D-Zero I.A. Dryer
Pressure Vessel Engineering Note

Dan Olis
October 4, 2000

D0 Engineering Note
3823.112-EN-540

PRESSURE VESSEL ENGINERING NOTE
PER CHAPTER 5031

Prepared by: DAN OLIS AND ADRIAN VALDEZ
Preparation date: 9-14-00

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

This vessel conforms to Fermilab ES&H Manual Chapter 5031

Vessel Title INSTRUMENT AIR DRYER TOWER

Vessel Number PPD 10063 (LEFT), PPD 10064 (RIGHT) — Obtain from Safety Officer

Note two vessels, two stickers JWC.

Division/Section

Vessel Drawing Number ____

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

Working Temperature Range -25 °F 500 °F

Contents COMPRESSED AIR AND DESICCANT

Designer/Manufacturer
AIR DRYING SYSTEMS, 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
JWCooper

of Division/Section PPD Date: 9/29/00 — 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: Larry F. Carter 3236 Date: 9-27-2000

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): —

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

Purpose of Vessel(s): CONTAINS DESICCANT TO DRY THE SUPPLY AIR FOR D-ZERO INSTRUMENT AIR SYSTEMS

Vessel Capacity/Size: 1.44 FT^3 Diameter: 8" Length: 48"

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

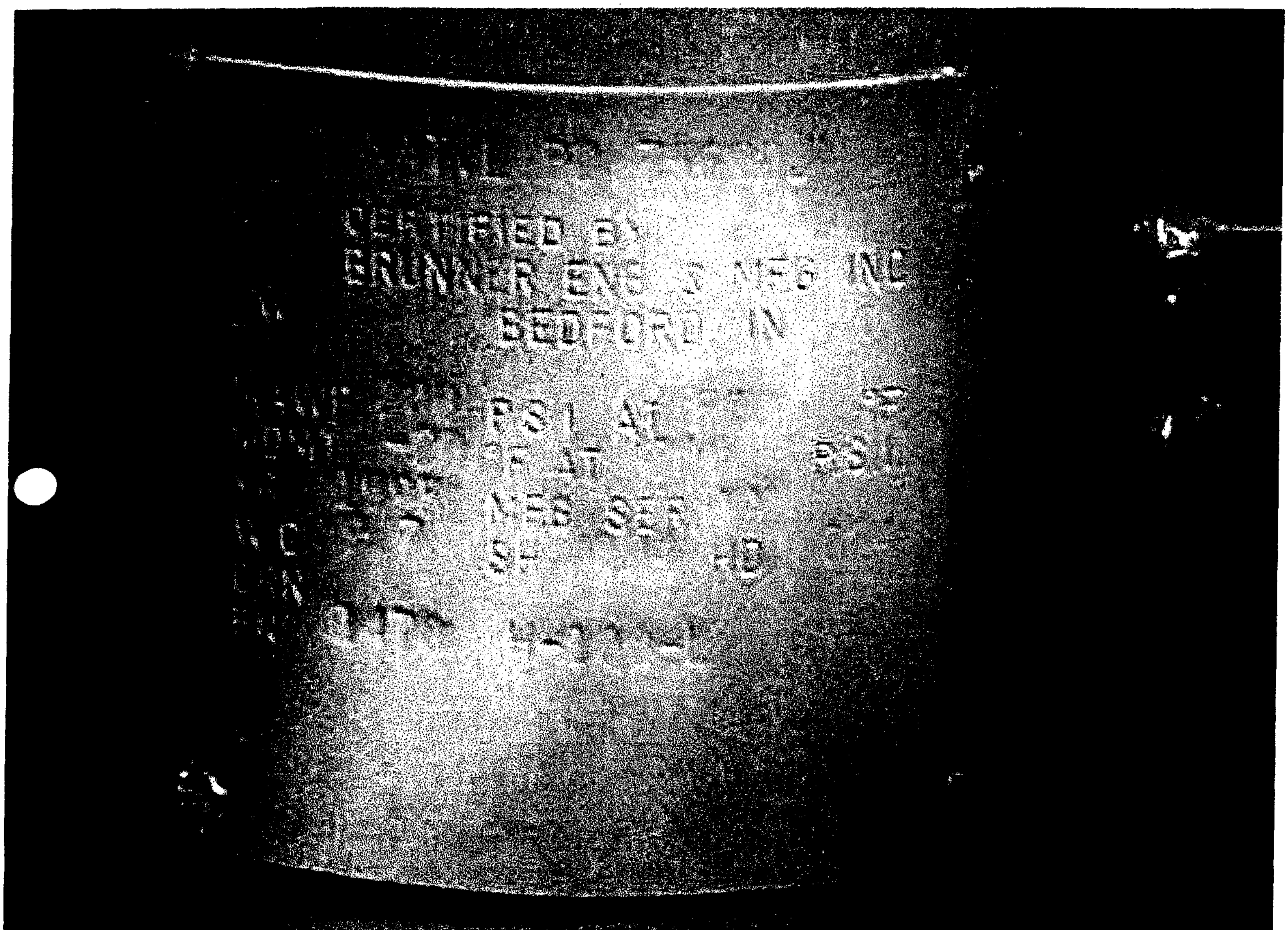
Copy data here:

