D-Zero Silicon Detector Purge
I.A. Dryer
Pressure Vessel Engineering Note

Dan Olis
September 26, 2000

D0 Engineering Note
3823.112-EN-538

PRESSURE VESSEL ENGINERING NOTE
PER CHAPTER 5031

Prepared by: DANIEL OLIS (ID 10394)
Preparation date: 8/31/00

1. Description and Identification
Fill in the label information below:

This vessel conforms to Fermilab ES&H Manual Chapter 5031

Vessel Title SILICON DETECTOR E. A. DAYER

Vessel Number PPD 10070 (WEST), PPD 10071 (EAST) — Obtain from Safety Officer

Division/Section

Vessel Drawing Number —

Maximum Allowable Working Pressures (MAWP):
Internal Pressure 200 PSIG PSIA
~~External Pressure~~ AMBIENT ~~PSIA~~

Working Temperature Range -20 °F 450 °F

Contents COMPRESSED AIR, DESICCANT

Designer/Manufacturer
ARROW PNEUMATICS, INC.

Test Pressure (if tested at Fermi) Acceptance Date: — Document per Chapter 5034 of the Fermilab ES&H Manual

PSI, Hydraulic Pneumatic

Accepted as conforming to standard by
(note two signers)

of Division/Section PPD Date: 9/21/00 — Actual signature required

NOTE: Any subsequent changes in contents, pressures, temperatures, valving, etc., which affect the safety of this vessel shall require another review.

Reviewed by: Harry F. Carter 3236 Date: 9-18-2000
HARRY F. CARTER
Director's signature (or designee) if the vessel is for manned areas but doesn't conform to the requirements of the chapter.

Date:

Amendment No.:	Reviewed by:	Date:

Lab Property Number(s): 87338

Lab Location Code: RP15-325 (DAB) (obtain from safety officer)

Purpose of Vessel(s): DESICCANT TOWERS ON I.A. DRYER FOR SUPPLY TO D-ZERO SILICON DETECTOR

Vessel Capacity/Size: 3.96 FT^3 Diameter: 12.25" Length: 56"

Normal Operating Pressure (OP) 125 PSI

MAWP-OP = 75 PSI

List the numbers of all pertinent drawings and the location of the originals.

Drawing #	Location of Original

2. Design Verification

Does the vessel(s) have a U stamp? Yes ✓ No_____. If "Yes", fill out data below and skip page 3; if "No", fill out page 3 and skip this page.

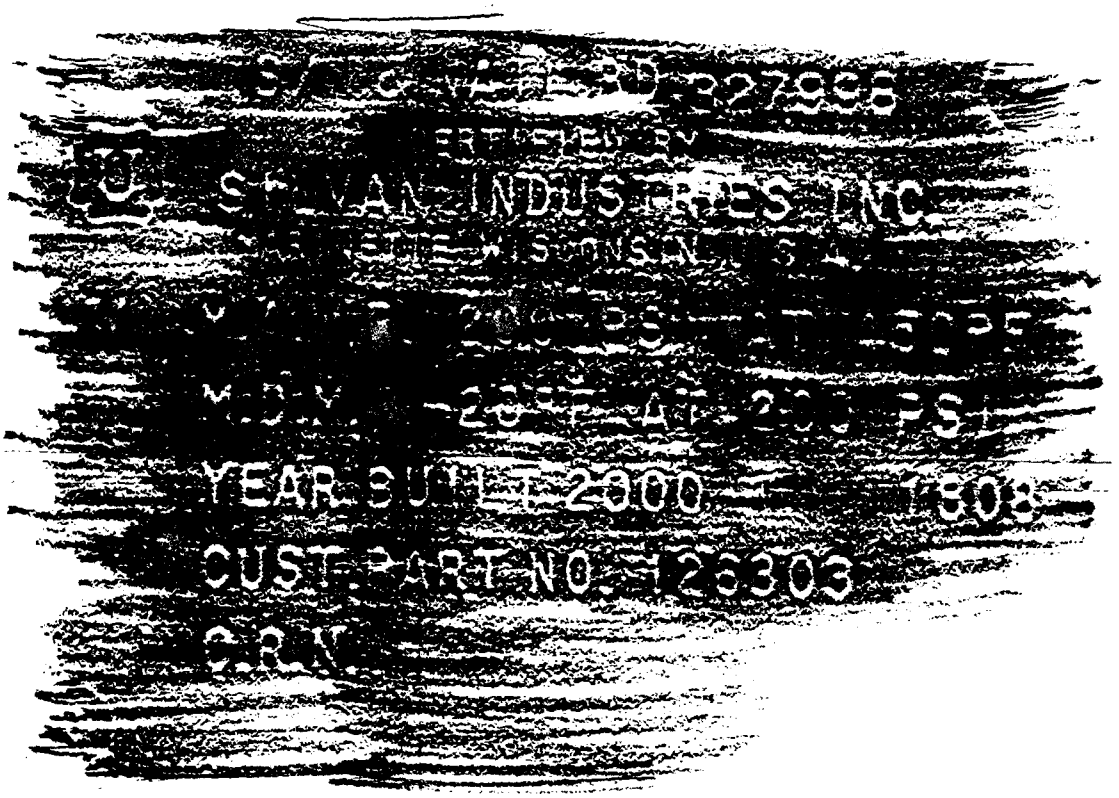
Staple photo of U stamp plate below.

