PRESSURE VESSEL ENGINERING NOTE - 097 1/9
PER CHAPTER 5031

Prepared by: Andy Stefanik
Preparation date: Jan 28, 2005

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

This vessel conforms to Fermilab ES&H Manual Chapter 5031

Vessel Title Coolant Expansion/Contraction Tank

Vessel Number NMI-018 ←Obtain from Division/Section Safet

Vessel Drawing Number None.

Maximum Allowable Working Pressures (MAWP):
Internal Pressure 125 psi
External Pressure No

Working Temperature Range -20 °F 240 °F

Contents Coolant: 75% water/25% propylene glycol

Designer/Manufacturer Wessels Company
Greenwood, IN 46143

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

_______PSIG, Hydraulic______ Pneumatic__________

Accepted as conforming to standard by

____

of Division/Section______________ Date:________ ←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: [signature] Date: 3-2-05

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

_______________________________ Date:______________

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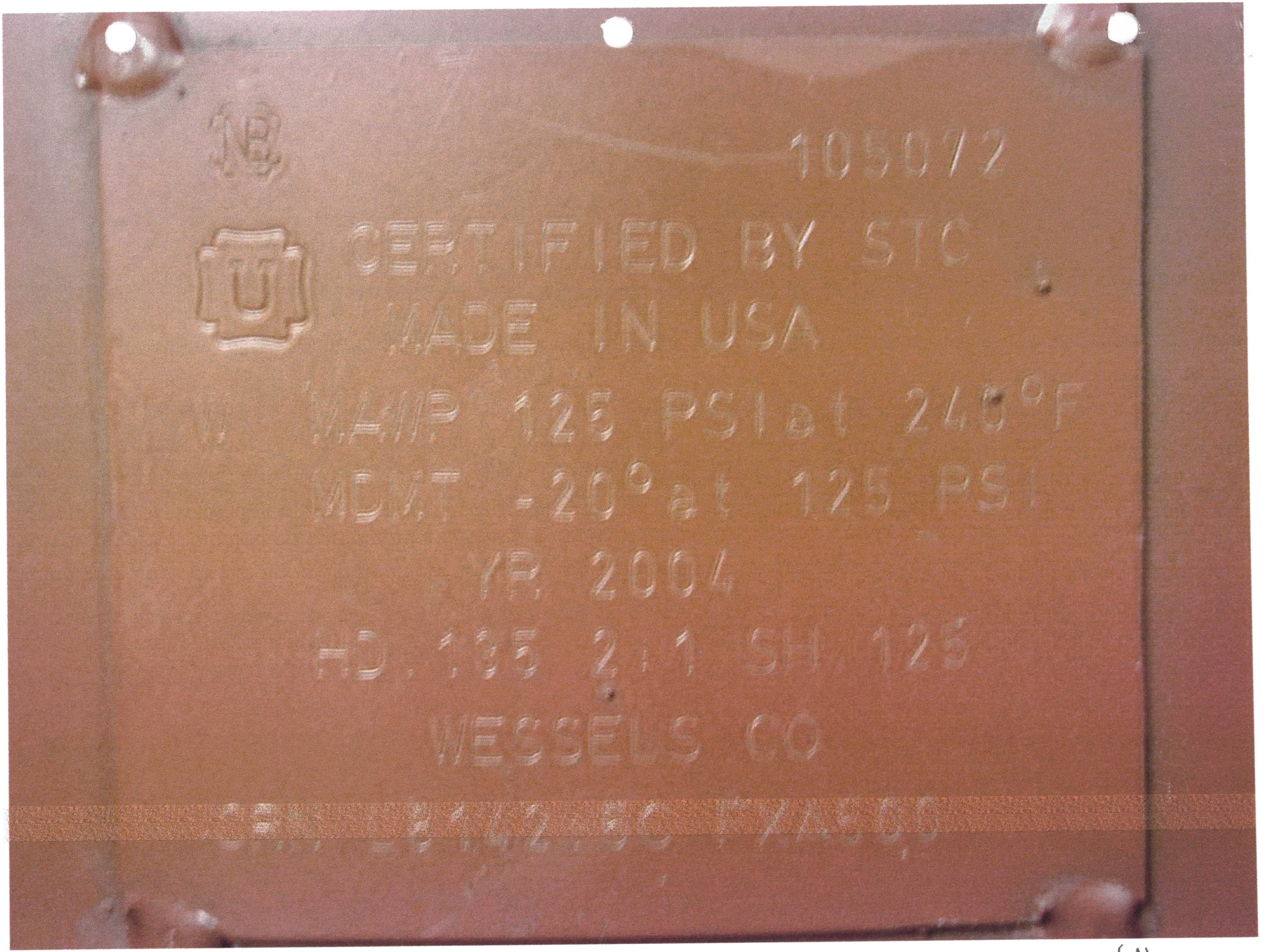
______________________________________ Date:______________