PHOTOS ATTACHED

NAT.L. BD 75699J
MAWP 200 PSI @ 500°F
MDMT -25°F @ 200 PSI
YR. 1995 MFG. SER.XX
W.C. 9.7 SH. .094 HD .094
P.N. 1470 H-100-L

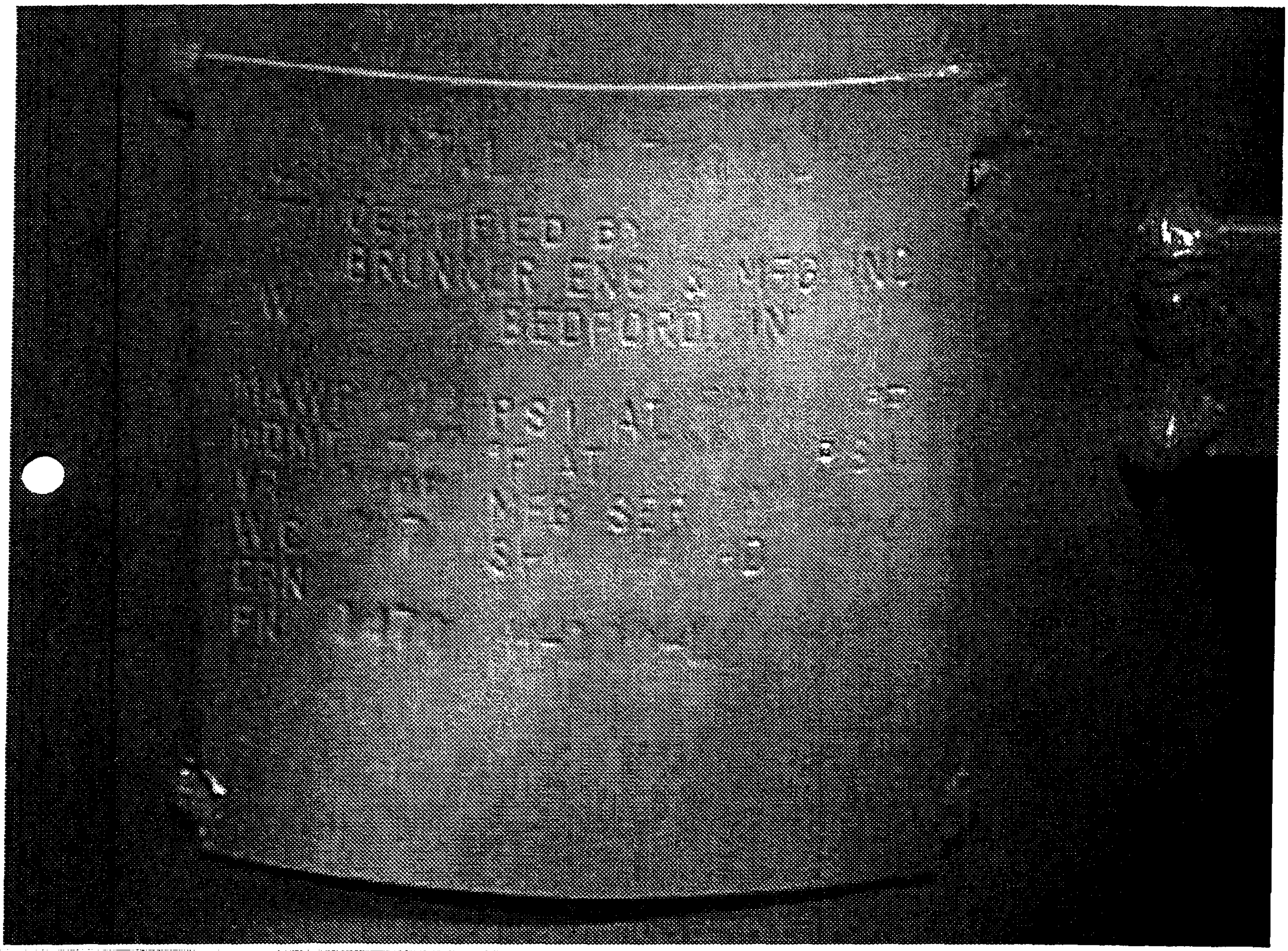
NAT.L BD 75690J
MAWP 200 PSI @ 500°F
MDMT -25°F @ 200 PSI
YR 1995 MFG. SER. XX
W.C. 9.7 SH. .094 HD .094
P.N. 1469 H-100-R

