factor over the other (2176) formulation.

2. Seat Configuration Description and Test Procedure

The first configuration (fabricated by Rubber Development) was manufactured using Fluorel formulation 2176 and features a circular coil end mount (similar to all previous seats tested[1]). The second configuration (fabricated by Moulding Solutions) was manufactured using Fluorel formulation 2180 and differs from the first configuration in that the coil end mount is square. The square end ensures that all coils are seated the same way and receive the same support conditions. The 2180 formulation was recommended by chemists at Dyneon for UHV applications.

An undamped coil (HC03) was placed between the respective seats in the pendulum test apparatus[1]. Tests were conducted in the axial and shear directions in a range of frequencies from approximately 0.5 Hz to 1.7 Hz. Ambient temperatures during these tests ranged from approximately 21.7 ^{0}C (71.1 ^{0}F) to 22.1 ^{0}C (71.8 ^{0}F).

3. Test Results and Discussion

Figures 1 and 2 present the test results for the two formulations in the form of frequency dependent parameters distinguished by the symbols for 2176 and 2180.

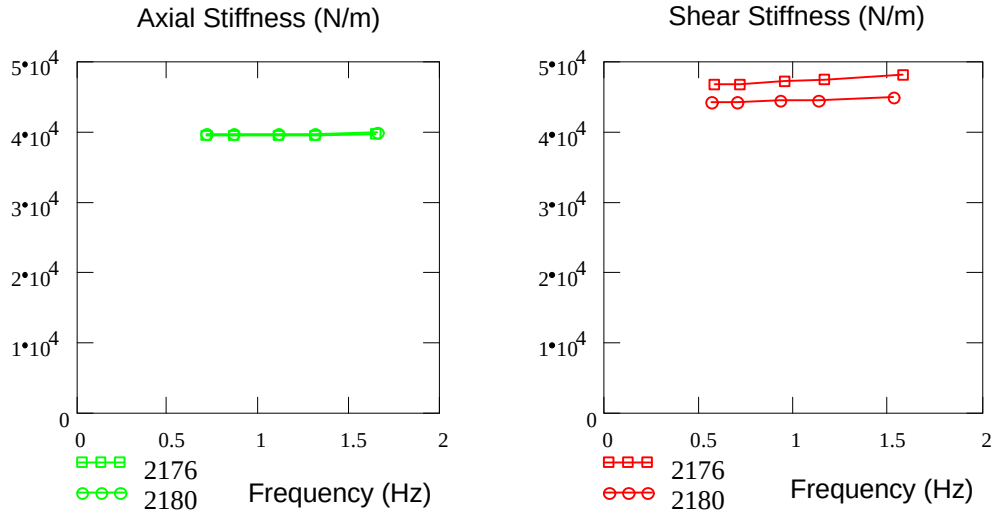

Figure 1: Axial and shear stiffness as a function of frequency.

Inspection of Figure 1 reveals very small differences in stiffness in measured data comparing the two seat configurations. The 2180 formulation is slightly softer in shear

than the 2176 formulation. Note that, although formal durometer tests were not performed, the 2180 seats feel clearly softer than their 2176 counterparts.