NB
105072
U
CERTIFIED BY STC
MADE IN USA
MAWP 125 PSI at 240°F
MDMT -20° at 125 PSI
YR. 2004
HD. 135 2:1 SH. 125
WESSELS CO

Manufacturer's U1 Data Sheet

Waiting for it to arrive.

Starts on page 8.

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3. System Venting Verification Provide the vent system schematic.

Does the venting system follow the Code UG-125 through UG-137?
Yes ✓ No___

Does the venting system also follow the Compressed Gas Association Standards S-1.1 and S-1.3?
Yes _____ No ✓

A "no" response to both of the two proceeding questions requires a justification and statement regarding what standards were applied to verify system venting is adequate.

List of reliefs and settings:

Manufacturer	Model #	Set Pressure	Orifice Area or Flow Rate	Size
1) Crosby	991307MD	125psi	0.503in²	1½" x 2½"
See pages 6 and 7 for 991307MD specs.				
2) Control Devices, Inc.	SCB7510-0A125	125psi	~~496 scfm air~~	¾" INLET
See Appendix DD for Model STB specs.				

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. Existing, Used and Unmanned Area Vessels

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

If "Yes", follow the requirements for an Extended Engineering Note for Existing, Used and Unmanned Area Vessels.

7. Exceptional Vessels

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

If "Yes", follow the requirements for an Extended Engineering Note for Exceptional Vessels.

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CROSBY

Crosby's Series 800 adjustable blowdown and Series 900 fixed blowdown OMNI-TRIM® pressure relief valves have a simplified, single trim design with superior application versatility.

Features

- Relieving capacities certified by National Board of Boiler and Pressure Vessel Inspectors. Certification includes air and steam for Series 800, and air, steam and water for Series 900.
- Valves manufactured in accordance with the requirements of ASME Boiler and Pressure Vessel Code Section VIII and Section III.
- Superior seat tightness. Precision lapped flat metal-to-metal seats, or elastomer or TFE O-ring soft seats provide the ultimate in seat tightness.
- Maximum corrosion resistance. Trim components are stainless steel as standard. All 316 stainless steel, Monel®, Hastelloy® and NACE* optional constructions are available.
- Spring standardization. Standard Series 800 and Series 900 OMNI-TRIM® pressure relief valves are suitable for inlet temperatures to 750°F [399°C], using a 17-7PH stainless steel spring.
- Positive built-in lift stop.
- Fewer parts result in increased reliability and ease of maintenance.
- Series 800 pressure relief valves have an external blowdown adjustment allowing for short blowdown, smaller differential between operating and set pressures, and reduced product loss.
- Series 900 OMNI-TRIM® valves use a single trim design for liquid, gas and vapor services.
- Series 900 OMNI-TRIM® valves provide reliable blowdown without the need for adjustment.