BOTH CERTIFIED BY: BRUNNER ENG. & MFG. INC.
BEDFORD, IN.

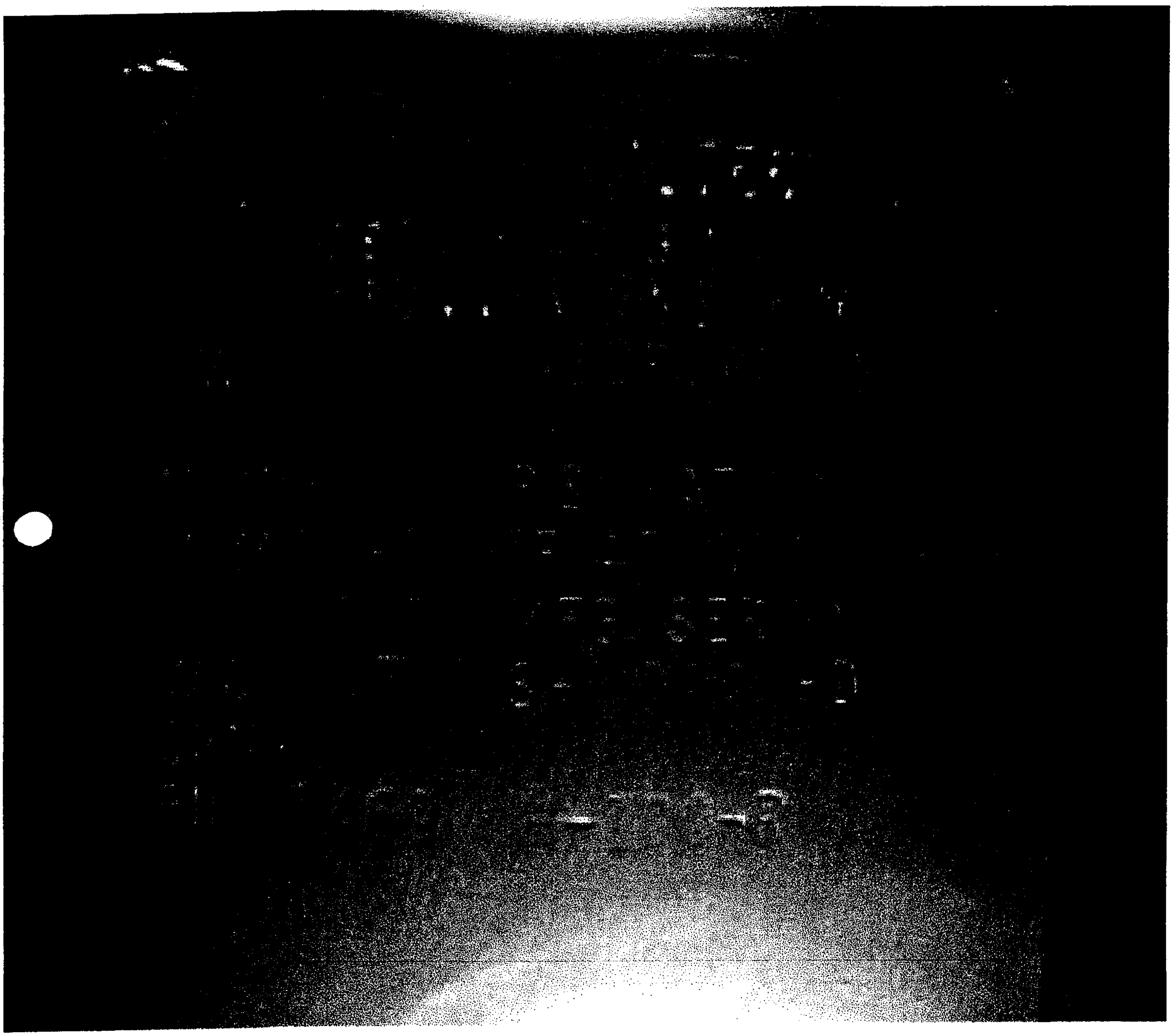


LEFT TOWER PPD 10063

5



LEFT TOWER PPD 10063



RIGHT TOWER PPD 10064

RIGHT TOWER PPD 10064

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
LEFT	F.C. KINGSTON CO.	112C	200 PSI	120 SCFM	1/4"
RIGHT	F.C. KINGSTON CO.	112C	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 devices for these pressure vessels are set to a pressure of 200 PSI and a flow rate of 120 SCFM. In order to demonstrate that the flow rate is sufficient, two relieving cases are considered:

1) Air dryer supplied from Ingersoll-Rand compressor
2) Air dryer exposed to fire conditions

- Ingersoll-Rand compressor

The air dryer serves as a backup dryer to two separate instrument air systems in the D-Zero Assembly Building. The dryer is located in room 215 and piped into both the Cryogenic Instrument Air System and the Silicon Detector Dry Purge Air System. A sketch of the piping arrangement is included in the appendix. Nominally the dryer is off-line until it is required to allow repair of either of the primary dryers serving the above two systems. When needed, bypass valves will be opened to divert flow from either system through the backup dryer.

Both of DAB's instrument air systems are supplied from Ingersoll-Rand screw compressors, models EP25U. Each compressor has a flow capacity of 97 SCFM at 125 PSIG delivery as can be seen on the attached data sheet. The modulate on-line/off-line control system integrated with the compressor will not allow the compressor discharge pressure to exceed 103% of