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Vibration Measurement and Mount Design for Cryocoolers on GMT and Large Telescopes

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ABSTRACT

Cryocoolers have long been demonstrated to be a dominant source of vibration that have caused significant problems with AO systems on large telescopes. Existing large telescopes have already imposed strict vibration requirements on instruments in response to existing problems, and have often struggled to achieve them. As the field moves into the next generation telescopes with GMT, TMT and eELT, vibration requirements continue to get ever tighter. Instrument teams must respond to these more demanding requirements by careful selection of cryocoolers and thoughtful design of cryocooler mounts that are matched closely with the specific requirements of the telescope. As we will demonstrate in this paper there is not a one-size-fits-all solution for every instrument and every telescope.

In this paper we demonstrate a general method of deriving the required performance for an anti-vibration mounts for cryocoolers. First we characterize a linear Stirling-type cryocooler as a source of vibration, and determine what compliant mounts would be required to make them acceptable for use on the VLT, GMT and TMT. Measurements are taken of vibration from a Cryotel GT linear Stirling cooler (with active vibration cancellation enabled). By comparing the measured vibration against the requirements of each telescope, we are able to determine the required transfer function and therefore the required spring rate for compliant mounts. The results indicate that while some simple rubber mounts may be sufficient for use with the VLT and TMT, but a compliant mount with natural frequency below 14 Hz must be used for GMT.

Keywords: Vibration, Cryocooler, GMT, Stirling, VLT, TMT

1. METHOD

A Cryotel GT was used as a source because it is sold with an Active Vibration Cancellation (AVC) module and advertises low vibration operation. In a similar method to the one used by Vaccarella [1], Cryocooler vibration was measured by mating the Cryotel to a multi-axis vibration characterizer (MAViC), which suspends the cryocooler in 5 degrees of freedom. The MAViC isolates at a natural frequency below 0.7Hz, combining this with a rigidly mounted six axis accelerometer capable of DC measurements, allows very accurate measurements to be made.

Figure 1-1: Test setup for vibration testing done at the ANU

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Measurements were compared against the instrument requirement for the VLT [2], GMT, and TMT [3]. Based on those, the amount of required isolation can be derived and used as a guideline for designing cryocooler mounts.

2. RESULTS

For acceptance on the VLT, the acceleration PSD is normalized and compared to the limits published in [2]. Without any attenuation, the Cryotel GT is acceptable for use hard-mounted to a Nasmyth platform instrument, but the 60 Hz spike makes it unsuitable for use on the Cassegrain focus without a softer mount.

The same data are used in Figure 2-1 to assess the acceptance of the Cryotel GT for use on GMT and TMT. Very clear in the GMT and TMT specifications are both the difference in sensitivity, and the tightness of the requirements. Clearly a carefully designed AV mount is needed for this cryocooler to be used on either telescope.

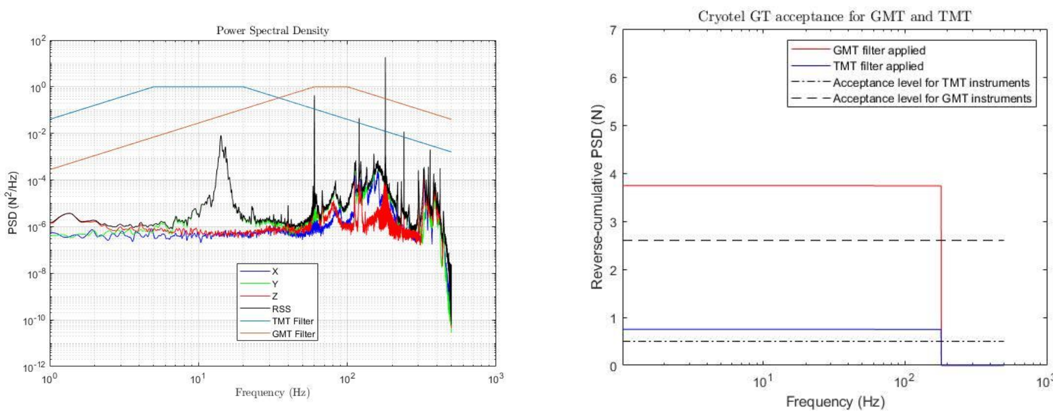

Figure 2-1: Acceleration data compared to the acceptance criteria for GMT and TMT

3. CONCLUSIONS

In the case of the VLT, the Cryotel GT may be used without any further attenuation. To cool larger instruments for GMT, such as GMTIFS, approximately 14 Cryotel GT coolers would be needed. In order to keep the force transmitted below 0.5 N, each of the 14 coolers must transmit less than 0.13 N if assumed to be out of phase. The required fundamental frequency for an AV mount can be determined by multiplying the PSD by the ideal spring transfer function and integrating as shown in Figure 3-1. As a reference for the required performance, the AV mount developed by ESO [4] is used as an example of a 7 Hz isolator.

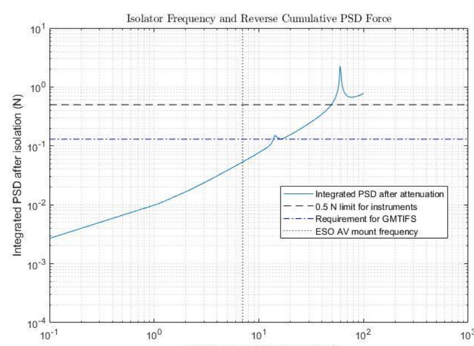

Figure 3-1: Required mounting frequency for an AV mount

4. REFERENCES

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