Copy "U" label details to the side

ATTACHED

Copy data here:

ATTACHED



VESSEL PPD# 10070 (WEST)

S/N & NATL. BD. 327998

U CERTIFIED BY

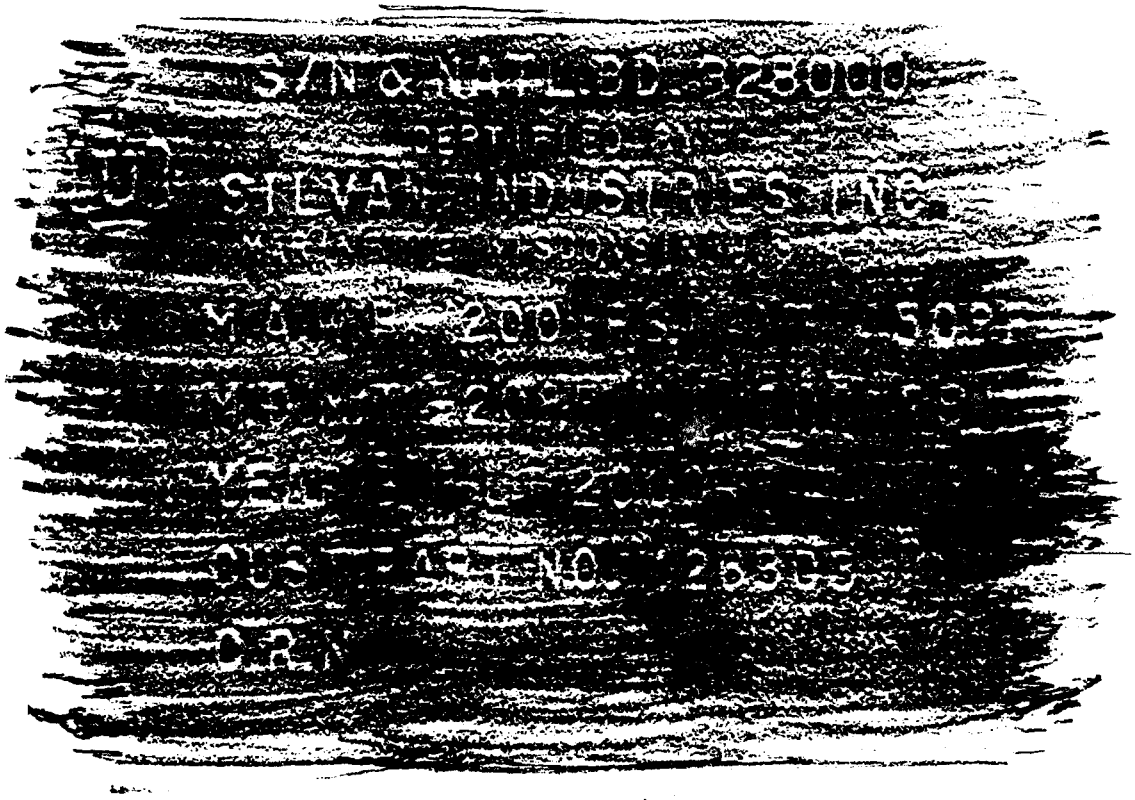
SILVAN INDUSTRIES INC.
MARINETTE WISCONSIN U.S.A.

