E706 CRYOSYSTEM DESIGN NOTE

E706EN017

TITLE: Pressure Vessel Engineering Note (14.1)
House Compressor Receiver, E706 LAC
RD2054, NB688599

AUTHOR: Danny D. Burke, ME, RD/Cryogenics Department

DATE: February 6, 1987

REVIEWED BY:

R.C. Niemann	3/29/87		30 Mar 87
Name	Date	Project Manager	Date

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R.C. Niemann — Name; 3/29/87 — Date; Project Manager; 30 Mar 87 — Date

PRESSURE VESSEL ENGINEERING NOTE
PER MANDATORY STANDARD SD37

Prepared by: Dan Burke, ME

Preparation date: January 27, 1987

1 Description and Identification

Fill in the label information below:

This vessel conforms to engineering standard SD37

Vessel Title E-706 House Comp. Receiver

Vessel Number RD 2054, NB 688599 ← Obtain from Division/Section Safety Officer

Vessel Drawing Number Not Available

Maximum Allowable Working Pressure (MAWP) 200 PSIG

Working Temperature Range 20 °F 450 °F

Contents Compressed Air

Designer/Manufacturer Buckeye Boiler Co.

Test Pressure (if tested at Fermi) Acceptance Date:

PSI, Hydraulic Pneumatic

Accepted as conforming to standard by K. C. Stanfield ← Actual signature required in this space

of Division/Section Research Div.

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

Reviewed by: R. C. Niemann Date: 4/2/87

Director's signature (or designee) if the vessel is for manned areas but doesn't conform to the requirements of the standard.

Date:

Lab Property Number(s): NAL 56349

Lab Location Code: MES MWA (obtain from Safety Officer)

Purpose of Vessel(s): To supply air for general use in support of the Liquid Argon Calorimeter Facility.

Vessel Capacity/Size: 80 Gal. Diameter: 18" Length: 60"

Normal Operating Pressure (OP) 120 PSIG

MAWP-OP = 80 PSID

Is the above enough to provide relief cracking pressure tolerance plus system uncertainty tolerance per M-9. Yes.

As an option, provide a photo of the entire vessel in the Appendix.

List the numbers of all pertinent drawings and the location of the originals. (Append copies).

Drawing #	Location of Original

2 Design Verification

Does the vessel(s) have a U stamp? Yes X 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 if photo is not clear of if copies are unreadable.

Copy data here:

U. Buckeye

WS Boiler Co.

Dayton, Ohio

MAWP 200 PSI @ 20°Min

450° Max F.

SH 154 HD 140 HD RAD E

YR 1985.

