Flexible transfer lines.
Pressure drop analysis.

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RAL
Proposed flexible transfer lines

VERY LOW-LOSS LIQUID HELIUM TRANSFER WITH LONG FLEXIBLE CRYOGENIC LINES

by

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Table 1. Main characteristics of the corrugated stainless-steel tubes

<table>
<thead>
<tr>
<th>Tube No.</th>
<th>Inner diameter (mm)</th>
<th>Outer diameter (mm)</th>
<th>Wall thickness (mm)</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>13</td>
<td>0.3</td>
<td>AISI 304L</td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>25</td>
<td>0.3</td>
<td>AISI 304L</td>
</tr>
<tr>
<td>3</td>
<td>39</td>
<td>44</td>
<td>0.4</td>
<td>AISI 304L</td>
</tr>
<tr>
<td>4</td>
<td>60</td>
<td>66</td>
<td>0.5</td>
<td>AISI 304L</td>
</tr>
<tr>
<td>sheath</td>
<td>66</td>
<td>73</td>
<td>3.5</td>
<td>Polymer</td>
</tr>
</tbody>
</table>

Fig. 1. Cross-section of a flexible transfer line showing the four corrugated stainless-steel pipes, helical braid spacers, metallized film insulation and external protective sheath.
Pressure drop in a flexible line

- Friction factor for a flexible line is about 4 times higher than for a plain rigid line of the same diameter.

References: Friedrich Haug’s measurements; K.Schippl’s paper; Alcatel Kabel AG catalogue on transfer lines.
Liquid nitrogen cooling system: Diagram

Modes Of Operation
1. Tests of Fill and Vent Lines (No Magnet)
2. Initial Cool down with Magnet
3. Cool down after Pulse
4. Night Layover at 100K
5. Warm-up to RT

Drawn by Peter Titus
Flexible transfer line as a fill pipe

Transfer line pressure drop vs. Fill time

Fill volume = 300 l of LN

Geometry:
40 m of horizontal flexible transfer line with 4 bends

Fill volume =
300 l of LN

Geometry:
40 m of horizontal flexible transfer line with 4 bends
Flexible transfer line as a cold vent pipe

Cold line pressure drop vs. Cold nitrogen gas flow rate

Geometry:
40 m of horizontal flexible transfer line with 4 bends

Note:
formula for compressible flow is used
Conclusions so far

• For filling the magnet with liquid nitrogen use both internal and return pipes in the transfer line.

• For the venting use a separate transfer line and both pipes in it.
  But do not expect high venting rate!

To do:

• Understand better a venting process
  (what is the maximum venting rate is achievable?)

• Repeat the analysis for the proper length of the transfer lines.