


LAR DEWAR
CONDENSING COILS
AT DØ

SPECIFICATION AND REVIEW

J. Michael
12/5/89
Douglas Clark
Rev. A, 4/2/90

DØ Engineering Note
3740.512-234, Rev. A

Approved  Date 4/6/90

LAr Dewar Condensing Coils

These internal coils are used to condense and cool the gaseous argon contained in the LAr storage dewar at DØ, at a rate not to exceed 40KW. The coolant is LN₂, piped in from another, similar, dewar of 36' higher elevation (see Diagram A). The specific design of the coils are outlined in Process Engineering drawing #C-32545, attached.

The material components are as follows.⁽¹⁾ The internal coil piping material is constructed ⁽²⁾ of 165' of 1-1/2" NPS schedule 40 pipe, of type 5083 aluminum. 3" NPS schedule 80 type 5086 aluminum pipe is used for the headers of the triple hairpin coil welded assembly. The coils are supported by a series of aluminum brackets fixed to the roof of the dewar.

Note 35 on the drawing points out the brackets which hold the coils to the roof of the dewar. They are not connected in any way to the coils, and act only as supports. This feature allows for contraction of the coils, and avoids any longitudinal thermal contraction stresses at the vessel nozzles that might have occurred.

A stress analysis of the internal coil feed lines is outlined in DØ engineering note 239. The analysis shows that the stresses experienced by the nodes where the coil feed lines pierce the inner vessel are on the order of one fifth of the stresses allowable for this design.

The coils have been pressure tested at Process Engineering at 200 psi, which is above the accepted percentage for pressure tests of vessels of 125% of maximum allowable working pressure. The maximum pressure which could theoretically develop in the condenser coil is 150psi. Anything above this pressure will vent through PSV614N, set at 150psi. In addition, the coils have been satisfactorily leak checked at PEI and at Fermilab.

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WHAT IF...

As always, it is prudent to anticipate worst case scenarios, and to circumvent any problem that may occur. In the case of the condenser, the worst that can happen is condenser coil failure allowing nitrogen to flow directly into the argon dewar. The nitrogen supply could be at 50 psig (maximum cooldown value, typical is 35 psig) with an added pressure due to the elevation difference. This added pressure is equivalent to the product of the height differential between the liquid levels in each dewar (see diagram A) and the density of the fluid. Thus it is at a maximum only when the liquid nitrogen dewar is completely filled. (The argon dewar would always remain full until the nitrogen dewar emptied).

Extra Pressure = height x density(at saturated temperature)

$$\text{EP} = 36 \text{ ft} \times 48 \text{ lbs/ft}^3 = 1728 \text{ lbs/ft}^2 = 12 \text{ lbs/in}^2$$

$$\text{Total Source Pressure} = 50 \text{ psig} + 12 \text{ psig} = 62 \text{ psig}$$

65 psig Relief Case

When the 65 psig argon dewar relief is selected, it will not lift and the errant nitrogen flow will cease at the equilibrium pressure. Note that the condenser outlet valve will try to limit the condenser pressure to, typically, 33 psig and vent heavily. The argon dewar pressure, the nitrogen flow rate and rate of level change alarms will flag the problem. If the condenser outlet is closed, any subsequent gas generation will vent

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through the PRV on the nitrogen dewar. (The 50 psig used in this example is for cooldown only, i.e. two weeks/year. The normal operating pressure, 35 psig, would reduce the total pressure to 47 psi.)

16 psig Relief Case

When the 16 psig argon dewar relief is selected, the level in the LAr dewar could be filled to activate the relief. That is not likely because the typical operating level of the LAr dewar is less than or equal to 4,000 gls (15,000 gls max. less 11,000 gls to cryostat) and the LN2 dewar level is limited to 14,000 gls max, i.e. the combination is less than or equal to 18,000 gls. and the LAr dewar capacity is 20,000 gls. If one or both of these expected constraints were violated the vent line could be filled with LN2. That venting, in addition to the the argon dewar pressure, the nitrogen flow rate and rate of level change alarms, will flag the problem. The venting would act to lower the dewar pressure, and in no case would the pressure exceed the source pressure calculated above. In addition, the flow to the cryostats will be terminated to prevent the unlikely possibility of increasing the source pressure to the cryostats as well as to minimize the LN2 contamination.

