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VIBRATION CONTROL BEST PRACTICES FOR PXIE

BACKGROUND

PXIE SRF cavities are expected to be sensitive to microphonics. Requirements are in development [1] to address this concern. It is expected that the PXIE cryomodule systems and their interfaces will be designed with explicit vibration mitigation features to respond to those requirements. Active vibration control may be employed.

There are numerous other systems in PXIE and in CMTF that could induce vibrations or otherwise exacerbate the sensitivity of the SRF cavities. It is the purpose of this document to specify simple “best practices” to be followed in equipment installation in PXIE and CMTF to minimize vibration for the accelerator. This document will not be applicable to cryomodules or their immediate interfaces, where more rigorous assessment will be required. This document does, however, specify minimum practices to be observed.

Existing PXIE/CMTF Vibration Environment

The vibration environment of PXIE and CMTF has been measured [2]. A representative integrated vertical displacement plot is given in Figure 1. In the area of PXIE, vertical ground motion is approximately 100nm RMS, and is dominated by a 60Hz term.

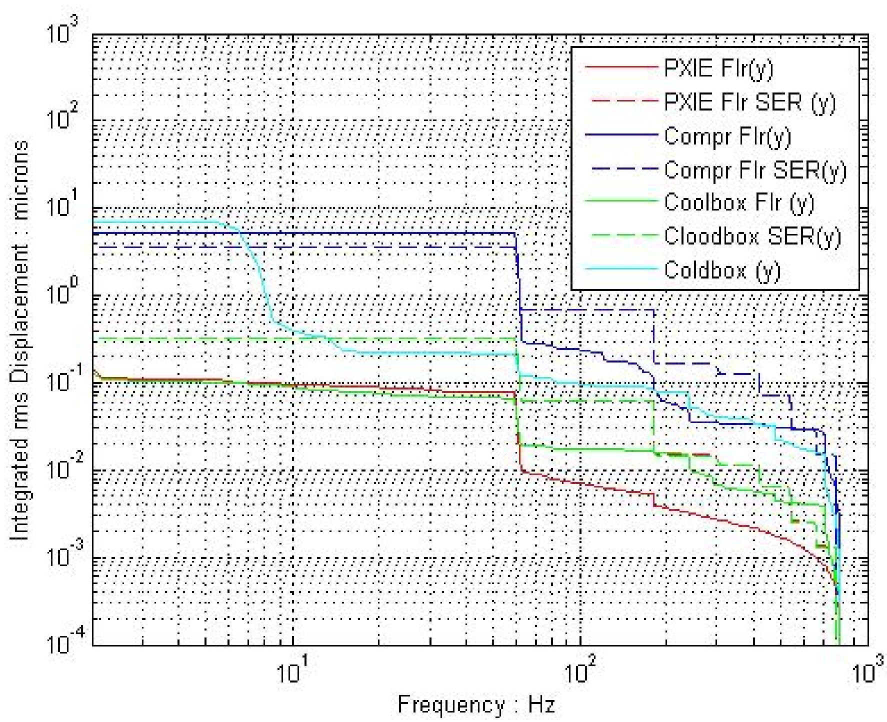

Figure 1: CMTF Integrated Vertical Displacement

This environment is driven by the cryoplant, and is not expected to be improved upon as PXIE is built.

Known vibration sources

Numerous vibration sources are expected in the CMTF building. These include:

- Environmental sources
    - E.g. Truck traffic to CMTF
- Rotating equipment
    - Pumps
    - Fans
- Fluids systems
    - Water hammer
    - Flow vibration
- Acoustic sources

Equipment known to have one or more of these vibration sources should be designed and installed in a way to minimize vibration induced on PXIE.

Guidelines for isolating vibration-inducing equipment

Any equipment known, believed, or observed to be producing significant vibration should be isolated at its interfaces to minimize propagation of the vibration.

The method for vibration isolation will depend on the nature of the component being isolated. Some general guidelines are given below.

1. **Geographic Isolation:** Mount known vibration sources as far a practical from PXIE SRF components. Avoid mounting vibration sources on or near structures with rigid connections to the beamline or the cryomodules.
2. **Passive Vibration Isolation**: Vibration sources should be equipped with explicit isolation features.   Isolation should be between the equipment and the floor, as well as between the equipment and any other significant load path (e.g. rigid piping out of a pump). In almost all cases this will be passive isolation. Options include:
    - Compliant mounting (spring mounting)
    - Wire-rope vibration isolators (e.g. http://www.isolator.com/)
    - Damping mounts (e.g. rubber standoffs)
    - Tuned mass dampers
3. **Frequency matching:** Ensure effective isolation at the offending frequency. Compliant isolators (e.g. wire rope isolators) will typically have a low natural frequencies, and will attenuate vibration only at frequencies significantly above their own low natural frequency.
4. **Consider acoustical coupling**: Loud equipment should be completely avoided within the PXIE cave. If it cannot be, sound-deadening measures should be taken
5. **Consider fluid coupling**: Even with vibration-isolated piping, vibration may be created and/or transmitted through cooling fluids. Consider local accumulator tanks near critical components to limit vibration and water hammer.
6. **Robustness:** Ensure that lifetime and robustness of isolating equipment is compatible with the hardware being isolated. For limited-life items like scroll pumps, rubber damping mounts may

be appropriate. For equipment installations expected to last decades, spring or wire rope mounting may be more appropriate.

7. **Reliability:** avoid pneumatic isolators and others with non-graceful failure modes

Guidelines for beamline structural design

Vibrations must be kept especially low on beamline structure. This is not only because of direct coupling to the cryomodules, but also because vibration can compromise beam options and instrumentation. The following are only guidelines, stricter requirements may apply in some areas.

1. **Avoid low natural frequencies (<10Hz) in structure**: Low frequencies imply low stiffness, and beyond a certain limit incidental loading and alignment stability becomes a concern.
2. **Avoid natural frequencies near 60Hz and harmonics**: As can be seen in Figure 1, there is very large excitation at 60Hz.
3. **Ensure that connections to vibration sources are compliant**: For example, fluid hosing should have an appropriate service loop.
4. **Consider viscoelastic damping of transmission paths**: this may be effective, particularly for higher frequency terms propagating through stiff paths like beampipe.
5. **Confirm that scroll pumps are isolated**: Ideally, scroll pumps backing turbos would be far away from the beamline, and would act through a roughing manifold. Where this is not possible, scroll pumps should have no direct mechanical coupling to the beamline except for the vacuum hose. Viscoelastic damping on the outside of the vacuum hose should be considered.
6. **Retrofit OEM turbopump cooling fans**: generally speaking, turbopump cooling fans are a problem because of direct mechanical coupling to the beamline. Implement soft mounting between fan and pump to limit transmission

Component Selection

For components prone to vibration, not all components are created equal. Below is a list of products known to have relatively low vibration:

Scroll Pumps

- Edwards NXDS series

I would like to build this list, suggestions for other good components welcome

References:

[1] J. Holzbauer, TBD vibration requirements document

[2] M. Mcgee, CMTF Vibration Measurement, Oct 2-3 2013 (replace with newer measurements when available)

[3]