W M.A.W.P. 200 PSI AT 450 F
M.D.M.T. -20 F AT 200 PSI

YEAR BUILT 2000 1808

CUST. PART NO. 126303

C.R.N.



VESSEL PPD # 10071 (EAST)

S/N & NATL. BD. 328000
CERTIFIED BY
U SILVAN INDUSTRIES INC.
MARINETTE WISCONSIN U.S.A.
W M.A.W.P. 200 PSI AT 450 F
M.D.M.T. -20 F AT 200 PSI
YEAR BUILT 2000 1808
CUST. PART NO. 126303
C.R.N.

3. System Venting Verification Provide the system schematic in the Appendix.

Is it possible to isolate the relief valves by a valve from the vessel?
Yes___ No ✓
If "Yes", the system must conform to code rules. Provide an explanation on the appended schematic. (An isolatable vessel, not conforming to code rule is non-compliant under this chapter.)

Is the relief cracking pressure set at or below the M.A.W.P.?
Yes ✓ No_____ Actual setting 200 PSI
(A "No" response violates this chapter.)

Is the pressure drop of the relief system at maximum anticipated flow such that vessel pressure never rises above the following? (UG 125)
Yes ✓ No_____ 110% of MAWP (one relief)
116% of MAWP (multiple reliefs)
121% of MAWP (unexpected heat source)

Provide test or calculational proof in the Appendix.
~~(Non-conforming pressure rises is non-compliant under this Chapter.)~~

List of reliefs and settings:

	Manufacturer	Model #	Set Pressure	Flow Rate	Size
WEST	F.C. KINGSTON CO.	112 C	200 PSI	120 SCFM	1/4"
EAST	F.C. KINGSTON CO.	112 C	200 PSI	120 SCFM	1/4"

Does the primary relief device follow UG-129? Yes ✓ No_____
(A "No" response is non-compliant under this chapter)

4. Operating Procedure

Is an operating procedure necessary for the safe operation of this vessel?
Yes_____ No ✓ (If "Yes", it must be appended)

5. Welding Information

Has the vessel been fabricated in a non-code shop? Yes_____ No ✓
If "Yes", append a copy of the welding shop statement of welder qualification (Procedure Qualification Record, PQR) which references the Welding Procedure Specification (WPS) used to weld this vessel.

6. Exceptional, Existing, Used and Unmanned Area Vessels

Is this vessel or any part thereof in the above categories?
Yes_____ No ✓

If "Yes", follow the Engineering Note requirements for documentation and append to Note.

Relief Device Capacity

The relief device on each pressure vessel is set to a pressure of 200 PSI and a flow rate of 120 SCFM. To demonstrate that the relief capacity is sufficient, two relieving cases are considered:

1) Receiving vessels supplied from Ingersoll-Rand compressor
2) Receiving vessels exposed to fire conditions

- Ingersoll-Rand compressor

  The air dryer is supplied from two Ingersoll-Rand screw compressors. The compressors are hard-wired in an 'either-or' configuration so that only one unit can run at a time. The IR compressor model EP25U has a flow capacity of 97 SCFM at 125 PSIG as can be seen in the attached data sheet. The modulate on-line/off-line control system integrated with the compressor will not allow the discharge pressure to exceed 103% of rated pressure, or 129 PSIG. Figure 3 from the IR EP25U owner's manual shows this and is attached. Therefore the maximum discharge pressure is well below the relief pressure and there is no risk of exceeding the vessels' MAWP of 200 PSI.

