Flexible transfer lines.
Pressure drop analysis.

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Proposed flexible transfer lines

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

CERN LEP-MA/89-38

by

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

Tube No.	Inner diameter (mm)	Outer diameter (mm)	Wall thickness (mm)	Material
1	10	13	0.3	AISI 304L
2	21	25	0.3	AISI 304L
3	39	44	0.4	AISI 304L
4	60	66	0.5	AISI 304L
sheath	66	73	3.5	Polymer

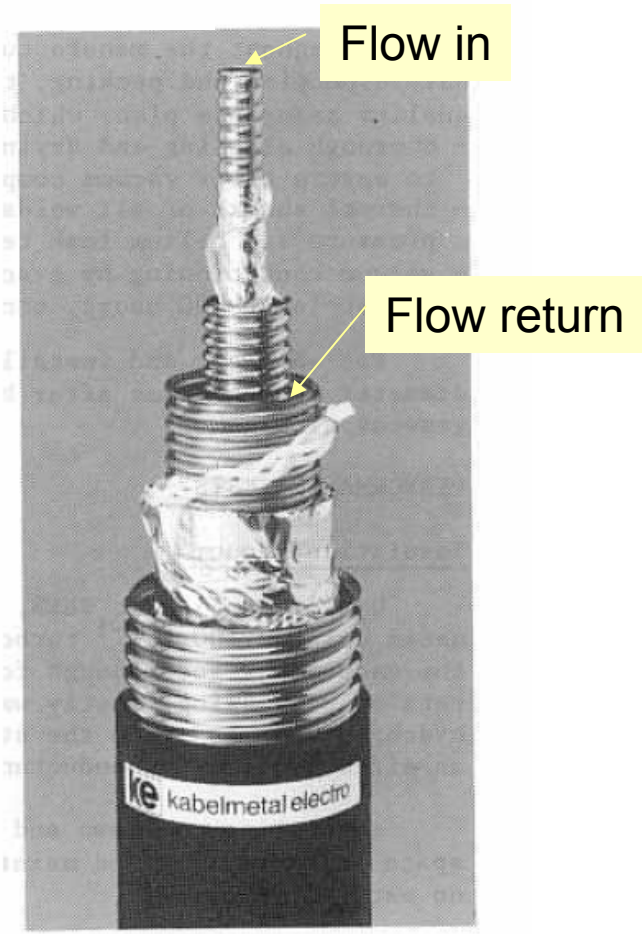


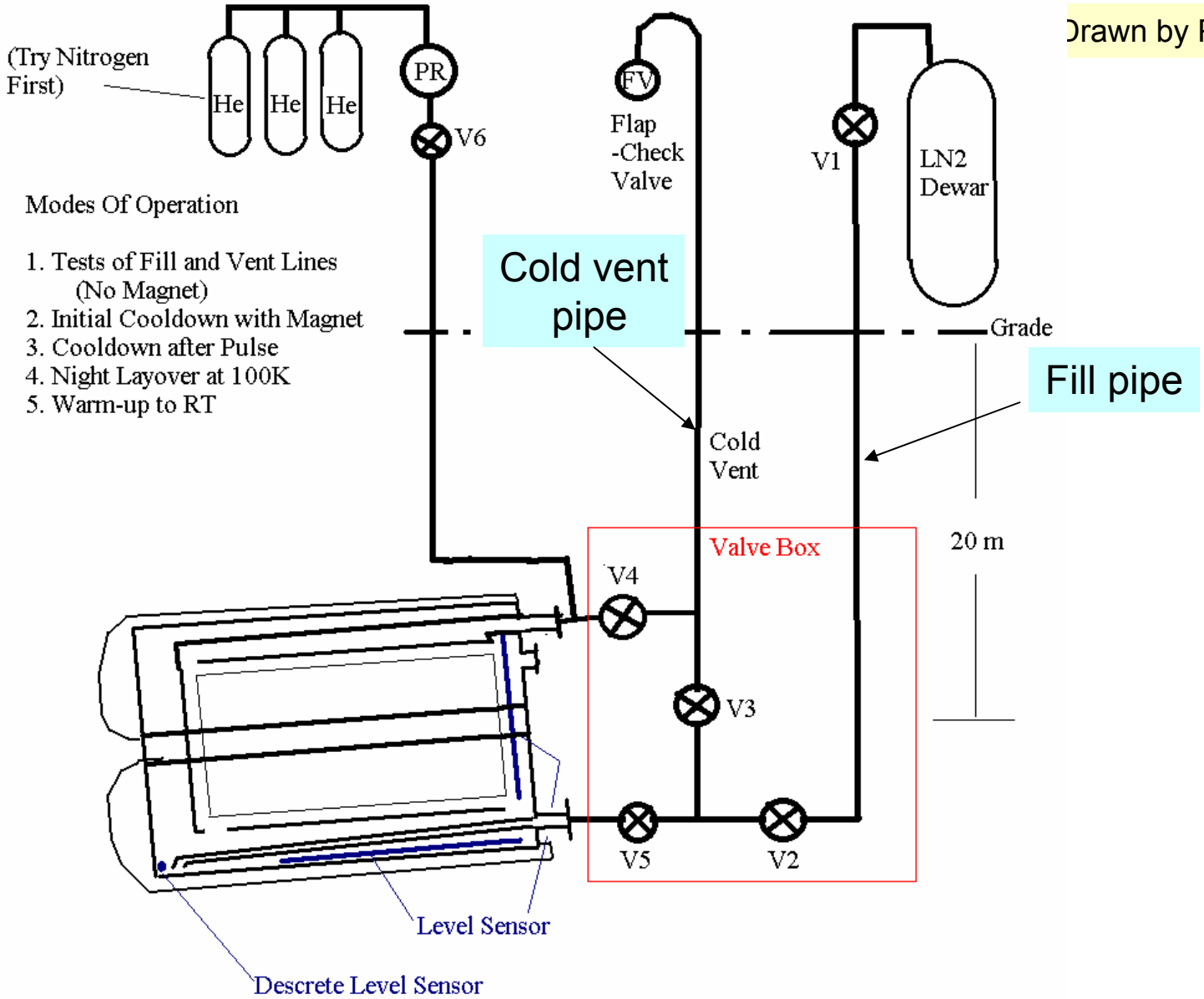
Fig. 1. Cross-section of a flexible transfer line showing the four corrugated stainless-steel pipes, helical braid spacers, metallized film insulation and external protective sheath.