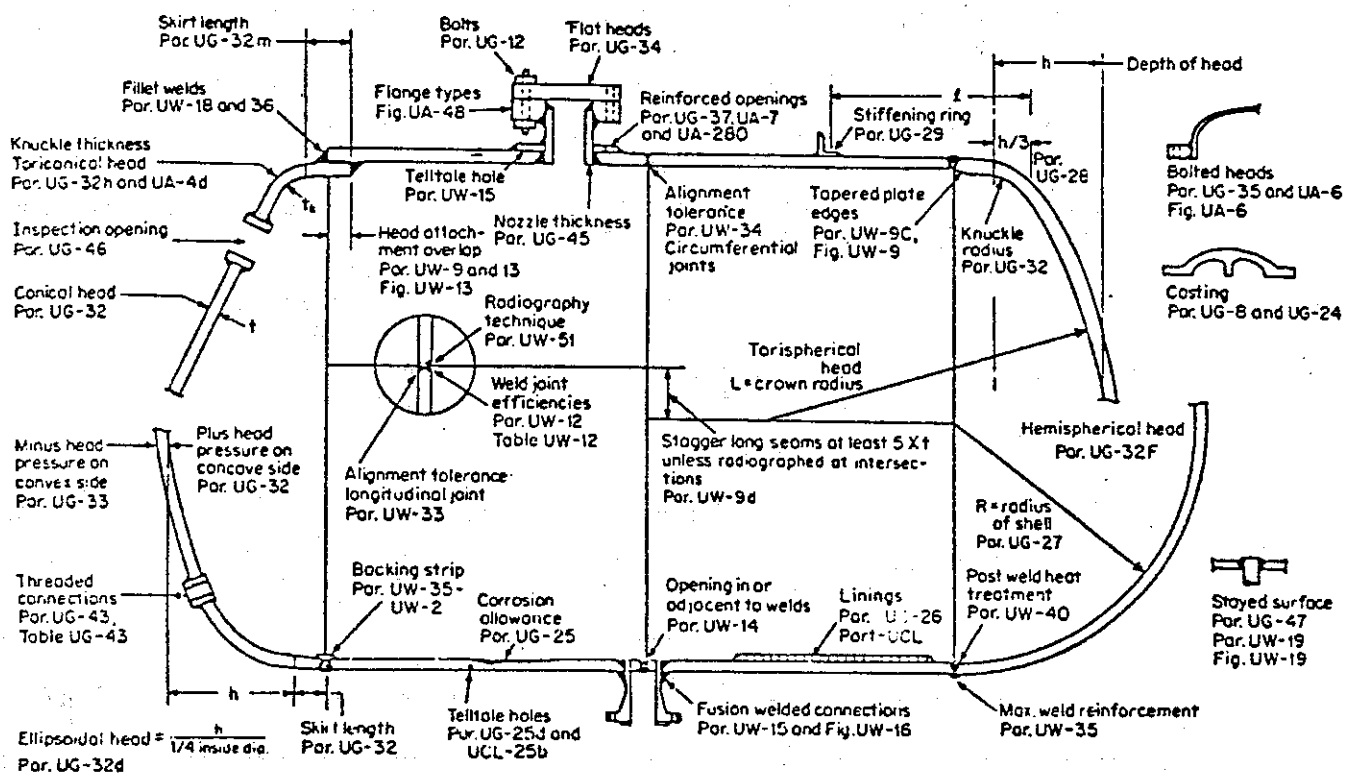
Part No. 320-8533

01-2325-A

CRN E-7399

NB 688599

On the sketch below, circle all applicable sections of the ASME code per Section VIII, Division I. List the results of all calculations. (Insert copies of calculations in the appendix).



Summary of ASME Code

Item	Reference ASME Code Section	CALCULATION RESULT (Required thickness or stress level vs. actual thickness or calculated stress level)
		vs.
		vs.
		vs.
		vs.
		vs.

If this vessel is exceptional or had exceptional parts, list their details under 5.6. Yes_____ No_____

3 System Venting. Provide the system schematic in the Appendix, if the vessel safety is system sensitive.

Is it possible to isolate the relief valves by a valve from the vessel?

Yes_____ No__X__

If "Yes", the system must conform to M-5. Provide an explanation on the appended schematic. (An isolatable vessel, not conforming to M-5 violates the Standard.)

Is the relief cracking pressure set at or below the M.A.W.P.?

Yes__X__ No_____ Actual setting __200__ PSIG
(A no response violates the Standard.)

Is the pressure drop of the relief system at maximum anticipated flow such that vessel pressure never rises above the following? (UG 125)

Yes__X__ 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 violate the Standard.)

List of reliefs and settings:

Manufacturer	Relief	Setting	Flow Rate	Size
Eaton Corp. N.C.	95122-1/4	200 PSIG	183 SCFM	1/4

Is the relief device an ASME stamped device? Yes__X__ No _____

4 Operating Procedure

Is an operating procedure necessary for the safe operation of this vessel?

Yes____ No__X__. If "Yes", please append.

5 Welding Information

Has the vessel been fabricated in a Fermilab shop? Yes_____ No__X__

If "Yes", append a copy of the welding shop statement of welder qualification and a copy of the Welding Procedure Specification (WPS) used to weld this vessel.

6 Exceptional, Existing, Used, and Non-Manned Area Vessels

Is this vessel or any part thereof in the above categories? Yes_____ No__X__

If "Yes", follow the Engineering Note requirements for documentation in free form below.