rated pressure. Figure 3 from the IR EP25U owner's manual shows this and is attached. Therefore the maximum discharge pressure of the unit is 129 PSI, well below the relief setting of 200 PSI. Although in the system design the dryer will only service one air system at a time, it is physically possible to open valves such that the dryer is fed from both systems. Yet, again, the modulate on-line/off-line control system on each compressor will not allow the vessel pressure to exceed 129 PSIG. Therefore there is no risk of exceeding the vessel's MAWP of 200 PSI.

Note that each compressed air system shows a redundant air compressor. The second compressor serves as a backup unit. The two compressors on each system are hard wired through a selector switch, which allows electrical power to only one unit at a time.

- Fire Conditions

During exposure to fire conditions, the vessel requires a minimum flow capacity of 6.8 SCFM. This is well below the relief device's rated capacity of 120 SCFM. See the calculation attached in the appendix.

Relief Summary

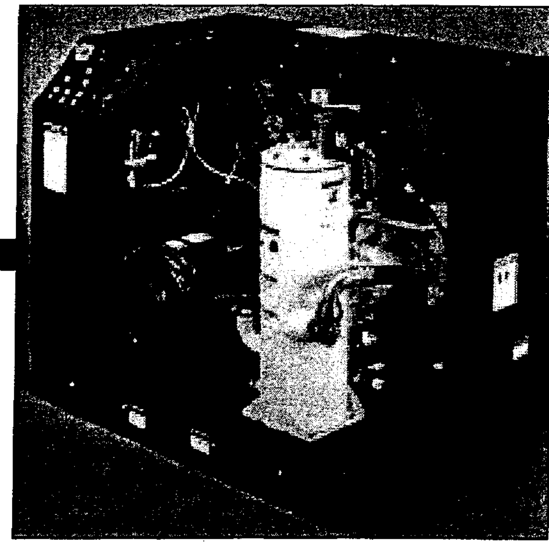
Cases	Required Capacity
1) Ingersoll-Rand Compressor	97 SCFM at 125 PSIG Unit will not deliver at relief pressure of 200 PSIG.
2) Fire Conditions	6.8 SCFM

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

%MAWP at relieving flow	105%

A1

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		50 Hz Units		Rated	Opt.	Base Mount		Tank Mount	
	Nom HP	CFM FAD(1)	Nom KW	m3/min FAD(1)	PSIG/ BARG	Tank Size	Dimen. lxwxh (2)	Weight lbs	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).