- Fire Conditions

  During exposure to fire conditions, the vessel requires a minimum flow capacity of 18.6 SCFM. This is well below the relief device's rated capacity of 120 SCFM. This calculation is attached in the appendix.

Relief Summary

Cases	Required Capacity
1) Ingersoll-Rand Compressor	97 SCFM at 125 PSIG Unit will not deliver at relief pressure of 200 PSIG.
2) Fire Conditions	18.6 SCFM

Relief Device	Actual Capacity
1) F.C. Kingston Co. Fig. 112 C, ¼"	120 SCFM @ 200 PSI

Technical Specification Guide

- Air-cooled, 115°F (46°C) ambient design
- Integral Mounted 15° CTD aftercooler
- Swingout oil/aftercooler for easy cleaning
- Poly-V belt drive w/automatic tensioning system
- Factory fill of cost saving 2 year/8,000 hr SSR Ultra Coolant
- Two year airend warranty when using Ultra Coolant
- Three micron inlet air filter
- Duplex tapered roller bearings
- Triple-lip shaft seal with scavenge
- Coolant dam for reliability
- Less than 3 ppm coolant carryover
- Coolant sight level indicator
- SAE-O-ring, leak free design
- Electro-pneumatic controls
- Efficient on-line/off-line control
- Auto start and stop
- EPACT high efficiency motor
- 230/460/3/60 or 380-415/3/50 ODP motor
- Motor overload protection
- Mounted and wired full voltage starter

Model	60 Hz Units Nom HP	CFM FAD(1)	50 Hz Units Nom KW	m3/min FAD(1)	Rated PSIG/ BARG	Opt. Tank Size	Base Mount Dimen. lxwxh (2)	Weight lbs	Tank Mount Dimen lxwxh (2)	Weight lbs
XF20	20	89	15	2.52	100/6.9	120 Gal	45/30/38	915	76/30/64	1315
EP20	20	79	15	2.24	125/8.6	120 Gal	45/30/38	915	76/30/64	1315
HP20	20	73	15	2.07	140/9.7	120 Gal	45/30/38	915	76/30/64	1315
HXP20	20	61	15	1.73	200/13.8	120 Gal	45/30/38	915	76/30/64	1315
XF25	25	108	18.5	3.06	100/6.9	120 Gal	45/30/38	935	76/30/64	1335
→ EP25	25	97	18.5	2.75	125/8.6	120 Gal	45/30/38	935	76/30/64	1335
HP25	25	91	18.5	2.58	140/9.7	120 Gal	45/30/38	935	76/30/64	1335
HXP25	25	78	18.5	2.21	200/13.8	120 Gal	45/30/38	935	76/30/64	1335
XF30	30	123	22	3.48	100/6.9	120 Gal	45/30/38	955	76/30/64	1355
EP30	30	112	22	3.17	125/8.6	120 Gal	45/30/38	955	76/30/64	1355
HP30	30	106	22	3.00	140/9.7	120 Gal	45/30/38	955	76/30/64	1355
HXP30	30	93	22	2.63	200/13.8	120 Gal	45/30/38	955	76/30/64	1355

(1) FAD (Free Air Delivery) CFM and M3/MIN are ratings of full package performance in accordance with CAGI-Pneurop acceptance test standard ISO 1217: 1996 annex C. **Ingersoll-Rand is a member of CAGI-PNEUROP.**
(2) Add 8 inches to the width for the enclosure option.

Ingersoll-Rand compressors are not designed, intended or approved for breathing air applications. Ingersoll-Rand does not approve specialized equipment for breathing air applications and assures no responsibility or liability for compressors used for breathing air service.

