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Design and Realization of a Simple Gas Leakage Test Setup for the Finuda Straw Tube Detector at DaΦne

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Abstract

A simple setup to measure gas pressure drops is described. Up to 50 independent channels can be simultaneously tested. The setup is being used to test gas leakage for the 3000 straw tubes which are being produced in the Astra laboratory at Frascati for the Finuda experiment. This work benefitted from the help of Mauro Giardoni who designed the leakproof connectors. Luciano Passamonti also provided important help during the assembling stage.

1 Introduction

The straw tube detector for the FINUDA experiment at LNF DAΦNE [1], composed of 2424 1.5 cm diameter Al-mylar straw tubes, is being built in the ASTRA laboratory at Frascati. Straw tubes, each one acting as individual drift chamber, will be used with a Ar-Isobuthane or Ar-CO_2 mixture, and operated at a minimal overpressure (60 mbar) and modest flux (1 volume/day). Gas leakage from the straw tubes:

- affects performances, due to mixture contamination with air;
- wastes gas in the detector.

The simple setup devised allows one to test online to the straw tubes fabrication process the extent of the leakage, and to discard faulty tubes.

Design principles for the setup were:

- test of 50 tubes at one time
- max intrinsic leakage *(baseline leakage)*: 2-3 mbar/day
- precision better than 0.5 mbar
- simple operation
- long term reliability
- low cost.

2 The Setup

Gas leakage is detected by measuring the pressure drop after a time interval. The setup is shown schematically in Fig. 1. Each straw tube under test is connected to a U-manometer via its 2-mm diameter Rilsan tubing, sealed to the feed-through with 3 min epoxy. The bore map of the aluminum and Plexiglas plates is in fig. 2

The open end of the 2-mm tubing is connected to the test setup by means of the connector [2] shown in Fig. 3. Designed in order to minimize leakage between the D1 distributor and each straw Rilsan tube, this connector consists of one O-ring with a 2 mm inner diameter and a Delrin cylinder. Once the Rilsan tube is inserted in the connector, the nut pushes the Delrin cylinder which forces the O-ring to tighten the Rilsan tube. Fig. 4 shown a picture of test-setup.

Each U-manometer - a 6/4 mm Rilsan semitransparent tubing - is filled with GALILEO Rotoil LV 32 low viscosity vacuum pump oil. Such a choice was found optimal after having investigated several options. Distilled water was discarded because of evaporation, acidity and colorlessness. Ethyl alcohol was discarded because attacking the Rilsan tubing. A test of a water column topped by two caps of oil was also discarded for operational difficulties in installing the toppings.