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.

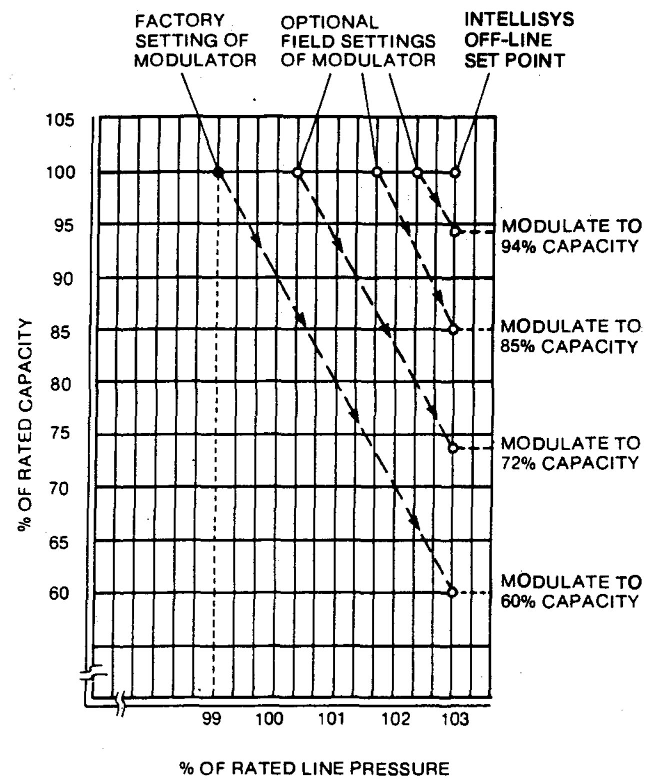
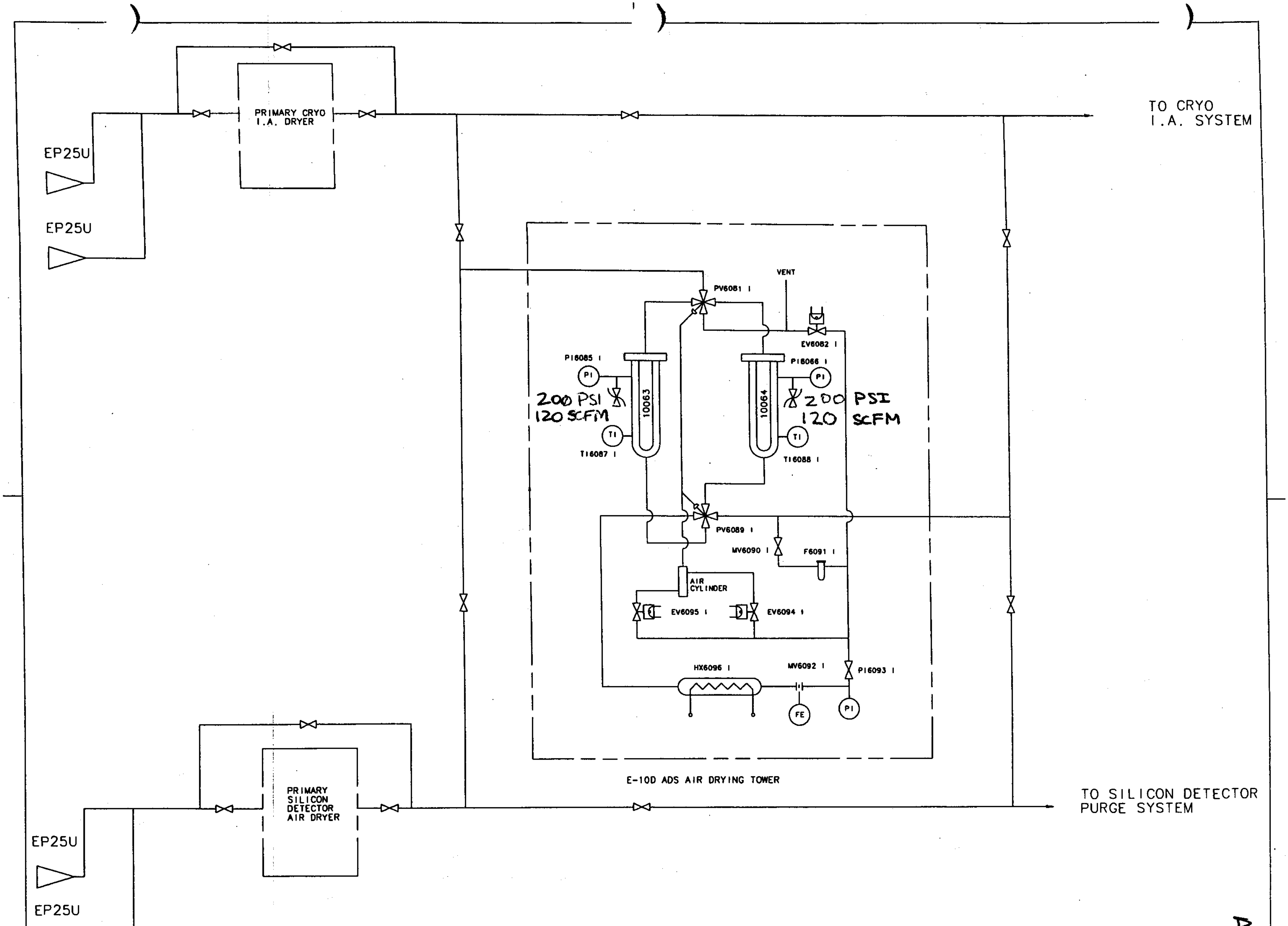