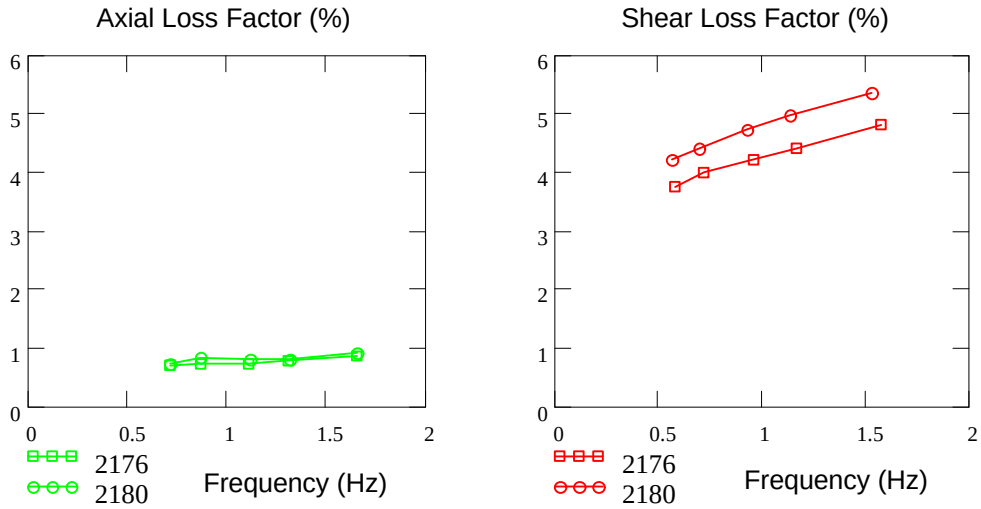

Figure 2: Axial and shear loss factor as a function of frequency.

Figure 2 shows that formulation 2180 provides an increase in loss factor relative to formulation 2176. Note that the increase in loss factor is directly related to the lower stiffness of the 2180 seats. The figures that follow display the change in percentage terms expressed by

$$\%change = \left[\frac{2180 - 2176}{2176}\right] 100. \tag{1}$$

Percent change in stiffness and loss factor for both axial and shear is plotted in Figure 3.

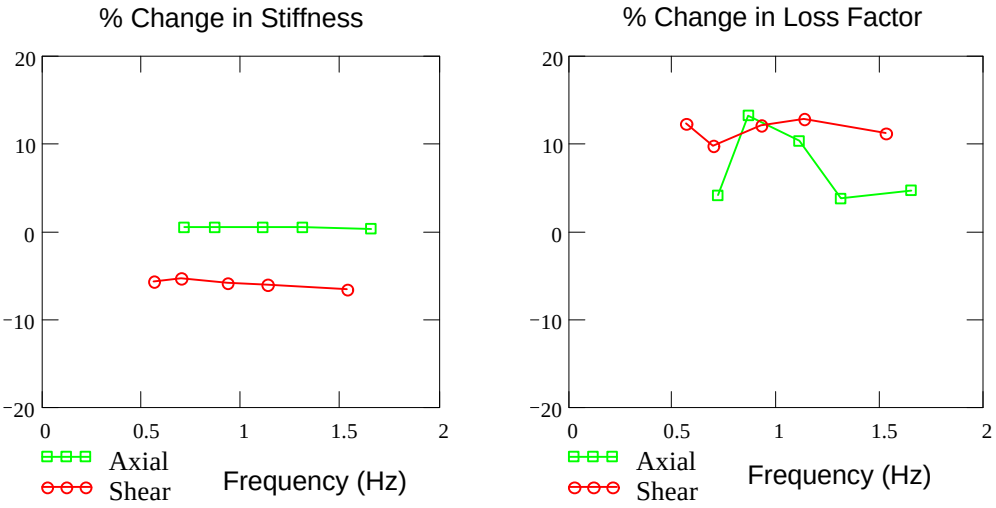

Figure 3: Percent change in stiffness and loss factor defined by Eq. (1).

Figure 3 shows that the axial stiffness is nearly identical and that the shear stiffness of the springs on 2176 seats is greater than on 2180 (negative % change). Loss factor increases from 2176 to 2180 as shown by the positive % change in the loss factor plot in Figure 3.

4. Conclusions

Test results presented in this report indicate some performance variations of two different viscoelastic seat designs. However, differences are small and the new formulation provides a softer and more damped response than the old one.

5. References

1. E. Ponslet, *Low Frequency Damping Measurement Setup and First Results*, HYTEC Inc., Los Alamos, NM, document HYTEC-TN-LIGO-17, June 1997.

Note 1, Linda Turner, 09/03/99 02:19:17 PM
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