1 Background

This compressor receiver is to be used in conjunction with the Ingersoll-Rand Corp. compressor, as shown in Appendix A. The compressor is a Model 71T2-10D, as follows:

1st Stage relief 60 PSIG @ 63 SCFM, air
@ 200 PSIG, total flow capacity is 35 SCFM, air
@ 100 PSIG, total flow capacity is 40 SCFM, air

The compressor system will be hereinafter referred to as the "House" compressor. The House compressor is located South of the Liquid Argon Calorimeter (LAC), and is inside the MW Detector Hall.

Information stamped on the body of the ASME certified safety valve (U-stamped) is as follows:

EATON CORP. N.C.
95122 1/4 200 PSI
CRN-03378.6 183 SCFM
NB [UV] 86

The relief valve cannot be isolated, and is installed such that no discharge can hit people, or equipment, and cannot be plugged or otherwise reduced in capacity.

2 Summary

Required Capacity/Area	Capacity/Area Available
CGA S1.3-1980 $Q_S \geq 19.98 SCFM$	183 SCFM
API RP520 Fire Exposure $A \geq 0.0313 sqin$	0.049 sqin

3 Requirements of CGA S1.3-1980

According to CGA S1.3-1980, Para. 5.3.2, the applicable equation for the minimum required flow capacity is:

$$Q_S = 0.029 W_e ,$$

where Q_S = Flow capacity in cubic feet per minute of free air ,

W_e = Water capacity of the container in pounds .

According to the manufacturer's specifications, the volume of the receiver is 80gal. The water capacity is therefore:

$$W_e = 8.36 lb/gal\ H_20 \times 80 gal. ,$$

$$W_e = 688.8 lb, \text{water capacity} .$$

The minimum required flow capacity is therefore:

$$Q_S = 0.029(688.8) = 19.98 SCFM ,$$

$$Q_S = 19.98 SCFM, \text{air minimum capacity} .$$

The capacity available is, according to the manufacturer's U-stamped value:

183SCFM > 19.98 SCFM minimum required.

The Cryo compressor receiver is adequately relieved.

In addition to these requirements, since the total flow capacity at the receiver MAWP = 200 PSIG is 35 SCFM, air, and the receiver relief valve capacity is 183 SCFM, air, the compressor is protected against pressure controls failure.

4 Exposure to an External Fire

Requirements of *API Recommended Practice 520*, Fourth Edition, December 1976, for sizing for gas expansion due to an external fire, Sec. C.3, Page 39, are that the minimum effective discharge area should be:

$$A = \frac{F' A_3}{\sqrt{P_1}}$$

where A = effective discharge area of the valve in sqin.

F' = factor from API RP-520, Fig. C-3, Page 41, use $F' = 0.045$ if not known.

A_3 = exposed surface area of the vessel in sqft.

P_1 = set pressure plus the allowable overpressure ($1.10 P_{set}$) plus atmospheric pressure (PSIA).

For this vessel:

