Refno: PS/ML/Technical note/85-11

TECHNICAL NOTE 11 June, 1985

Author(s): Mats Möller

Subject: Pressure drops in the helium supply lines, for the ACOL cryogenic and cryopumping system.

---

1. SCOPE

The ACOL cryogenic and cryopumping system is equipped with a helium high pressure supply and return line distribution system (see Fig 1). It consists of one high pressure-line (HP) and one low pressure-line (LP), each with a length of approximately 110 m.
This document presents the calculation for the pressure drops in the system. It also proposes the dimensions of the tubes.

2. SPECIFICATION

1.	Pressure in HP-line:	20 bar
2.	Pressure in LP-line:	5 bar
3.	Length of HP-line:	110 m
4.	Length of LP-line:	110 m
5.	Volume ratio VLP/VHP:	1/4
6.	Flow of helium:	400 norm m^3/h
7.	Temperature:	20-30°C
8.	Max allowable pressure drop per line:	<0.5 bar

3. CALCULATIONS

The calculated pressure drop as function of the tube internal diameter, at t=20°C and at t=30°C, is shown in Table 1.

Table 1: The pressure drop in HP- and LP-line

Tube diameter id(mm)		Pressure drop Δp(bar), at t=20°C	Pressure drop Δp(bar), at t=30°C
HP:	20	0.68	0.70
	25	0.23	0.24
	30	0.10	0.11
LP:	40	0.100	0.104
	50	0.034	0.036
	60	0.014	0.015

Conclusion:
In order to satisfy the max allowable pressure drop of less than 0.5 bar, a tube of 25 mm is needed to be used for the HP-line. This gives with the volume ratio 1/4, the diameter of the LP-line; 50 mm.

Remarks:
The influence of one-time losses (valves,turnes,etc) has not been included in this calcultaion.
A rough estimate of these losses indicates that they are very small.
Example: A 90° bend gives a drop of 0.0005 bar.

4. THEORY USED FOR THE CALCULATION

The pressure drop:

$$\Delta p = p_1 - p_2 = p_1(1-\sqrt{1-\lambda v_1^2 \rho_1 l/(p_1 d)})$$

The universal gas law gives:

$$\rho = p/(R \cdot T)$$
$$R = Rm/M$$

Continuity equations:

$$\dot{m} = \rho \cdot v \cdot A = \text{constant}$$
$$\dot{V} = v \cdot A$$

Flow equations:

Reynolds number	$Re = v \cdot d/\nu$
kinematic viscosity	$\nu = \eta/\rho$
if Re>2320	$\lambda = 0.3164/\sqrt[4]{Re}$

Chemical and physical constants for helium

$M = 4.00$ kg/kmol
$R = 2079.01$ j/(kg K)
$\rho_0 = 0.179$ kg/m^3

dynamic viscosity η at p=1 atm

t (°C)	η (μNs/m^2)
0	18.7
20	19.6
50	21.0

dynamic viscosity η at t=20°C

p (bar)	η (μNs/m^2)
20	19.6
50	19.6
100	19.6

REFERENCES

[1] Dubbel, Taschenbuch fur den Maschinenbau, 15. Auflage.
[2] G.W.C. Kaye, Tables of Physical and Chemical Constants.

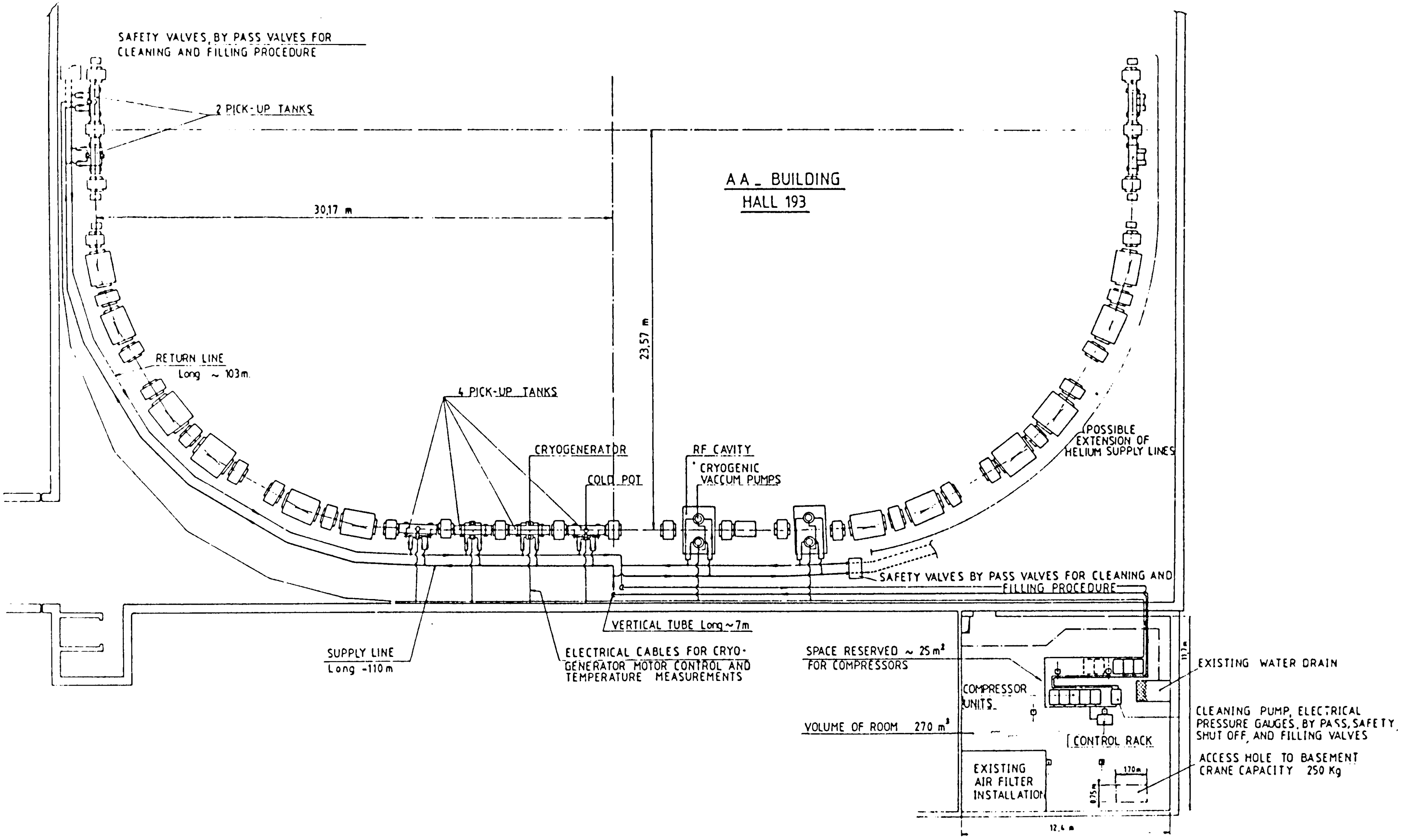

FIG. 1: HELIUM SUPPLY DISTRIBUTION FOR CRYOGENERATORS AND CRYOGENIC VACUUM PUMPS