



LIGO Laboratory

Date:	8 Apr 2016
Refer to:	L1600062-v1
Subject:	Review Committee Report: Non-Magnetic Blade-spring Damper (NMBD)
From:	Review committee: Dennis Coyne (chair), Giles Hammond, Brian O'Reilly, Brett Shapiro

Recommendation

We recommend that the project proceed with installation of the Non-Magnetic Blade-spring Damper (NMBD).

Background

The purpose of the Non-Magnetic, Blade-spring Damper (NMBD), D1400298, is to damp the first internal mode of the blade-spring of the Upper Intermediate Mass (UIM) of the quadruple pendulum suspension. The development team (Calum Torrie, Norna Robertson, Eddie Sanchez, Gary Traylor, Betsy Bland, et. al.) have finished testing and (due to the urgent schedule needs) are into fabrication in support of the current vacuum vent activities at LLO. This technical review is of the design, performance testing and planned installation procedures.

We reviewed the following documents and teleconferenced with Norna and Calum on April 6th to review comments, questions and define follow-up actions.

- [T1600046](#): Requirements, recent results and conclusions from testing of the UIM NMBD
- [E1600011](#): BRD and Blade Damper installation procedure in UIM in-situ

Other documentation regarding the non-magnetic, UIM blade spring damper are collected at (linked from) [E1600007](#). (Some questions and answers are also posted as an "other file" in the DCC entry for [T1600046](#).)

Actions

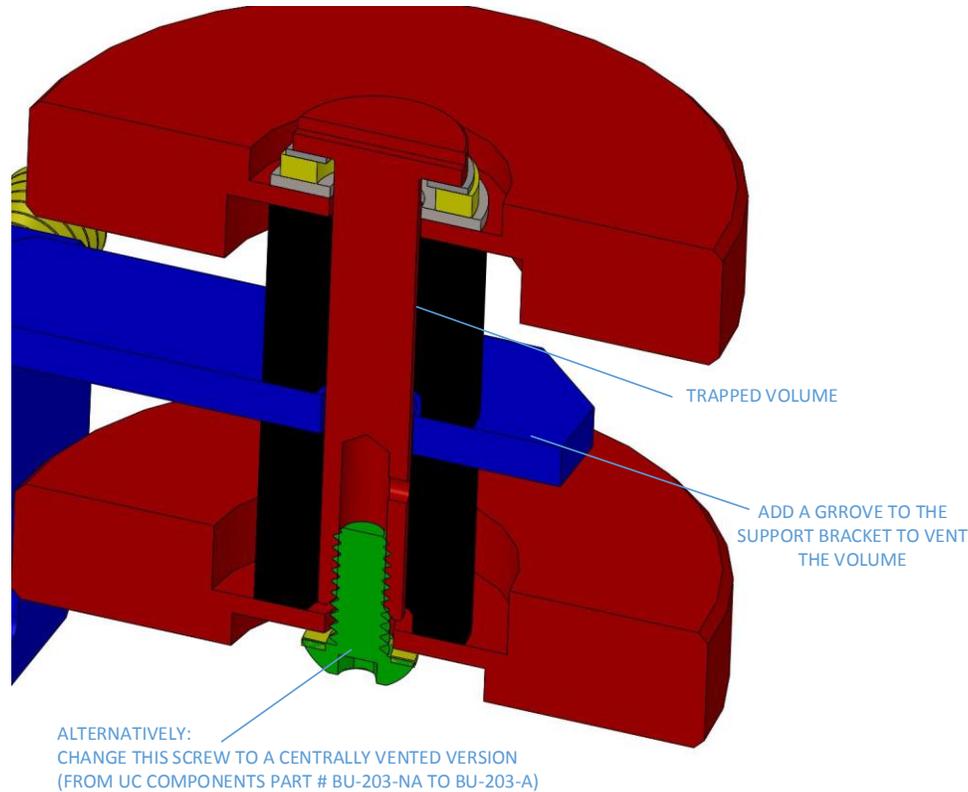
The following actions are required follow up to the review.

- 1) Assembly temperature: Due to a concern that the viscoelastic damping performance may be temperature dependent, the units should be assembled and their damping performance tuned/tested in a lab at approximately the same temperature as the LVEA/VEA environments at the observatories.

Done: Subsequent to the meeting, the lab in which the NMBD are assembled, tuned and tested, was set to 68 F, the same temperature intended for the LVEA/VEA spaces at LLO. In addition, an analysis/estimate ([T1600098](#)) of the likely change in damping

performance indicates that units tuned/tested at 75 F, should experience only about a ~14% increase in Q when employed at 65 F, i.e. an acceptable variation.