$F' = 0.016$, Fig C-3, API-RP520

$A_3 = 30. sq.ft.$,

$P_1 = 200(1.10) + 14.696 PSIA$,

$P_1 = 234.7 PSIA$,

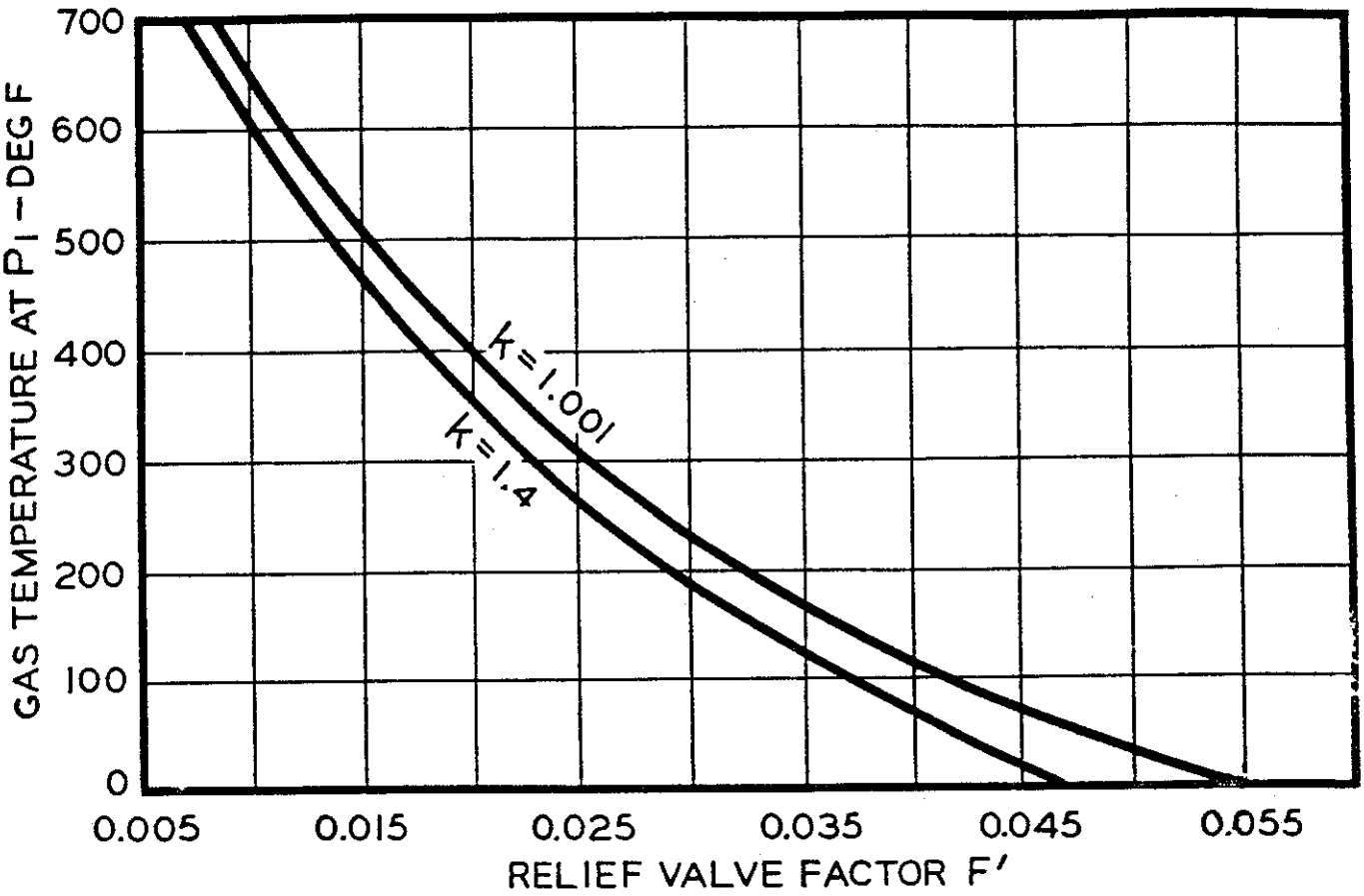
$A = 0.016(30)/(234.7)^{1/2}$,

$A = 0.0313 sqin$ minimum effective valve discharge area.

The effective area of the valve used is 0.049sqin. Since

$$0.049 > 0.0313,$$

the vessel is adequately relieved.



NOTES:

1. Table 1 gives k values for some gases; for others, the values can be determined from the properties of gases as presented in any acceptable reference work.

C = 356
K = 0.62

2. These curves are for vessels of carbon steel.

3. These curves conform to the relationship $F' = \left(\frac{0.1406}{CK}\right)\left(\frac{\Delta T^{1.25}}{T_1^{0.6506}}\right)$ = 0.016

Where:

C = coefficient which is determined by the ratio of the specific heats of the gas at standard conditions. This can be obtained from Figure 2, Figure B-2, or Table C-1.

K = coefficient of discharge, which value is obtainable from the valve manufacturer. The K for a number of nozzle-type valves is 0.975.