Pressure drop in a flexible line

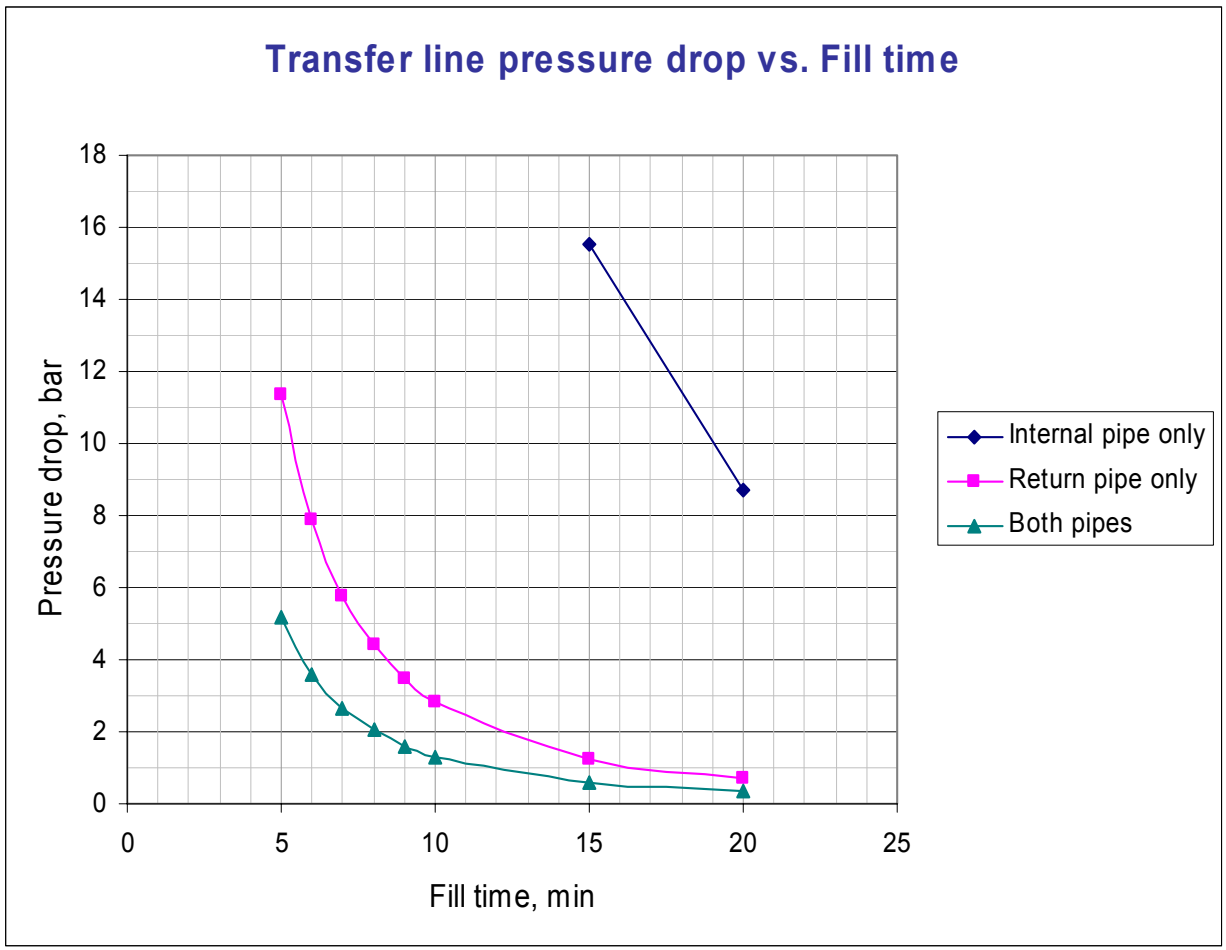
• Friction factor for a flexible line is about 4 times higher than for a plain rigid line of the same diameter.