FIG. 3



CRYO. AND SILICON DETECTOR I.A. BACKUP DRYER SYSTEM SCHEMATIC

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
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SUBJECT: RELIEF SYSTEM PRESSURE DROP — % MAWP CALCULATION

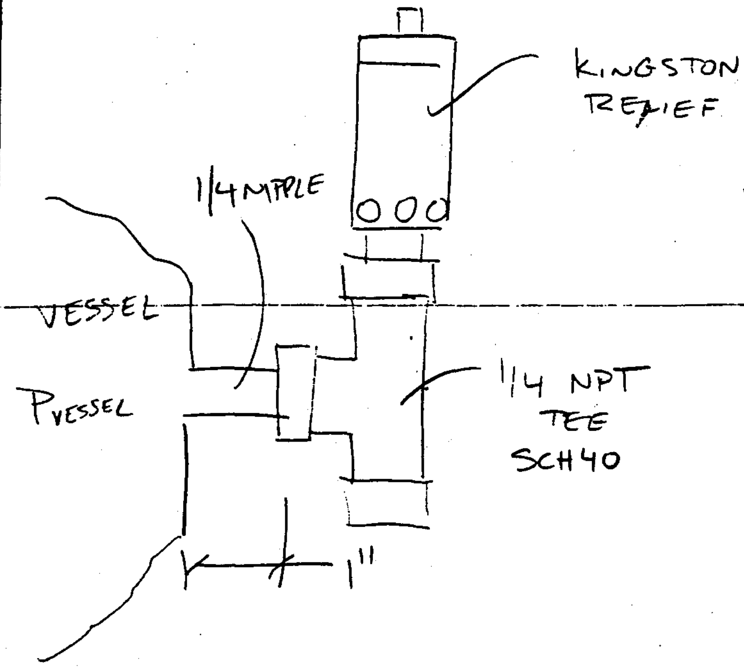
NAME: D. OLIS

DATE: 8/31/00

REVISION DATE:

RELIEF PRESSURE = 200 PSIG

FIND P_{VESSEL} FOR Q = 120 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" D = ID OF $\frac{1}{4}$" SCH40 = .364"

$K_{ENTRANCE} = 0.5$

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

$$\rho = \frac{P}{RT} = \frac{(200+14.7)\frac{LBF}{IN^2} \times \frac{144\ IN^2}{FT^2}}{\left(53.3\ \frac{FT\,LBF}{LBM\,°R}\right)(70+460)°R} = 1.094\ \frac{LBM}{FT^3}$$

$$V = \frac{Q_{ACT}}{A} \qquad Q_{ACTUAL} = Q_{STP} \times \frac{\rho_{STP}}{\rho_{ACTUAL}}$$