Nothing contained on these pages is intended to extend any warranty or representation, expressed or implied, regarding the product described herein. Any such warranties or other terms and conditions of sale of products shall be in accordance with Ingersoll-Rand's standard terms and conditions of sale for such products which are available upon request.

MORE THAN AIR. ANSWERS.

Online answers: www.air.ingersoll-rand.com

INGERSOLL-RAND
AIR COMPRESSORS

Rotary Compressor Division
Ingersoll-Rand Company
Davidson, NC 28036

Form 3176
Printed in USA

6.4 CAPACITY CONTROL
ON LINE-OFF LINE CONTROL

For those plants which have a widely varying air demand, the on line-off line control will deliver air at full capacity, (the compressor maximum efficiency condition) or will operate at zero capacity with low receiver pressure (the compressor minimum power condition).

When the compressor is in the on line-off line mode, pressurized air is removed from the inlet valve allowing it to fully open. The blowdown valve closes the atmospheric vent.

MODULATE/ACS CONTROL

For those plants which have relatively high constant air demand, relative to the compressor capacity, the recommended control mode is modulation.

The modulation control system retains the features of the on line-off line control, but provides for throttling of the inlet flow up to the off line air pressure set point value.

By applying line pressure to an adjustable modulator valve, the throttling position of the inlet valve is controlled, thus allowing the modulator to "trim" the inlet valve position as dictated by the line pressure.

The modulating pressure range is about 4 psig (0.3 BAR) and the modulator is factory set to straddle the compressor rated pressure. Modulation begins when the line pressure reaches about 99 percent of the compressor rated pressure and continues as/if the line pressure rises. Modulation becomes stable when the compressor output equals the plant air demand. When the modulation is at the factory setting, the maximum capacity reduction will be approximately 60 percent of the compressor rated capacity (as indicated in Figure 3).

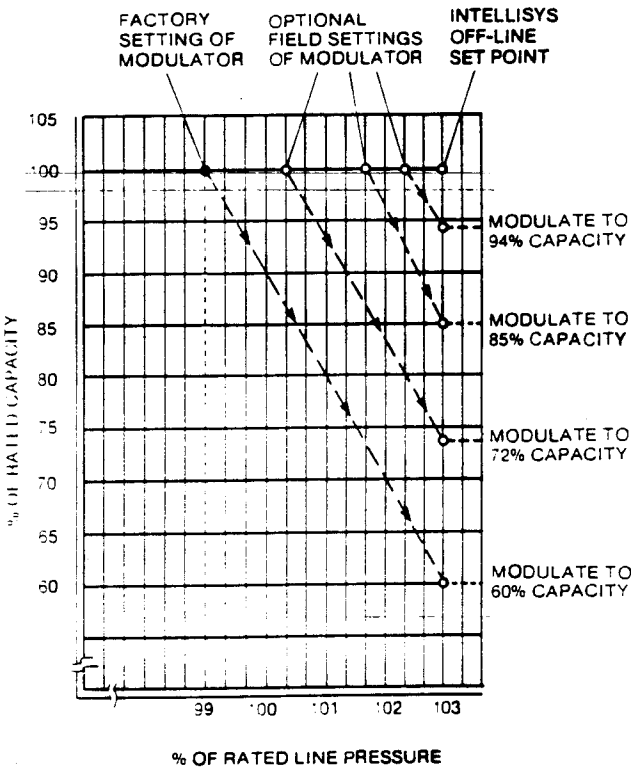


FIG. 3

If the air demand has decreased to a level below the 60 percent modulated output, the line pressure will increase slightly to actuate the Intellisys. The compressor will then shift to the off line control position, and operate unload with the compressor vented.

It is sometimes desirable to begin modulation at a higher pressure than the standard factory setting, thereby increasing the modulated capacity at the time the Intellisys is actuated. Refer to Figure 3 for modulated capacities available when this is done.