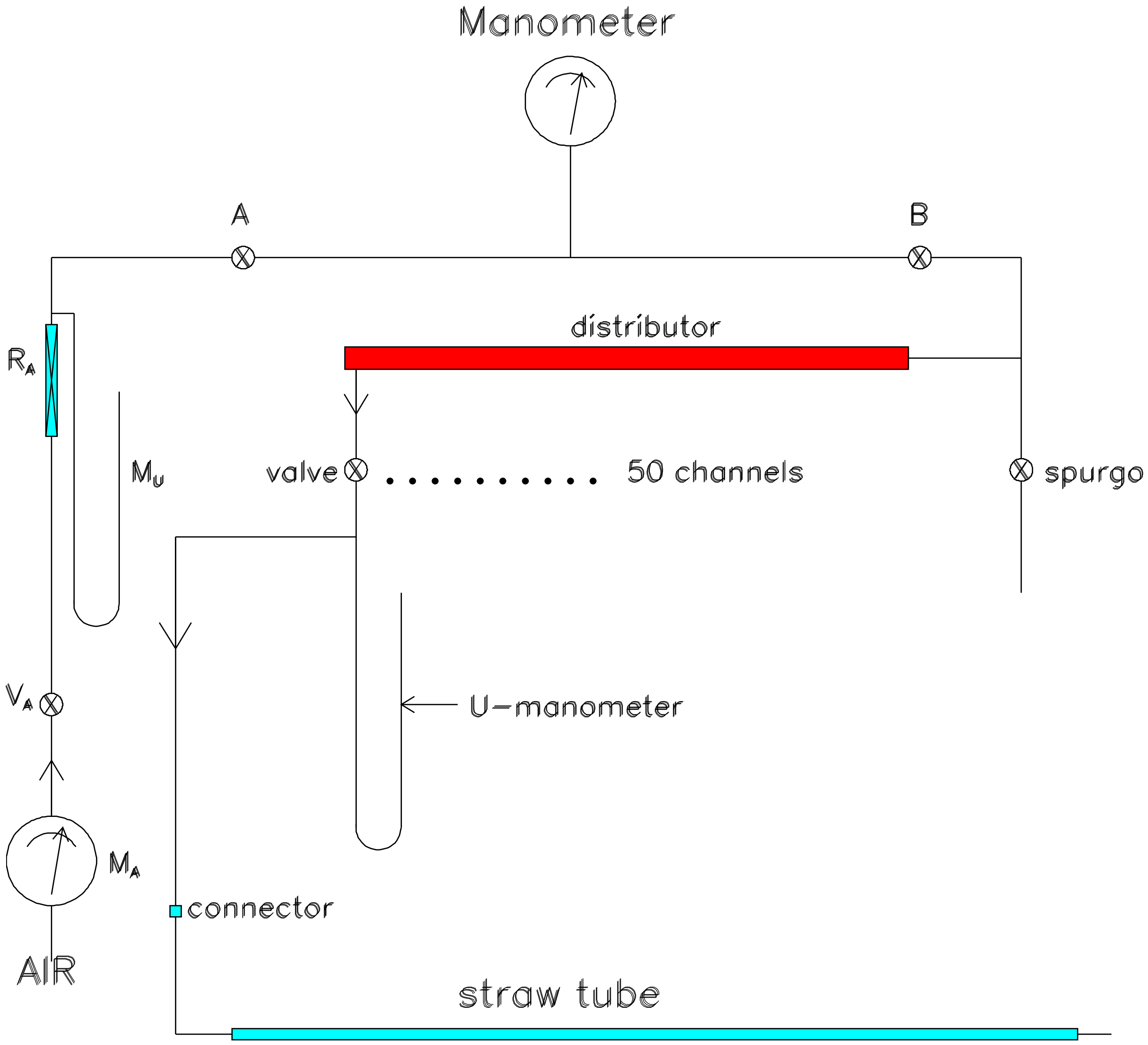

Figure 1: Overall sketch of the test setup.

All junctions (see Tab. 1 for a complete list of components [4]) are sealed with Dow-Corning vacuum grease. All switches have been tested prior to assembling. The distributor D1 allows to use one input line for all 50 channels. A purge valve SPURGO avoids spurring of oil in case of human error. The oil level in each U-manometer is measured with a precision of 0.15 cm which correspond to $\sim$ 0.2 mbar.

Table 1: Components of the test setup.

components	q.ty
valves (Mod. 2839)	53
L pipe-fitting (Mod. 1500)	55
branch (Mod. 1420)	55
I pipe-fitting (Mod. 1463)	60
Rilsan tube (6-4 mm)	200 m
manometer (100 mbar)	1
rotameter	1

In order to correct the straws pressure drop for the atmospheric pressure and temperature variations, the system is equipped with two straw tubes permanently connected, to be used as reference monitoring for the straw tubes under test. A detailed discussion how these two straws are used will be reported in an upcoming paper[3]. The Appendix shows operating instructions for the test procedure.

3 Commissioning

The setup has been commissioned using filtered compressed air. Baseline leakage has been tested by monitoring the pressure drops with inputs clogged with thermic-soldered 2 mm Rilsan tube. Each channel has been pressurized up to 80 mbar and the pressure drop monitored for 24 hours. Fig. 5 shows pressure variations after 24 hour operation for a given channel. In order to determine the real leakage of the system we have to correct for atmospheric pressure (Π^{atm}) and temperature (T^{atm}) variations monitored during the operation.