- 2) **Venting:** The design has a trapped volume which must be vented either (a) with a groove in the bracket at the location where either Flourel Spring/Damper sits, or (b) with a vented #2-56 screw.



Done: Subsequent to the meeting a groove was added to the brackets for the assemblies intended for LLO's ITMs. Future units will incorporate a vented #2-56 screw.

- 3) **Mitigate accelerometer effects on damping measurements:** The lack of damping measurement repeatability in tuning the NMBD, presumably due to the accelerometer mass, adhesive (bee's wax) and cabling should be either mitigated by moving the accelerometer to the clamped end of the blade spring, or eliminated by using a non-contact vibration sensor (e.g. a laser vibrometer).

Done: The final testing of the assemblies was performed with the accelerometer mounted next to the blade spring clamp. The measurements are now much more repeatable and less sensitive to the accelerometer cable dressing.

- 4) **Installation Procedure:** The installation "procedure" document, [E1600011-v2](#), needs work. This document is mistitled (in the pdf document) as "QUAD Bounce Roll Damper Install Notes". The title should convey the fact that installation of the NMBD is also addressed. Moreover either this document should be expanded to be an actual procedure and/or checklist (or a separate document should be written). This procedure should call out the "standard" and applicable steps of the chamber entry & exit procedure, as well as other "standard" procedures such as placing the quad masses on their earthquake stops, adding temporary shelving to catch tools or parts, etc.

Response pending.

Comments/Observations

The following are additional comments and suggestions are not as consequential as the above actions, but may be worthy of follow-up if practical.

- 1) Section 2 cites the ECR which authorizes this implementation of a “tuned mass damper”. It would be good to clarify that this is a broadband damper, or more generally a “dynamic absorber”¹ and not a “tuned mass damper”.
- 2) Section 4 of T1600046-v2: Should revise the text to explicitly state that during assembly the two threaded fasteners (items 7 and 10 in assembly D1400298-v7) are “bottomed out” and thus the amount of Viton compression is entirely adjusted by the thickness of the stack-up of washers.
- 3) The tolerancing of the features of the parts which control the amount of Spring/Damper ([D1500314](#)) compression is not optimal. While the length of the shoulder washer ([D1500312](#)) is tightly toleranced ($\pm .001$), the features of the other parts that define the default compression are indirectly dimensioned and tolerance loosely ($\pm .010$).
- 4) The title of the Spring/Damper piece part ([D1500314](#)) is “Viton Damper”, whereas the material callout is specification [E970130](#) which is for Flourel. Viton is a DuPont trademarked material, whereas Flourel is a 3M trademarked material.
- 5) The range of washer thicknesses for the parts called out in the assembly drawing (items 13, 14 and 15 in assembly [D1400298-v7](#)) are indicated in the table below. There is essentially no difference between the thickness ranges of items 13 & 14. You may wish to specify another washer option.

item # (D1400298-v7)	part #	thickness (in)
13	NAS620-C6L	.015 - .018
14	MS9549-5	.014 - .018
15	MS51496-P70	.029 - .035

- 6) The CAD model currently in the SolidWorks/PDMWorks vault needs to be updated as it is inconsistent with the drawings posted to the DCC. In particular the Spring/Damper part ([D1500314](#)) has a length of .283” in the vault, whereas [D1500314-v1](#) indicates a length of .313”. The CAD model has the NAS620-C6L washer thickness set to .010”, well below its actual minimum thickness.
- 7) Obsolete Eddy Current Damper (ECD) copper part installation ambiguity: Section 4 of T1600046-v2 states that it is currently not known if the copper ECD inserts (D060381) exist on the LHO quads. In section 2 of E1600011, the installation procedure, it is stated that these copper ECD inserts will be removed. This discrepancy should be clarified.
- 8) The nominal amount of compression of the Flourel spring/dampers should be documented; It appears to be ~10%. This level of compression is reasonable and comparable to o-ring applications and should not result in significant relaxation over time.
- 9) The nominal clearance, above and below, the NMBD when installed is expected to be ~ .08” (~2mm); This should be documented in the assembly procedure. It was

¹ e.g. J.C. Snowdon, Vibration and Shock in Damped Mechanical Systems, John Wiley & Sons, cr 1968.

mentioned in the teleconference that the actual clearance will depend upon whether the in situ blade spring is horizontal, or whether it droops, or is high. It was suggested that if the blade spring was higher than horizontal, then the aluminum bracket which mounts the NMBD can be "bent" (plastically, permanently deformed) to split the available clearance, top and bottom. A better solution, is to make a shorter bracket such that the minimal acceptable clearance between the NMBD and the spring is controlled by the machined bracket (and the NMBD is parallel to the blade spring). This minimum acceptable clearance value should also be defined in the installation procedure.