FERMILAB
ENGINEERING NOTE

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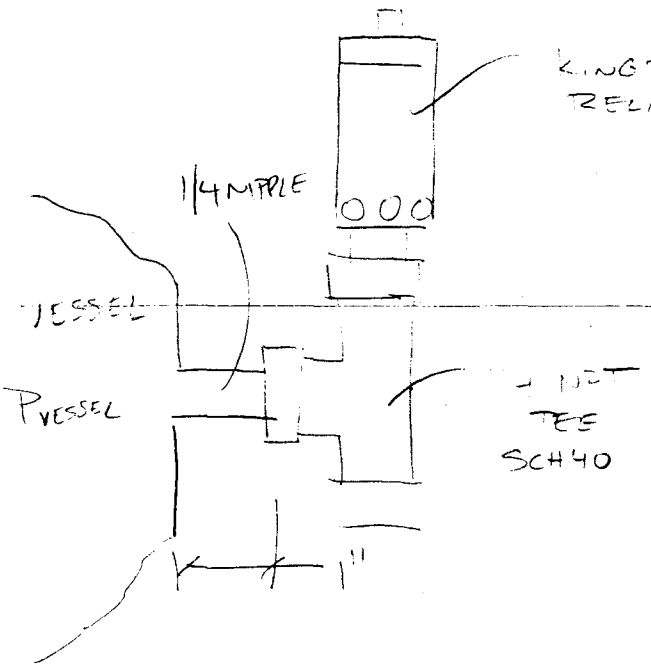
SUBJECT: RELIEF SYSTEM PRESSURE DROP — % MAWP CALCULATION

NAME: D. OLIS

DATE: 8/31/00 | REVISION DATE:

RELIEF RATE @ 110% = 300 SCFM

FIND ΔP_{RELIEF} FOR Q = 20 SCFM



$$P_{VESSEL} = P_{RELIEF} + \Delta P_{PIPING}$$

$$\Delta P = \left(f\frac{L}{D} + K_{ENTRANCE} + K_{TEE\ SIDE} \right) \frac{1}{2}\rho V^2$$

DARCY-WEISBACH EQN

$L = 1''$ $\quad D = ID\ OF\ \frac{1}{4}''\ SCH40 = .364''$

$K_{ENTRANCE} = 0.5$

$K_{TEE\ SIDE} = 1.8$ FOR SIDE FLOW

$$\rho = \frac{P}{RT} = \frac{\left(14.7 + \frac{0}{144}\right)\frac{lbf}{in^2} \times \frac{144\ in^2}{ft^2}}{53.3\ \frac{ft\,lbf}{lbm\,^\circ R}\left(70 + 460\right)^\circ R} = 1.094\ \frac{lbm}{ft^3}$$

$$V = \frac{Q_{ACT}}{A} \qquad Q_{ACTUAL} = Q_{STP} \times \frac{P_{STP}}{P_{ACTUAL}} \qquad (STP = \text{STANDARD TEMP. \& PRESSURE})$$

$$= 120\ \frac{ft^3\,STP}{min} \times \frac{.075\ lbm/ft^3\,STP}{1.094\ lbm/ft^3}$$

$$Q_{ACT} = 8.23\ ft^3/min$$

$$A = \frac{\pi}{4}(ID)^2 = \frac{\pi}{4}(.364)^2\ in^2 = .104\ in^2 = .000723\ ft^2$$

$$V = \frac{8.23\ ft^3/min}{.000723\ ft^2} \times \frac{min}{60\ sec} = \underline{\underline{190\ ft/s}}$$

f = FRICTION FACTOR. FIND f FROM MOODY PLOT USING R_e

$$R_e = \frac{\rho V D}{\mu} \qquad \mu_{AIR} = 3.80 \times 10^{-7} \frac{LBF\text{-}S}{FT^2}$$

$$R_e = \frac{\left(1.094 \frac{LBM}{FT^3}\right)\left(190 \frac{FT}{S}\right)\left(.364 \, FT\right)}{3.80 \times 10^{-7} \frac{LBF\text{-}S}{FT^2} \times 32.2 \frac{LBM \, FT}{S^2 \, LBF}} = 515{,}300 = 5.2 \times 10^5$$