T_1 = gas temperature, absolute, in degrees Fahrenheit + 460, at the upstream pressure, and is determined from the relationship:

$$T_1 = \left(\frac{P_1}{P_n}\right) T_n \qquad T_1 = \left(\frac{234.7}{114.7}\right) 520 = 1064.05\,R$$

T_n = normal operating gas temperature, in degrees Fahrenheit + 460.

P_n = normal operating gas pressure, in pounds per square inch absolute.

$\Delta T = 495.95\,R$

P_1 = upstream relieving pressure, in pounds per square inch absolute. This is the set pressure plus the allowable overpressure (see Paragraph C-6) plus the atmospheric pressure in pounds per square inch absolute.

$\Delta T = T_w - T_1$. Difference between wall temperature and the temperature of the gas at P_1.

T_w = vessel wall temperature, in degrees Fahrenheit + 460.

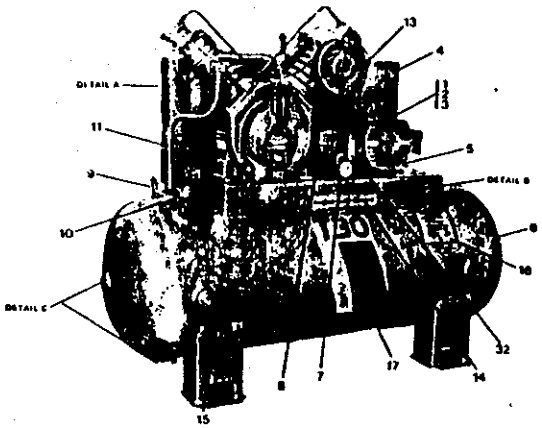
The curves are drawn using 1,100 degrees Fahrenheit as the vessel wall temperature. This value is a recommended maximum temperature for the usual carbon steel plate materials whose physical properties at temperatures in excess of 1,100 degrees Fahrenheit show signs of undesirable tendencies. Where vessels are fabricated from alloy materials, the value for T_w should be changed to a more proper recommended maximum.

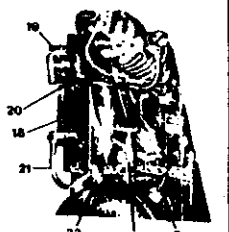
It is recommended that the minimum value of $F' = 0.01$ (when it is unknown use 0.045).

Figure C-3—Relief-Valve Factors for Noninsulated Vessels in Gas Service Exposed to Open Fires

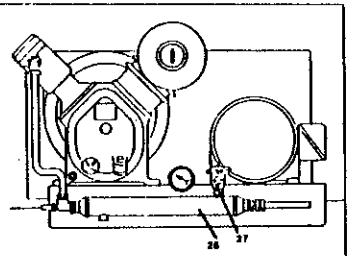
APPENDIX A Ingersoll-Rand Corporation Compressor