We correct for Π^{atm} and T^{atm} variations according to the formula:

$$P_i V = nRT_i \tag{1}$$

where P_i is the pressure read in U-manometer at time t_i. Assuming gas volume to be the same for all channels, eq. 1 can be written as:

$$\frac{P_i}{T_i} = constant \tag{2}$$

By indicating with Π_0^{atm} and T_0^{atm} atmospheric pressure and temperature at initial time, the corrected pressure P_i^c is given by:

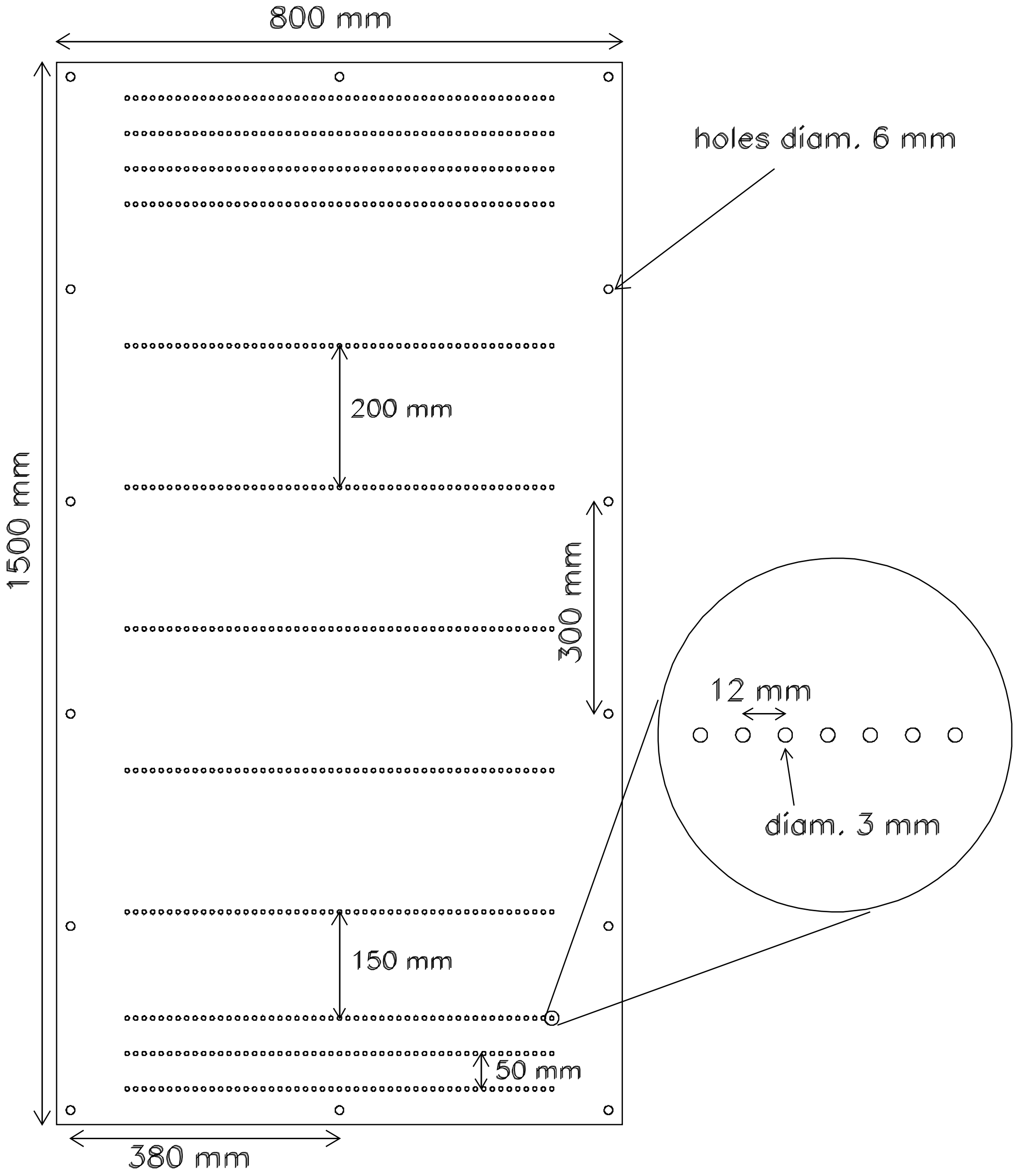

Figure 2: Bore map of the Plexiglass and Aluminum plates respectively with thickness of 5 mm and 3 mm.

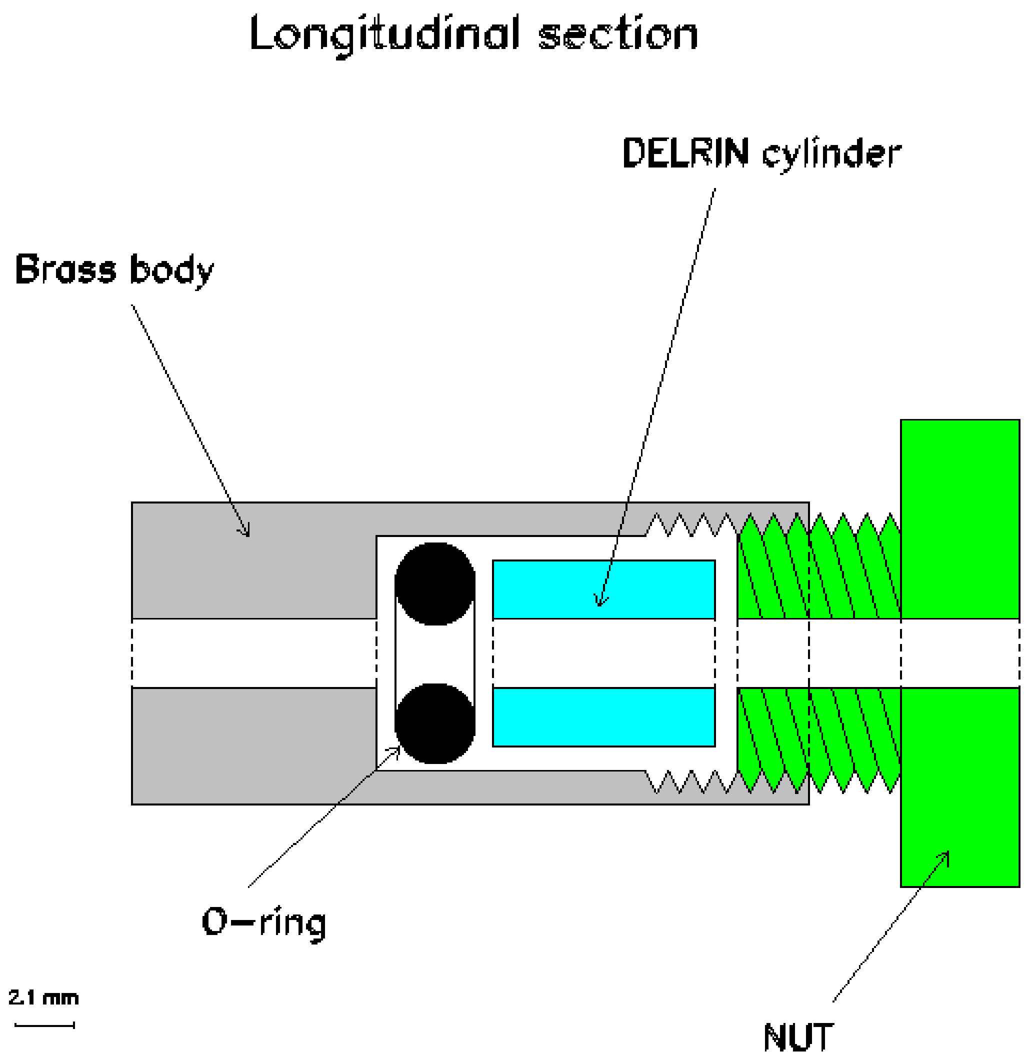

Figure 3: A schematic picture of the connector used to connect straws to the D1 distributor. The nut pushes the Delrin cylinder, which forces the O-ring to tighten the Rilsan tube connected to the straw.