Likelihood of this Occurrence

The primary failure rate/joint (welded in this case) in the condenser coils has a value of $3E-9$ /hr (ref. 3). Taking the number of joints as 29, this rate predicts condensers of this type should fail about once every 1500 years, on average.

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1. See George Mulholland letter from Scott Nason, 11/20/89, attached.
2. ANSI/ASME B31.3 \geq
3. Fermilab Safety Manual 5064TA-7 :NRC Equipment Failure Rate Est..

From: FNAL::MULHOLLAND 6-MAR-1990 16:21:15.16
To: OCRYOSAFETY.DIS
CC: MULHOLLAND
Subj: One of the promised answers.

Gentlemen,

This answer is inresponse to a request from the DO safety committee at

Catastrophic

The safety committee has asked that we consider the catastrophic failure of the LN2 condensing pipes in the LAr dewar.

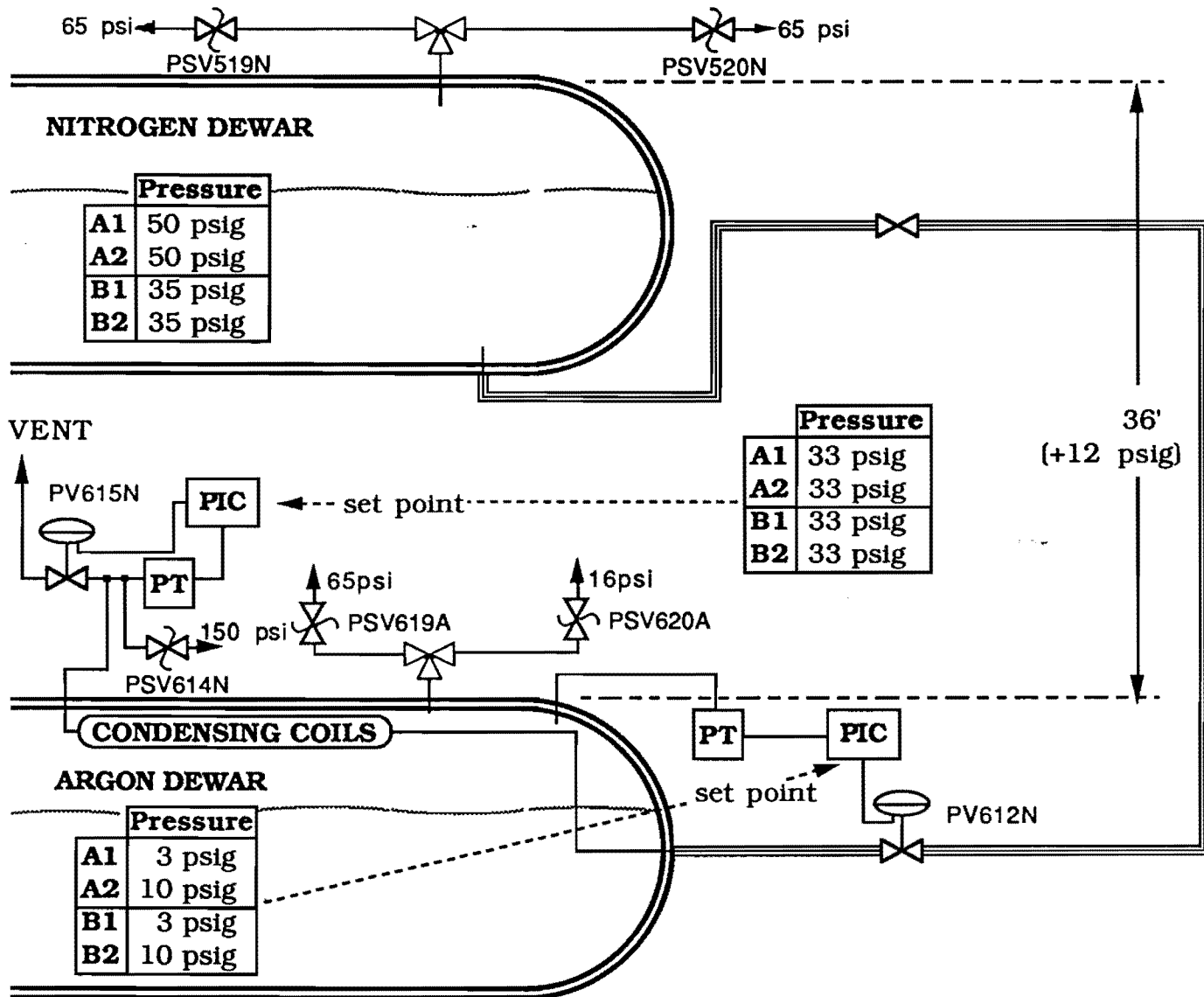
The presentations todate allow a quasi-static combination of LAr and LN2. That is a failure leads to a small but continous LN2 flow onto the surface of dewar LAr. Because both fluids are constrained to have a common pressure, and the equilibrium nitrogen is colder by ca. 10k then the equilibrium argon, the LN2 gives up its heat of vaporization (ca. 200 j/g) to extract the LAr heat of fusion (ca. 25j/g). After a long time (total LN2 flow equal to 1/8 total LAr capacity) the LAr is frozen, and then cools to the LN2 equilibrium temperature. All this occurs at the limiting pressure of the 16 psig relief valve, i.e. at a final temperature of 83.4k. Beyond this point the LN can accumulate on top of the Ar and the vent scenarios provided apply.