APPENDIX 1

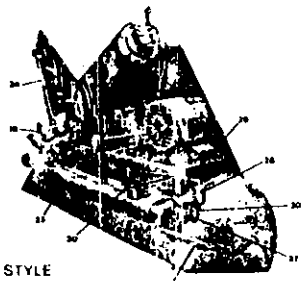




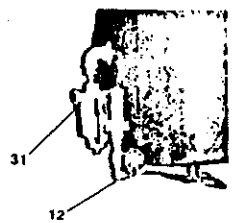
DETAIL A AIR COOLED AFTERCOOLER



DETAIL B-1 NEW STYLE WATERCOOLED AFTERCOOLER



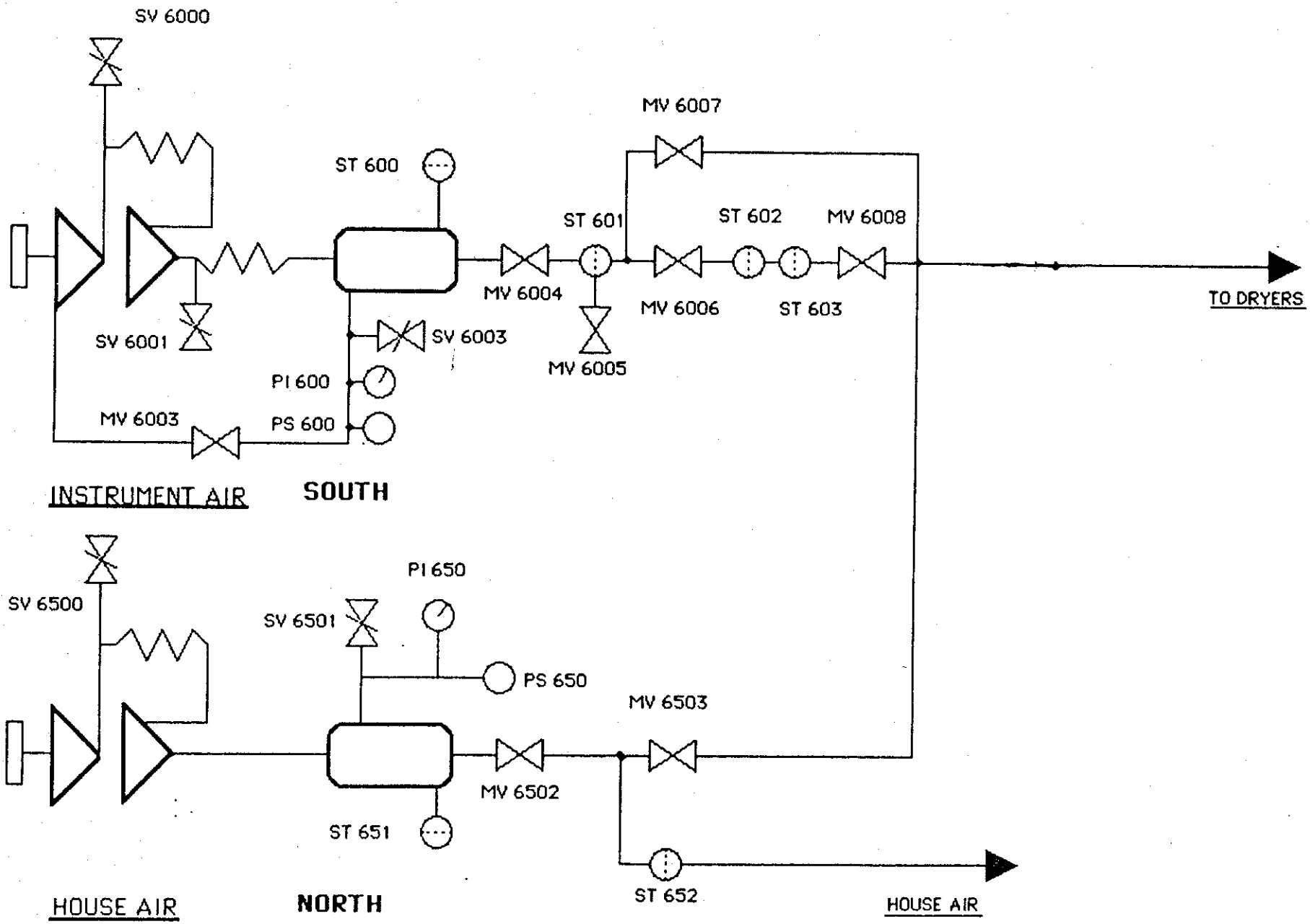
DETAIL B - OLD STYLE WATERCOOLED AFTERCOOLER



