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DO CRYOGENIC IN-LINE FILTERS

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D-Zero Engineering Note 3740.000-EN-188

Introduction

The D0 cryogenic system utilizes liquid argon (serving as the detector ionizing medium) and liquid nitrogen (refrigerant for the argon). In order to keep these fluids pure and minimize the likelihood of plugged instrumentation due to contamination, in-line filters will be installed on the following lines (see Cryogenic Flow Diagram, drawing #3740-ME-222394): 445LN, 412LN, 447LA, 427LA, and 422GA. The lines referred to by these labels are argon dewar LN2 supply, cryostat LN2 supply, LAr dewar fill/drain line, cryostat LAr fill/drain line, and dewar-to-cryostat argon gas line, respectively. Five filters are required. As of this writing, one has been built and tested. The others are to be identical in concept and construction.

Description

Each filter consists of a filter element and a vacuum-jacketed housing. The element is a Pall PMM™ metal membrane series 1000 filter cartridge of 2 1/2" diameter and 20" height, supplying 3 square feet of surface area via its pleated design (see fig. 1).

Fig. 1

1000 Series

Constructed of 316L stainless steel (porous medium) and 304 stainless steel (solid hardware). Each pleated medium section is assembled onto a stainless steel core, followed by welding of stainless steel endcaps to both ends. Gaskets at each end provide for sealing to the housing. 1000 Series elements are aligned within the housing by installing them onto tie rods and then securing them in place by a stainless steel seal nut.

Removal rating is 10 μ at 100% efficiency and 2 μ at 90%. At 10 gpm nominal liquid argon flow, this element has 0.23 psid of pressure drop associated with it. 10 gpm is commensurate with the fill or drain of one cryostat in eight hours; higher flowrates with associated higher pressure drops are possible. Operating characteristics include a maximum ΔP of 125 psid up to 600F in the normal (outside-to-in) flow direction, 10 psid in the reverse direction. ΔP across the filter should never exceed 1 or 2 psid in actual service. Although Pall will not quote a removal rating for flow in the reverse direction, there is no reason to believe that a value much worse than that quoted for the normal flow direction applies. The filter is secured to the housing by a tie rod and plates with Teflon gaskets. The filter will be removing both condensibles and any uranium oxide dust that the detector plates may generate.

The housing is a Fermilab design incorporating a vacuum jacket and removable cover for filter element replacement (see fig. 2, dwg. #3740.510-ME-255648). Each filter is to be incorporated into a "jumper tube" - a removable section of line which ties the cryogenic piping into a continuous circuit. In light of this installation scheme, compactness was paramount without overly infringing on filter surface area. The overall unit is 30" tall, 6" in diameter, and 10" between connections with an additional 21" of free space required below the bottom to allow removal of the cover. Intake and exhaust lines are 1 1/2" pipe with a 3" pipe vacuum jacket (to match jumper tube size). There is 15 mil of radial clearance between inner and outer tubes of the "bayonet" assembly to provide low heat leak yet allow for easy cover removal. All housing materials are 304 stainless steel; the device is stamped with a MAWP of 215 psig (well above the cryogenic line relief settings of 100 psig) and each will be pressure tested to at least 125% of MAWP before installation (see fig. 3). The cover attaches to the body with an Aeroquip Marman V-retainer coupling with a rated burst pressure of 400 psig. The flanges were machined at Fermilab (as were all other components except the bayonet assembly - this may also be made in house in the future) and the band clamp itself is a stock item. There is a pressure tap on either side of the filter element connected through a 3-valve manifold to a 0-5 psid locally read ΔP gauge. Those filters which must flow bi-directionally are equipped with a 4-way valve to interchange high and low sides of this ΔP gauge.

Quantity and Cost

Five filters are required, two of which must flow in both directions (the ones in lines 427LA and 422GA). The first unit cost \$3000 to build (including \$600 for the filter cartridge); subsequent units should be similar if not cheaper. The bayonet slide tubes were made on the outside for \$700 and could probably be done for less in-house. By comparison, Cryolab Inc. offers a vacuum insulated in-line filter suitable for our application at \$8000 for one, \$6800 each for 2-5.

Addendum

On 25 May 1989 the remaining 4 filters were successfully pressure tested. Test documentation has been added to that for the first unit. All five filter housings and elements will be cleaned per DO specifications prior to installation.