If, instead, the cooling pipes fail catastrophically, the limiting flow of LN2 pours onto the liquid surface, immediately vaporizing, and providing a gas relief requirement (very quickly becoming) equal to the incoming mass flow. That will build pressure rapidly toward the 16 psig relief and cause the dewar to vent.

The flow is limited by the inlet valve ($C_v = 1$) to ca. 4 gpm, for a 30 psig LN2 dewar and a 16 psig LAr dewar. That corresponds to $\dot{M} = 26.6 \text{ \#}/\text{m}$, or, at 2 atm., 48.3 acfm. At standard conditions, that is ca. 347 scfm.

The relief rating is 600 scfm (corresponding more if the flow is cold), the dewar vents periodically, and the process progresses toward the vent scenarios already provided as long as the LN2 holds out.

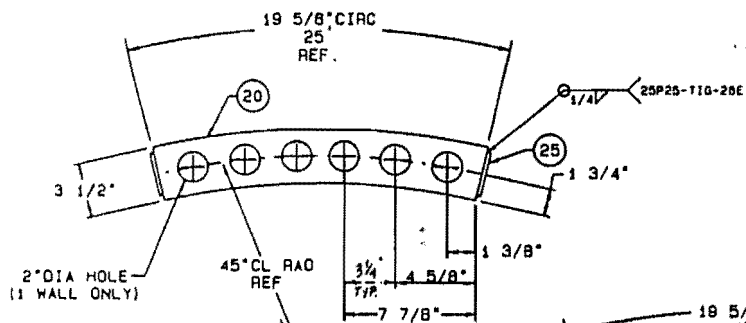
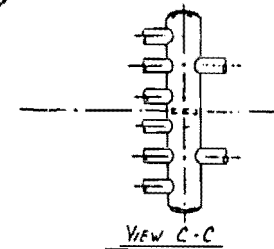
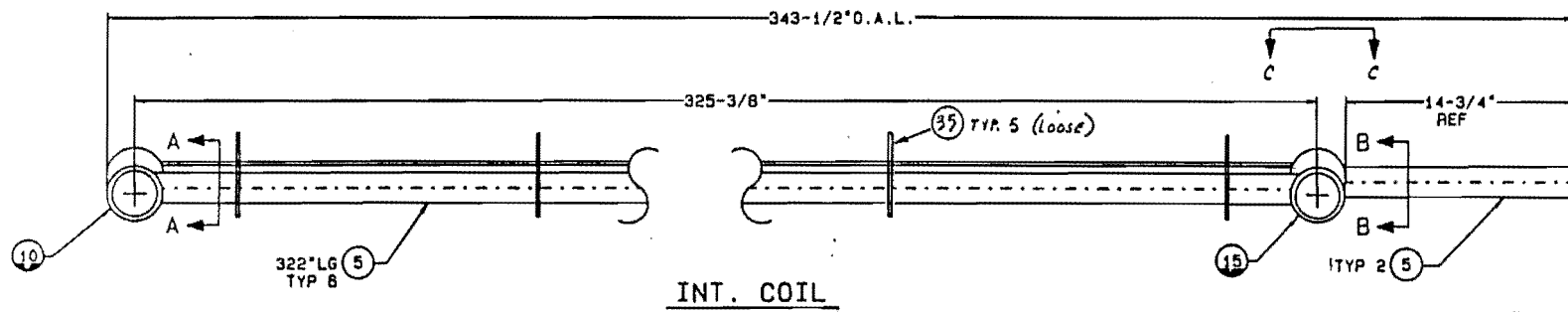
Diagram A: Dewars/Coils Configuration