References: Friedrich Haug's measurements;
K.Schippl's paper;
Alcatel Kabel AG catalogue on transfer lines.

Liquid nitrogen cooling system: Diagram



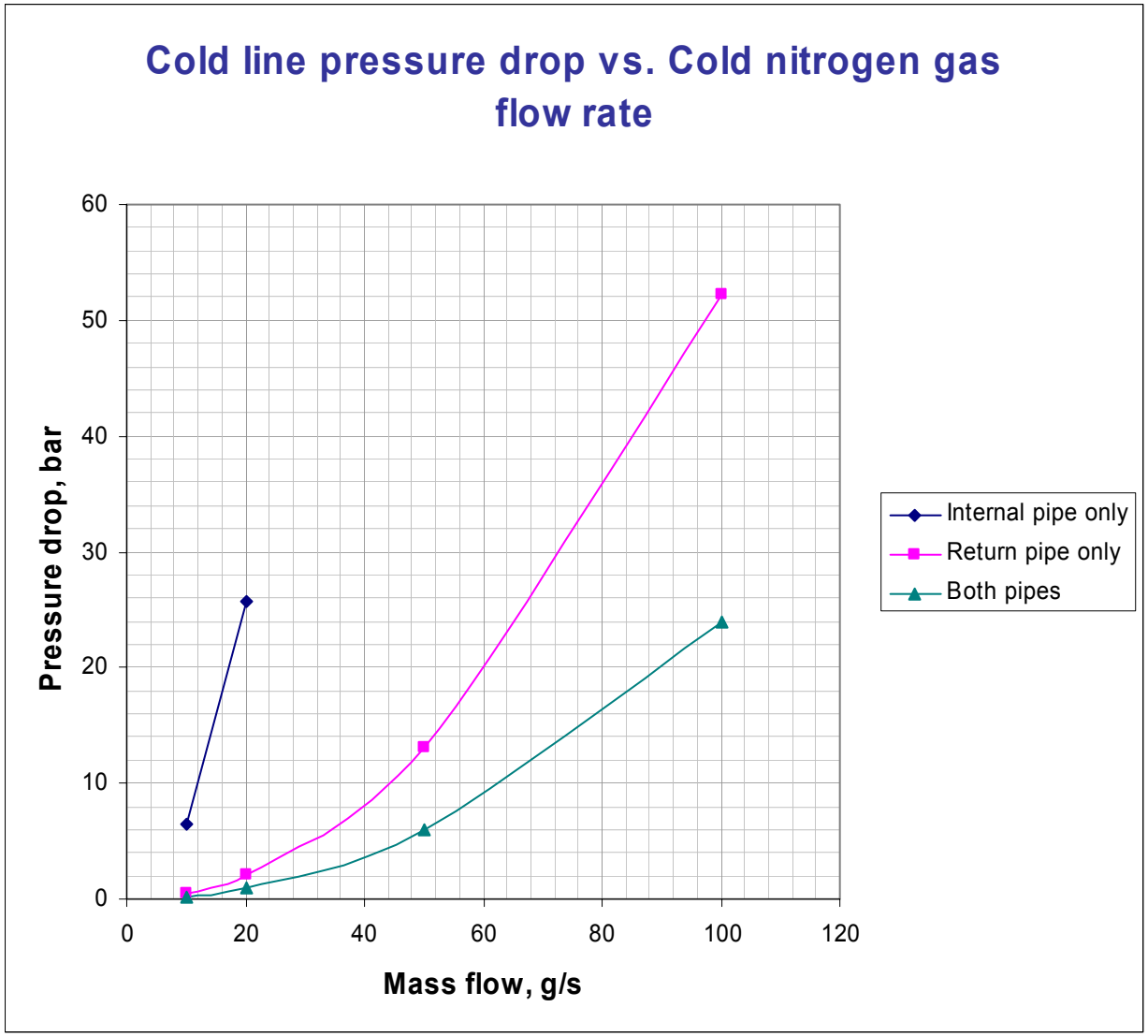
Flexible transfer line as a fill pipe



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



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.