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EXHIBIT B
Pressure Testing Permit*

Date: 9/29/88

Type of Test: ☐ Hydrostatic ☒ Pneumatic

Test Pressure: 270 psig Maximum Allowable Working Pressure: 215 psig

Items to be Tested: Cryogenic Filter #1 for the DØ LAr/LN₂ system

Location of Test: behind pbar off of Kautz Rd. Date and Time: _____

Hazards Involved: high pressure

Safety Precautions Taken: Test conducted in a concrete "C" section (personnel outside), instrumentation disconnected

Special Conditions or Requirements: Test performed in accordance with section 5034 of the Fermilab Safety Manual

Test Coordinator: Joel Truitt Dept/Date: 9/29/88

Division/Section Safety Officer: P. Schen Dept/Date: 10/12/88

Division/Section Head: D.C. Humphreys Dept/Date: 10/14/88

Results: _____

No problems

Witness: P. Schen RD Safety Dept/Date: 10-18-88
(Safety Officer or Designee)

*Must be signed by division/section safety officer and division head prior to conducting test. It is the responsibility of the test coordinator to obtain signatures.

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EXHIBIT B

Date: 5/16/89

Pressure Testing Permit*

Type of Test: ☐ Hydrostatic ☒ Pneumatic

Test Pressure: 270 psig Maximum Allowable Working Pressure: 215 psig

Items to be Tested: Cryogenic Filters #2, 3, 4, 5 for the DØ
LA_r/LN₂ system (Filters to be manifolded together appropriately).

Location of Test: behind pbar off of Kautz Rd. Date and Time: 5/25/89 1000

Hazards Involved: high pressure

Safety Precautions Taken: Test conducted in a concrete "C" section
(personnel outside), instrumentation disconnected

Special Conditions or Requirements: Test performed in accordance with
section 5034 of the Fermilab Safety Manual

Test Coordinator: Paul Fuent Dept./Date: 5/16/89

Division/Section Safety Officer: R. Schen Dept./Date: 5/18/89

Division/Section Head: Allybalin Dept./Date: 5/24/89

Results: Test completed - no problems

Witness: R. Schen
(Safety Officer or Designee)

Dept./Date: RD Safety 5-25-89

*Must be signed by division/section safety officer and division head prior to conducting test. It is the responsibility of the test coordinator to obtain signatures.

Appendix

CVI offers vacuum insulated cryogenic filters for process line sizes from 1/2" to 4". Rose Worthington of CVI quoted the cost of one filter, model number CFA-150, to be \$12,000 on 15 March 1990. This quote was based on the following parameters:

Process line size	1 1/2"
Cryogenic fluid	Argon
Flow rate	20gpm
Operating pressure (max)	150 psi
Nominal micron rating	5 μ
Allowable clean Δp	1psi

In addition the filter was to include a high point vent, upstream and downstream pressure taps, and a differential pressure gauge. Included with this engineering note is a photocopy of the cryogenic filter information found in the CVI catalog.

VACUUM INSULATED CRYOGENIC FILTERS

CVI CF-Series tee type filters are vacuum insulated for low heat influx while a bayonet type connection allows rapid disassembly, by removing a standard V-band clamp, to clean or replace the filter element.

The CF-Series filters are available with dutch twill weave filter elements in a wide range of sizes, filtration rates, pressure drops, pressure ratings, and flow capacities. CVI Incorporated can help you design a filter assembly to match your specifications.

Optional features of this filter can include a high point vent for the release of trapped gases or to purge the process stream, pressure taps at the inlet and outlet to determine pressure drop across the assembly, and ΔP gage, which can be mounted on the side of the vacuum jacket.

When ordering, specify the cryogenic fluid, flow rate, operating pressure, line size, nominal and absolute micron rating and permissible clean pressure drop.

Filter Assembly Model Numbers	Process Line Size	N.P.S.		Dimensions (in inches)								
		A	B	C	D	E	F	G	H	I	J	K
CFA-050	1/2"	1/2"	2"	4.50	2.245	2.18	10.43	4.00	10.75	2.50	4.50	5.25
CFA-075	3/4"	3/4"	2"	4.50	2.245	2.18	10.80	4.00	10.75	2.50	4.50	5.25
CFA-100	1"	1"	2 1/2"	5.56	3.334	3.18	15.44	5.00	15.44	3.00	5.50	6.25
CFA-150	1 1/2"	1 1/2"	3"	5.56	3.334	3.18	15.44	5.00	15.44	3.00	6.00	6.75
CFA-200	2"	2"	4"	6.625	4.334	3.18	15.93	5.00	16.25	3.50	5.50	6.25
CFA-300	3"	3"	5"	10.75	6.407	5.188	17.00	8.00	21.50	9.00	8.50	9.50
CFA-400	4"	4"	6"	12.75	8.407	6.687	23.00	10.25	28.50	10.00	9.50	10.50