(STP ≡ STANDARD TEMP. & PRESSURE)

$$= 120\ \frac{\cancel{FT^3 @ STP}}{MIN} \times \frac{.075\ LBM/\cancel{FT^3 @ STP}}{1.094\ LBM/FT^3}$$

$$Q_{ACT} = 8.23\ FT^3/MIN$$

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

$$V = \frac{8.23\ FT^3/MIN}{.000723\ FT^2} \times \frac{MIN}{60\ SEC} = \underline{\underline{190\ FT/S}}$$

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			A5

SUBJECT: RELIEF SYSTEM PRESSURE DROP — % MAWP CALCULATION

NAME: D. OLIS

DATE: 8/31/00

REVISION DATE:

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

$$R_e = \frac{\rho V D}{\mu} \qquad \mu_{AIR} = 3.80\times10^{-7}\ \frac{LBF\text{-}S}{FT^2}$$

$$R_e = \frac{\left(1.094\ \frac{LBM}{FT^3}\right)\left(190\ \frac{FT}{S}\right)\left(\frac{.364}{12}\ FT\right)}{3.80\times10^{-7}\ \frac{LBF\text{-}S}{FT^2} \times \frac{32.2\ LBM\ FT}{S^2\ LBF}} = 515{,}300 = 5.2\times10^{5}$$

MOODY PLOT GIVES $f = .013$

$$\Delta P = \left[(.013)\left(\frac{1.1\ in}{.364\ in}\right) + 0.5 + 1.8\right]\left(\frac{1}{2}\right)\left(1.094\ \frac{LBM}{FT^3}\right)\left(190\ \frac{FT}{S}\right)^2 \left\| \frac{LBF\ S^2}{32.2\ LBM\ FT}\right.$$

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

$$= 9.9\ PSID$$

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

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

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

FERMILAB ENGINEERING NOTE	SECTION PPD / E&TT	PROJECT DØ-	SERIAL-CATEGORY	PAGE A6

SUBJECT	NAME	
Relief Flow Capacity under Fire Conditions	Adrian Valdez	
	DATE 6/[illegible]/00	REVISION DATE

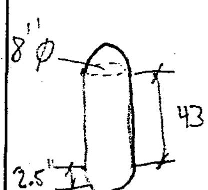
Per CSA S-1.3-1995 Sec 5.3.1 for uninsulated containers for non liquefied compressed gases.

$Q_a \equiv$ flow capacity [CFM] OF FREE AIR

$$Q_a = 0.00035\ P\ W_c$$

where: $P = MAWP + 14.7\ psia = 214.7\ psi$

W_c = Water capacity of container



$$W_c = \rho_{water} V \quad \text{and} \quad V = \frac{\pi D^2}{4}\left(L + 1\tfrac{1}{3} KD\right)$$

} Volume of cylindrical tank w/ ellipsoidal head

$D = 8''$ $L = 43''$

K = ratio of depth of head to radius of cylinder $= (2.5/4)$

$$\therefore V = \frac{\pi (8'')^2}{4}\left[43'' + 1\tfrac{1}{3}\left(\tfrac{2.5''}{4''}\right)(8'')\right]$$