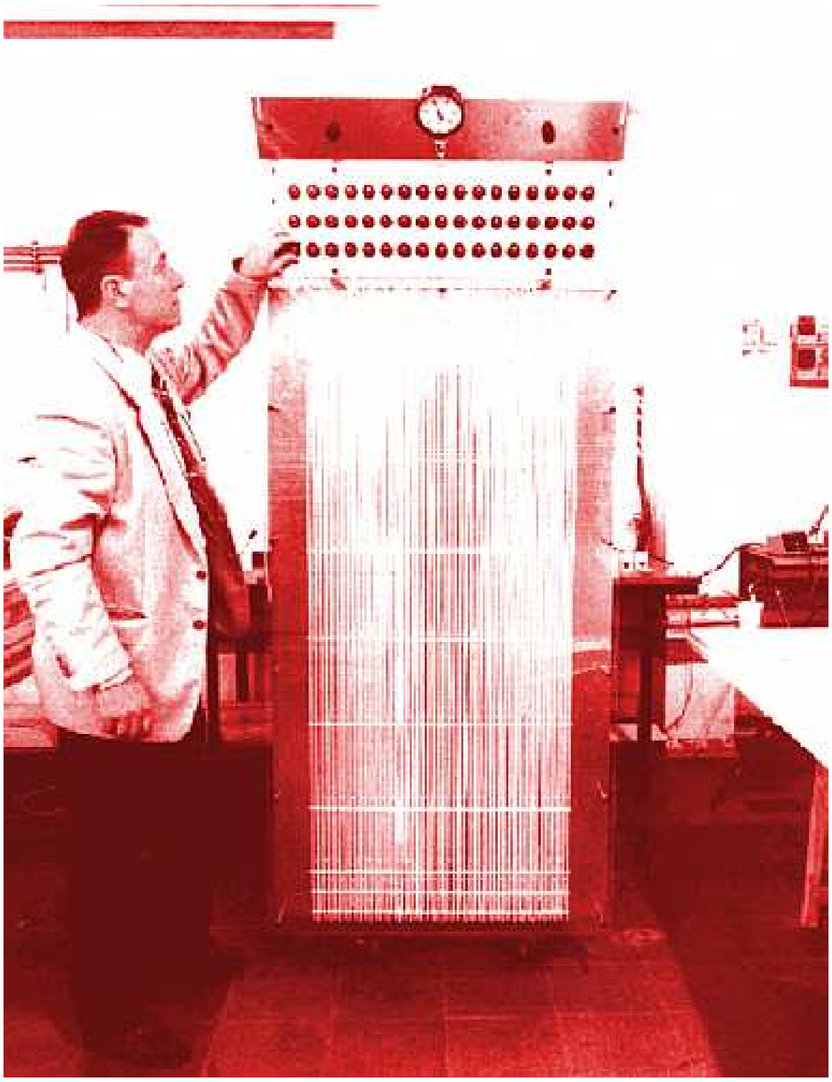

Figure 4: The test setup.

$$P_i^c = (P_i + \Pi^{atm})\frac{T_i}{T_0^{atm}} - \Pi_0^{atm} \tag{3}$$

After this correction we can see (Fig. 6) the real pressure drop versus time in the leakage setup. The τ slope parameter given by a best fit of an exponential to experimental data is a good estimator of the baseline leakage for each channel. In table 2 are listed the time constants for all 50 channels. The minimum value of τ is $\sim$ 1300 hours. According to the exponential drop of the overpressure, such time constant correspond to a pressure drop of $\sim$ 1.3 mbar/day well below the design specifications.

