Vibration measurements on LHCb Pump

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On behalf of Mechanical Measurement Laboratory

9/20/22
Instrumentation Overview

3 ICP triaxial accelerometers
- Measurement range: 50g
- Sensitivity 100mV/g
- Frequency range: 2…7000Hz

**MicroQuantus® Spectrum Analyzer with PAK capture software;**
- Online visualization
- Storage in an SSD hard drive
- Sampling Frequency: 1024 Hz
Throughtput

![Graphs showing vibration measurements on cooling system for LHCb](image)

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Compressor frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>180</td>
</tr>
<tr>
<td>300</td>
<td>500</td>
</tr>
<tr>
<td>520</td>
<td>650</td>
</tr>
<tr>
<td>720</td>
<td>850</td>
</tr>
<tr>
<td>900</td>
<td>1050</td>
</tr>
</tbody>
</table>

Vibration measurements on cooling system for LHCb - EDMS2777793
RMS vibration velocity (mm/s) at different frequencies
RMS vibration velocity (mm/s) at different frequencies

Table 3 — Summary of overall constant vibration velocity values for different compressor system parts

<table>
<thead>
<tr>
<th>Compressor system part</th>
<th>RMS vibration velocity values for horizontal compressors mm/s</th>
<th>RMS vibration velocity values for vertical compressors mm/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Frame (top)</td>
<td>5.3</td>
<td>8.0</td>
</tr>
<tr>
<td>Cylinder (lateral)</td>
<td>8.7</td>
<td>13.0</td>
</tr>
<tr>
<td><strong>Cylinder (red)</strong></td>
<td><strong>10.7</strong></td>
<td><strong>16.0</strong></td>
</tr>
<tr>
<td>Dampers</td>
<td>12.7</td>
<td>19.0</td>
</tr>
<tr>
<td>Mainline piping</td>
<td>12.7</td>
<td>19.0</td>
</tr>
<tr>
<td>Small bore connection</td>
<td>See Table E.3</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: For mainline piping vibration values above evaluation zone boundary C/D, see Table E.3.
Piping Vibration Criteria

API 618 (excerpt)

7.9.4.2.5.2.4 Piping Design Vibration Criteria

The predicted piping vibration magnitude shall be limited to the design level in Figure 4. The diagram in Figure 4 is based on the following:

a. a constant allowable vibration amplitude of 0.3 mm peak-to-peak (20 mils peak-to-peak) for frequencies below 10 Hz (the frequency of 10 Hz is also according to ISO 10816);
b. a constant allowable vibration velocity of approximately 0.22 mm/s peak-to-peak (0.25 in./s peak-to-peak) for frequencies between 10 and 200 Hz.

The limits in Figure 4 are intended as a design trigger point for analysis in accordance with 7.9.4.2.5.2.1. These values should not be used as field acceptance criteria.

Note: The requirements in this subsection are considered to be conservative. There are however situations in which high stress risers and unbonded small diameter attached piping can pose a problem even though the main pipe exhibits acceptable vibration limits. There are no criteria conservative enough to be used without a significant understanding of vibrational mechanics.

Figure 4—Piping Design Vibration at Discrete Frequencies
API 618 ref Norm: Vibration peak to peak on base line 25Hz
API 618 ref Norm: Vibration peak to peak on base line 25Hz

- **Velocity**
  - Peak to peak – Filter 10 to 200 Hz

- **Displacement**
  - Peak to peak – Filter below 10 Hz

Threshold
API 618 ref Norm: Vibration peak to peak on base line 25 Hz

**Velocity**
Peak to peak – Filter 10 to 200 Hz

**Displacement**
Peak to peak – Filter below 10 Hz

Threshold
API 618 ref Norm: Vibration peak to peak during ramp

Velocity
Peak to peak – Filter 10 to 200 Hz

Displacement
Peak to peak – Filter below 10 Hz
Conclusion

• After the first measurements, we can see that the compressor complies with ISO 20816-8-2018 standards.

• With regard to the piping, the exchanger and the downstream assembly is at the limit of compliance according to API 618 standards (the peak-to-peak velocity is slightly higher than the lateral requirement).

• Finally, the upper part of the piping (large diameter) is much higher than the requirement.
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