MOODY PLOT GIVES $f = .013$

$$\Delta P = \left[\left(.013\right)\left(\frac{1 \, IN}{.364 \, IN}\right) + 0.5 + 1.8\right]\left(\frac{1}{2}\right)\left(1.094 \frac{LBM}{FT^3}\right)\left(190 \frac{FT}{S}\right)^2 \frac{LBF \, S^2}{32.2 \, LBM \, FT}$$

$$= 1432 \frac{LBF}{FT^2}$$

$$= 9.9 \quad PSID$$

$$P_{VESSEL} = P_{RELIEF} + \Delta P = 200 + 9.9 = 210 \ PSIG$$

$$\%\,MAWP = \frac{P_{VESSEL} + P_{AMB}}{MAWP} \times 100 = \frac{210 + 14.7}{200 + 14.7} \times 100$$

$$\%\,MAWP = 105\%$$

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SUBJECT	NAME	
RELIEF CAPACITY REQUIRED UNDER FIRE CONDITION	D. OLIS	
	DATE 8/31/00	REVISION DATE

CALC. PER CGA S-1.3-1995
SEC 5.3.1 UNINSULATED CONTAINERS FOR NON-LIQUIFIED COMPRESSED GASES

Q_a = FLOW CAPACITY [CFM] OF FREE AIR

$= 0.00035 P W_c$

~~WHERE $P = MAWP + 14.7 = 200 + 14.7 = 214.7$ PSI~~

W_c = WATER CAPACITY [LBM]

$W_c = \forall \rho_{WATER} = (3.96\ FT^3)\left(62.6\ \frac{LBM}{FT^3}\right)$ ← CALC. ATTACHED

$W_c = 248$ LBM WATER

$Q_a = (.00035)(214.7)(248) = 18.6$ SCFM REQ'D UNDER FIRE EXPOSURE

FERMILAB
ENGINEERING NOTE

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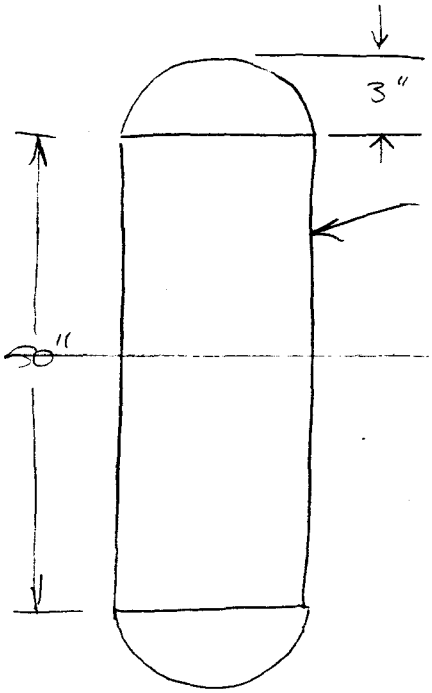
SUBJECT: VOLUME OF AIR DRYER DESICCANT TOWER

NAME: D. OLIS

DATE: 8/31/00

REVISION DATE:



$C = 38.5 \qquad C = \pi D$

$D = \frac{38.5}{12} = 12.25"$

$\forall = \frac{\pi D^2}{4}\left(L + \frac{4}{3}KD\right)$ ELLIPSOIDAL HEADS + TANK VOLUME

~~$D = 12.25 \quad L = 50$~~

$k = \frac{\text{RATIO OF HEAD DEPTH}}{\text{CYLINDER RADIUS}}$

$= \frac{3}{12.25/2}$

$k = .490$

$\forall = \frac{\pi}{4}(12.25)^2\left(50 + \frac{4}{3}(.490)(12.25)\right)$

$= 6836\ IN^3 = \underline{3.96\ FT^3}$ EAC -

SILICON DETECTOR PURGE SUPPLY I.A. SYSTEM