Legend

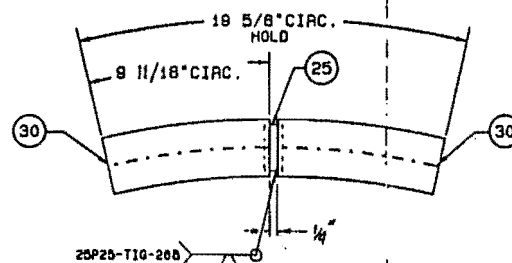
A1	Cooldown, LAr dewar receiving pressure.
A2	Cooldown, LAr dewar transmitting pressure.
B1	Normal operating, LAr dewar receiving pressure.
B2	Normal operating, LAr dewar transmitting pressure.

Note: The pressure in the coils is from saturated nitrogen, set from the temperature of the lowest argon dewar operating pressure.

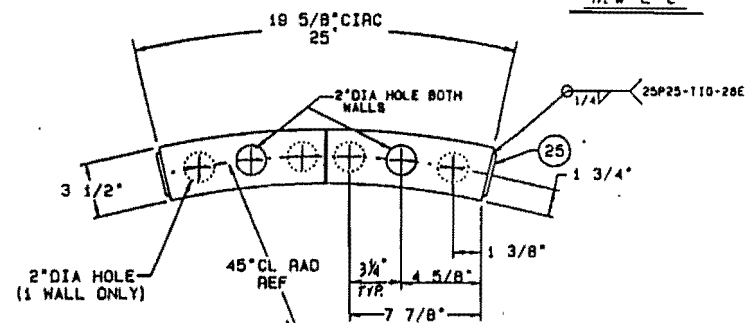


ITEM 10
SECTION A-A

S/N 841-649



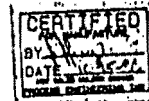
DETAIL ITEM 15
BAFFLE INSTALLATION



ITEM 15
SECTION B-B

S/N 841-867

NO	DATE	BY	CHKD	RECORD OF REVISION



PROCESS ENGINEERING INC. PLAISTON, OH 43080			TOLERANCES UNLESS OTHERWISE NOTED		
			PER PEI STD. F-19 & TEMA STD.		
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APPROVALS DRAFTER: SA CHECKER: [Signature] ENGINEERING DESIGN: [Signature] MANUFACTURING: [Signature] WELDING ENGINEERING: [Signature] QUALITY ASSURANCE: [Signature] MAT. RES. PLANNING: [Signature]		BY: [Signature] DATE: [Date]	JOB NO. C-17988 PART NO. 841847 SHEET NO. 1 OF 1	U/H 18 SCALE 3/16"=1" DRAWING NO. C-32545	0 REV.

Process Engineering Inc.

November 20, 1989

FERMI NATIONAL ACCELERATOR LABORATORY
Batavia Rd.; P.O. Box 500
Mail Station 357
Batavia, Illinois 60510

Attention: Mr. George Mulholland

Subject: Fermi P.O. No. 918320
Model 20000-H-65 Liquid Argon Storage Tank
PEI Job No. C-17986/N-03687

Dear George:

To address your recent questions on the subject unit:

1. The internal coil piping material is 1-1/2" schedule 40 (.145" wall), type 5083 or 5086 aluminum. The headers of the coil are 3" schedule 80 (.300" wall) type 5086 aluminum.
2. The coil feed lines are 1-1/2" schedule 10 (.109" wall) type 304 stainless steel (welded pipe), not 1-5/8" ODT as indicated on our customer drawing.
3. The internal coil, including the feed lines, was pneumatic tested at 200 psi.
4. The liquid level chart for this unit will not have the same 'trap error' as was found on the nitrogen dewar (C-28087 / N-64587) because the bottom gage line on this unit properly exits the annular space at the elevation of the bottom of the inner vessel. We believe the error in the layout of the bottom gage line on the nitrogen dewar was an isolated one.

Very truly yours,


Scott C. Nason
Design Engineer

cc: Mr. Kenneth L. Paul, Executive Vice President, PEI

PEI File C-85037

Hand-delivered, 11/20/89, at PEI