The maximum leakage accepted for a straw ($\sim$ 100 hours) is one order of magnitude less than baseline leakage and therefore negligible in the further analysis of straw leakage.

Table 2: Time constants and relative pressure drop for the 50 channels of D1 distributor.

Channel	τ (h)	pres. (mbar/day)		Channel	τ (h)	pres. (mbar/day)
1	1367	1.3		26	1363	1.3
2	1681	1.1		27	1670	1.1
3	2218	0.7		28	1363	1.3
4	2319	0.7		29	3249	0.5
5	3322	0.5		30	3317	0.5
6	1740	1.0		31	1769	1.0
7	1362	1.3		32	1696	1.1
8	1363	1.3		33	1463	1.2
9	1358	1.3		34	2368	0.7
10	1358	1.3		35	3765	0.4
11	1694	1.1		36	2309	0.7
12	2273	0.7		37	1654	1.1
13	1688	1.1		38	7054	0.3
14	1336	1.3		39	1674	1.1
15	8080	0.2		40	3074	0.6
16	7654	0.2		41	2654	0.7
17	1683	1.1		42	3688	0.5
18	2309	0.7		43	1614	1.1
19	1765	1.0		44	1536	1.2
20	1399	1.3		45	1794	1.0
21	1331	1.3		46	2080	0.8
22	3731	0.5		47	3273	0.5
23	3730	0.5		48	4654	0.3
24	1769	1.0		49	1358	1.3
25	3714	0.5		50	1683	1.1

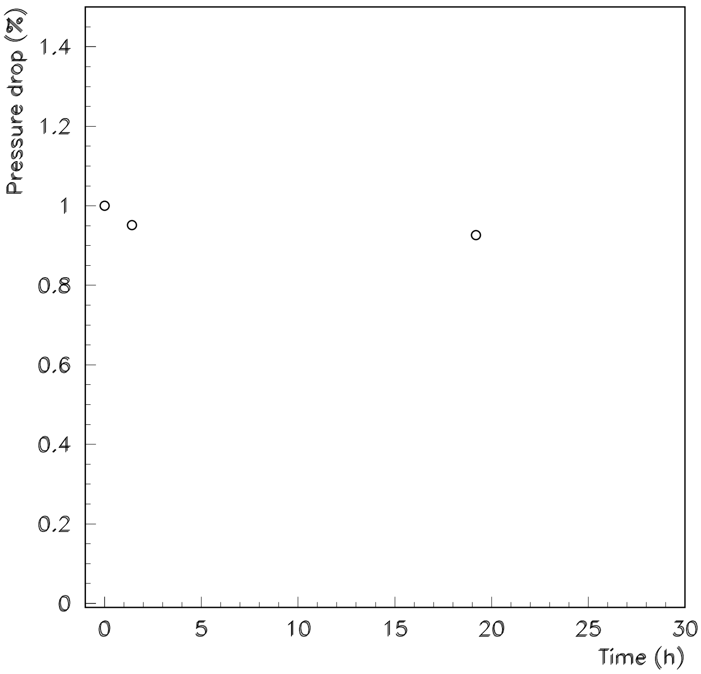

Figure 5: Pressure drop of a single channel without any correction.