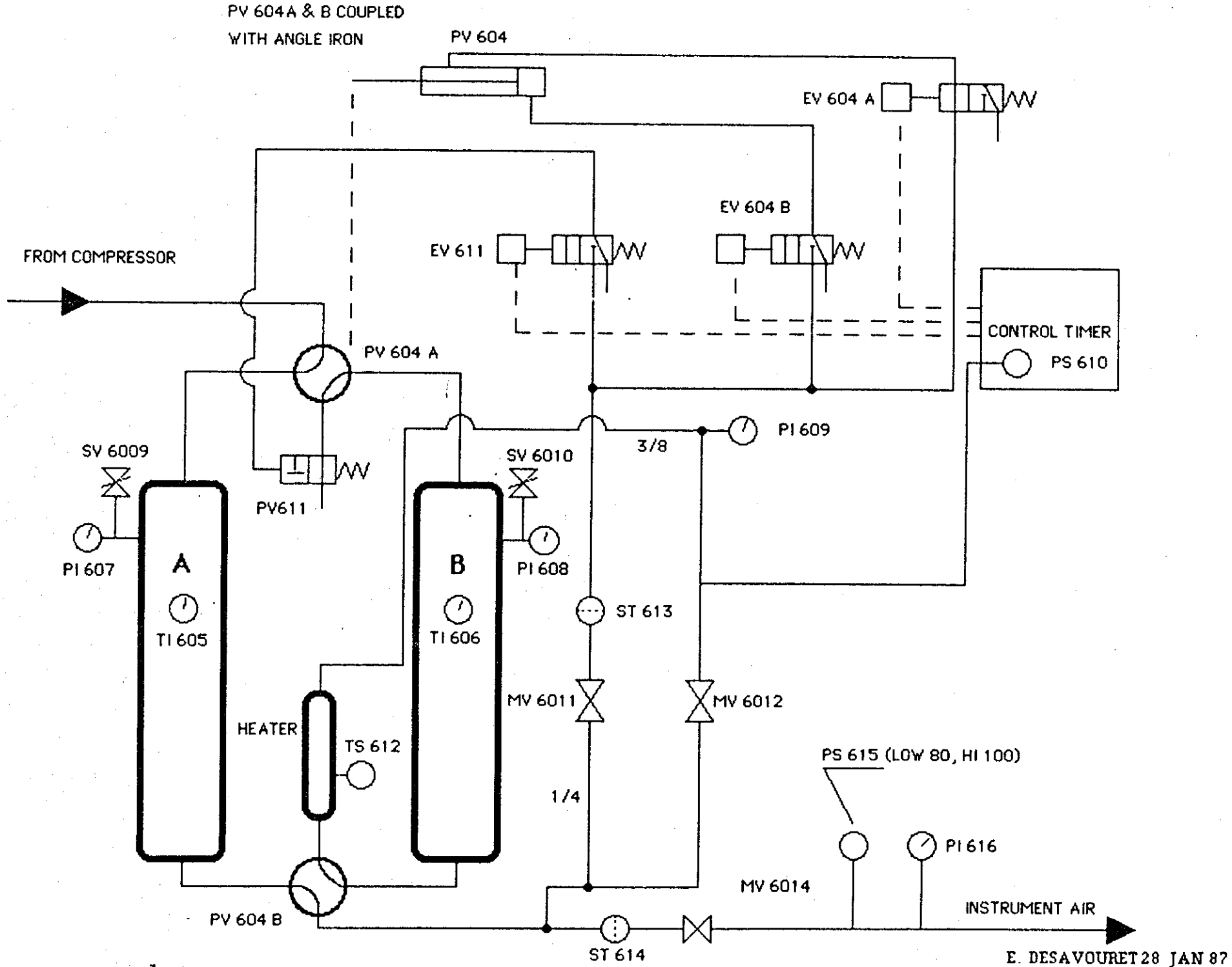
DETAIL C - AUTO DRAIN VALVE & MANUAL DRAIN