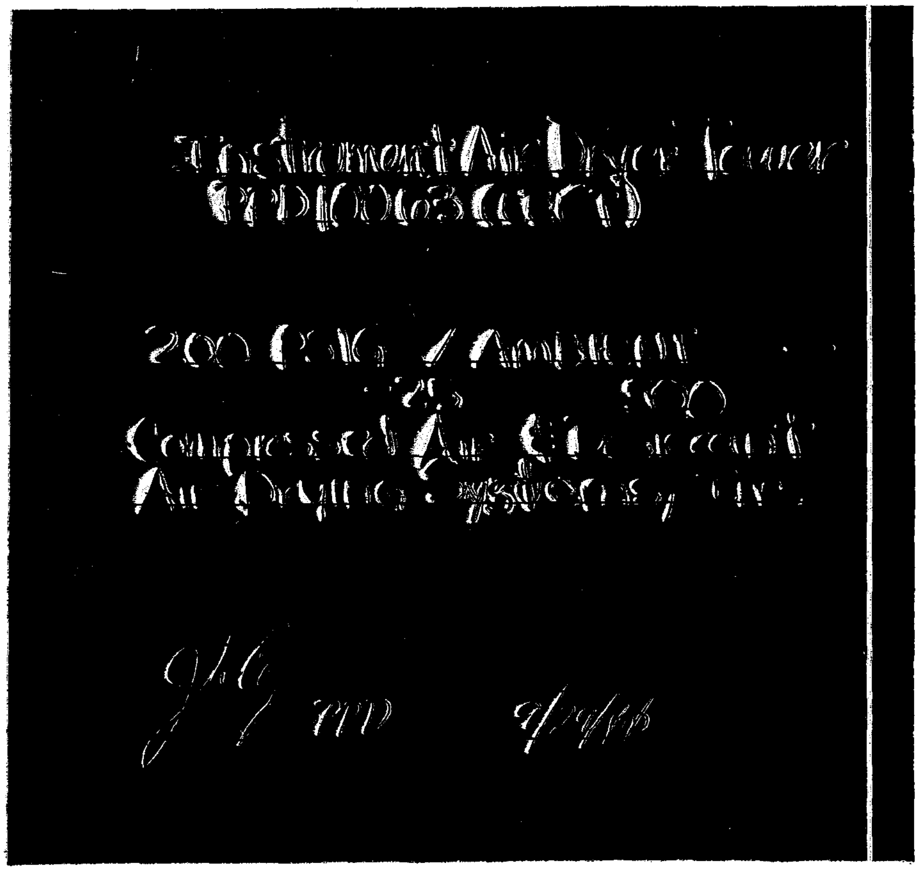
$V = 2498.19\ in^3$

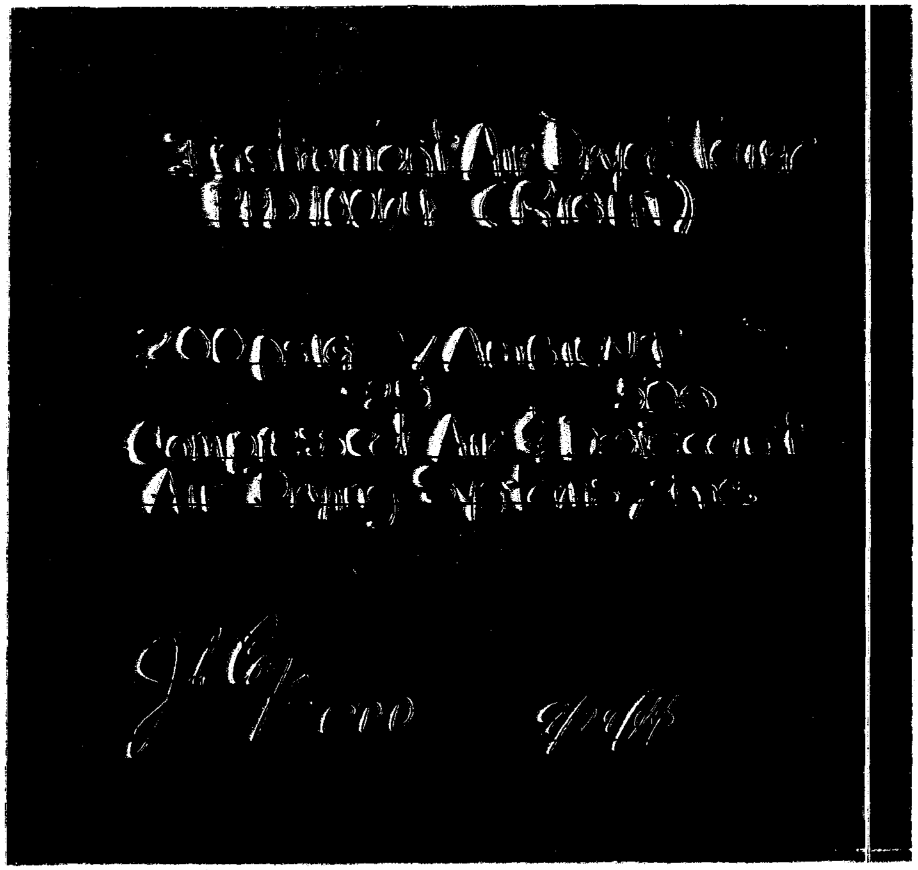
$V = 1.44\ ft^3$

$$W_c = (62.58\ lb_m/ft^3)(1.44\ ft^3) = 90.16\ lb_m$$

$$\therefore Q_a = 0.00035(214.7)(90.16)$$

$$\boxed{Q_a = 6.77\ scfm}$$


Instrument Air Dryer Tower
200 PSIG / Ambient
Compressed Air & Chemical
Air Drying Systems, Inc.


200 psig