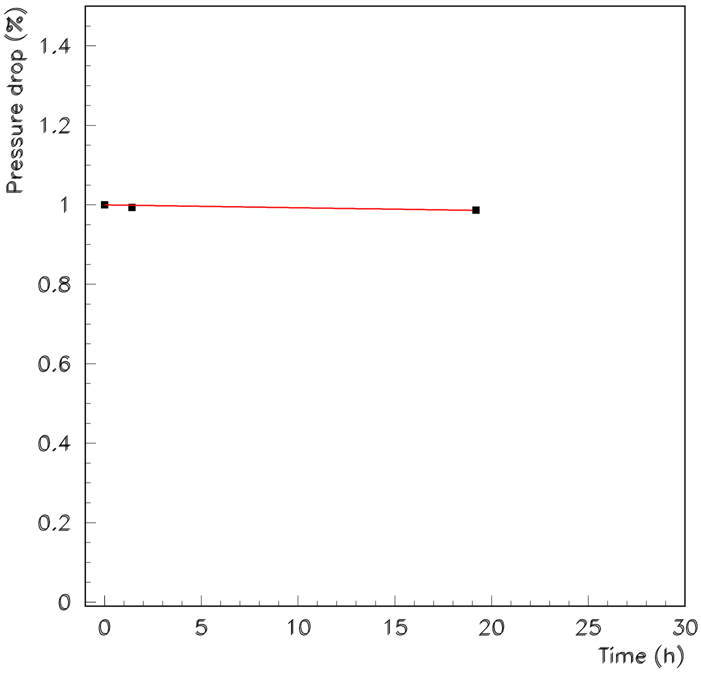

Figure 6: Tipical pressure drop of a single channel corrected for atmospheric pressure and temperature variation.

Appendix

Procedure for gas leakage test

- Gas used is filtered dry AIR.
- The test is run within one working day (9.00-16.00), $\mathbf{t_o = 9.00}$

1. $\mathbf{t = t_o}$ Check:
   (a) flux-meter F_A closed
   (b) valve V_A closed
   (c) AIR pressure = 1 bar (gauge M_A)
   (d) valves $R_1 - R_{50}$ open
   (e) valves SPURGO, A e B open
2. open the compressed AIR valve V_A
3. close SPURGO
4. start fluxing AIR (F_A) SLOWLY until the U-pressure gauge M_U has reached the blue mark
5. close the flux-meter F_A and valves A and B
6. (2 operators) close quickly valves $R_1 - R_{50}$
7. record on the form general run information:
   (a) RUN number
   (b) RUN date (dd/mm/yy)
   (c) name of operators
   (d) STRAW id is the production number identifying the straw tube under test
8. $\mathbf{t = t_o + 00.30}$ 1st READING - record on the form the following information:
   (a) time (hh,mm)
   (b) temperature (digital thermometer)
   (c) atm. pressure(cronothermobarometer)
   (d) oil level for each channel
9. $\mathbf{t = t_o + 01.00}$ 2nd READING - as above
10. $\mathbf{t = t_o + 01.30}$ 3rd READING - as above
11. $\mathbf{t = t_o + 02.30}$ 4th READING - as above

12. $\mathbf{t} = \mathbf{t_o} + \mathbf{03}.\mathbf{30}$ 5th READING - as above
13. $\mathbf{t} = \mathbf{t_o} + \mathbf{04}.\mathbf{30}$ 6th READING - as above
14. $\mathbf{t} = \mathbf{t_o} + \mathbf{05}.\mathbf{30}$ 7th READING - as above
15. $\mathbf{t} = \mathbf{t_o} + \mathbf{06}.\mathbf{30}$ 8th READING - as above
16. open switches SPURGO, A e B
17. mark the straw tubes with waterproof markers following the code:
    - n.3 RED dots (high leakage - oil level = 0 at end of run)
    - n.2 RED dots (medium leakage - oil level <20 at eor)
    - n.1 RED dot (low leakage - 30 > oil level > 25 at eor)
    - n.1 GREEN dot (no leakage - oil level >30 at eor)
18. (2 operators) move and stock the tested frame
19. (2 operators) new frame: check the blue tubing are on the lower side and the upper black tubing have been thermically sealed
20. $\mathbf{t} = \mathbf{t_o} + \mathbf{07}.\mathbf{00}$ end cycle

References

[1] FINUDA Collaboration *Technical report LNF* FINUDA note 19/LNF/ALL/95

[2] Original design by M.Giardoni.

[3] L.Benussi, et al. *The FINUDA leak detector: results*, FINUDA note (in preparation).

[4] **O.T.I.** *s.r.l* Roma