REF NBR.	PART NUMBER	DESCRIPTION	CCN NUMBER	UNITS PER ASSY	REC SPARES 1	2	3
10-1		MOTOR †		1			
10-2		PULLEY-MOTOR†		1			
10-3		BELT-V†		3		3	3
10-4	W136110T7	GUARD-BELT COMPLETE	32002503	1			
10-5	32142002	TIGHTENER-BELT COMPLETE 7 1/2 to 10 HP	32142002	1			
10-6	H41525	RECEIVER ASSY. AIR HORIZONTAL 120 GAL.	32018541	1			
10-*	H41518	RECEIVER ASSY. AIR HORIZONTAL 80 GAL.	32018533	1			
10-7	R63304T14	GUAGE-PRESSURE	32013872	1			1
10-8	W75400T5	SWITCH-PRESSURE	37005907	1			
10-9	X1396T28-200	VALVE-RECEIVER SAFETY	31385693	1			1
10-10	W75410T16	VALVE-ANGLE GLOBE	32006975	1			
10-11	W114266T4	TUBE ASSY. COMPR. DISCH. TO REC. 120 GAL.	32020838	1			
10-11	W114266T1	TUBE ASSY. COMPR. DISCH. TO REC. 80 GAL.	32020604	1			
10-12	32027120	VALVE-MANUAL DRAIN	32027120	1			
10-13	W45928	DECAL-ROTATION ARROW	30286686	1			
10-14	R40626	DECAL-INGERSOLL RAND	30288054	1			
10-15	W39846	DECAL-AIR RECEIVER DRAIN	30286678	1			
10-16	W143532	DECAL-MAINTENANCE	32015820	1			
10-17	H48296	DECAL-TYPE 30	32010068	1			
		OPTIONAL EQUIPMENT (DETAIL A)					
10-18	W136110T7A	AFTERCOOLER-AIR COOLED COMPLETE BG100	32002867	1			
10-19	X1396T28-260	VALVE-DISCH LINE SAFETY	37106184	1			1
10-20	W-14266T2	TUBE ASSY COMPR DISCH TO COOLER	32020612	1			
10-21	W114225T6	TUBE ASSY COOLER TO REC 120 GAL	32060758	1			
10-21	W114225T2	TUBE ASSY COOLER TO REC 80 GAL	32020687	1			
10-22	32061376	SILENCER-NOISE	32061376	1			
		(DETAIL B OLD STYLE)					
10-23	BL54328T3	AFTERCOOLER-WATER COOLED COMP (B42R)	32020687	1			
10-24	W114266T3	TUBE ASSY. COMPR DISCH TO COOLER	32110215	1			
10-25	W114225T13	TUBE ASSY. COOLER TO RECEIVER	32123440	1			
		(DETAIL B-1 NEW STYLE)					
10-26	32144412	AFTERCOOLER-WATER COOLED	32144412	1			
10-27	W60413P1	VALVE-AUTO WATER (USED ON OLD AND NEW STYLE COOLERS)	35229723	1			1
10-28	W75406	VALVE-WATER REVERSING (USED WITH CONSTANT OR DUAL CONTROL)	30220651	1			1
10-29	W114266T12	TUBE ASSY. WATER VALVE TO INTERCOOLER	32110231	1			
10-30	W114266T15	TUBE ASSY. REVERSING VALVE TO CONSTANT SPEED UNLOADER	32110256	1			
		(DETAIL C)					
10-31	W75422	VALVE AUTO CONDENSATE DRAIN	30835185	1			
		(AUXILIARY VALVES-CONSTANT SPEED OR DUAL CONTROL)					
10-32	R71524T1	CONSTANT SPEED (0-150PSI OPERATION)	32011728	1			
10-32	R71524T3	CONSTANT SPEED (150-250PSI OPERATION)	32011736	1			
10-32	R71524T3	DUAL CONTROL (0-150PSI OPERATION)	32011744	1			
10-32	R71524T4	DUAL CONTROL (150-250PSI OPERATION)	32011751	1			

†SPECIFY DISCHARGE PRESSURE OF COMPRESSOR AND COMPLETE MOTOR NAMEPLATE DATA
*NOT ILLUSTRATED



E. DESAVOURET 28 JAN 87


PV 604A & B COUPLED
WITH ANGLE IRON
PV 604
EV 604 A
EV 604 B
EV 611
FROM COMPRESSOR
CONTROL TIMER
PS 610
PV 604 A
PI 609
3/8
SV 6009
SV 6010
PV611
PI 607
A
B
PI 608
TI 605
TI 606
ST 613
MV 6011
MV 6012
HEATER
TS 612
1/4
PS 615 (LOW 80, HI 100)
PI 616
MV 6014
INSTRUMENT AIR
PV 604 B
ST 614
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