* Contact the factory for compliance to NACE MR-0175-2003 or later requirements.

tyco / Flow Control

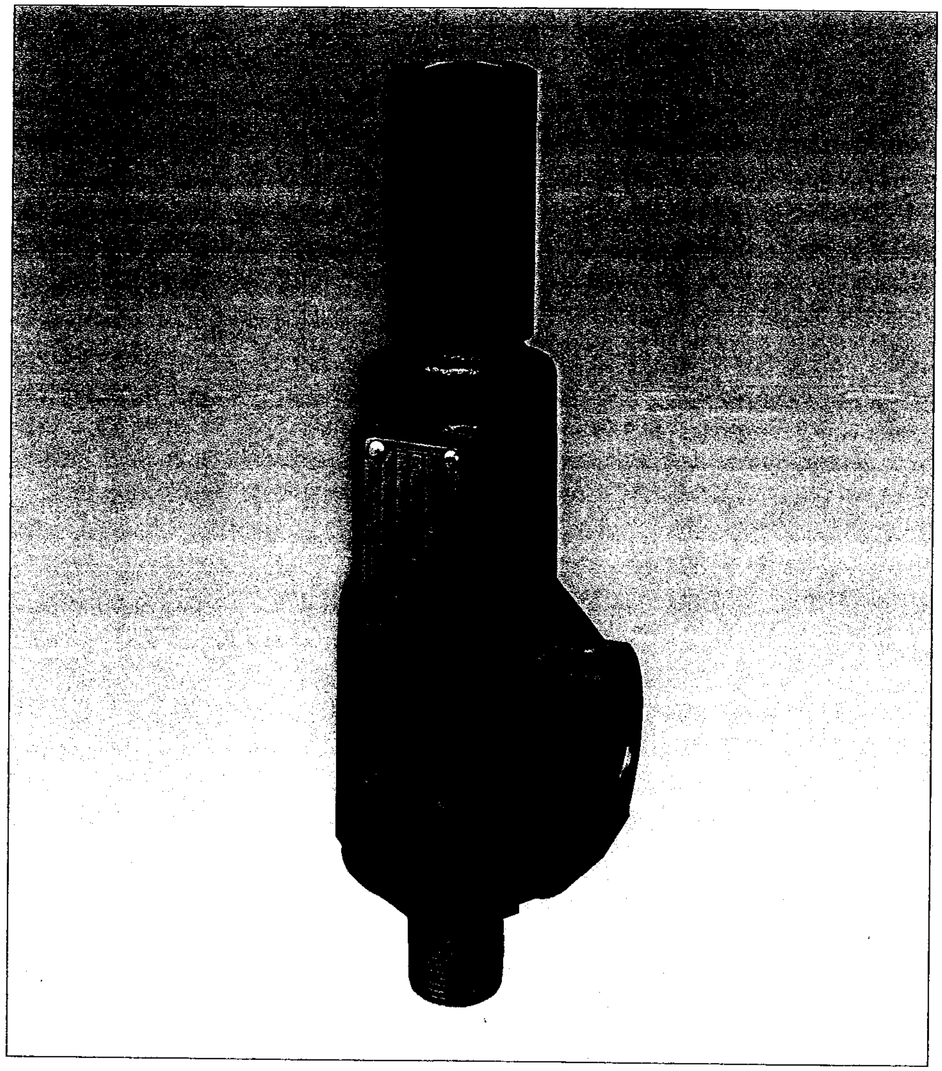

Table of Contents

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Series 900 OMNI-TRIM® Style Designation

1st Digit	2nd Digit	3rd Digit	4th Digit	5th Digit	6th Digit	7th Digit	8th Digit
9	9	1	3	0	7	M	D
Series	**Effective Orifice Area**	**Maximum Set Pressure**[2,6]	**Seat Material**[6]	**Materials of Construction**[1,3]	**Connection Size - NPS**[7]	**Connection Type**[4,5,8]	**Caps and Levers**
9 - Series 900 Adjustable Blowdown Relief Valve	5 - 0.074 sq. in. [47.74 sq. mm] 6 - 0.110 sq. in. [70.96 sq. mm] 7 - 0.196 sq. in. [126.4 sq. mm] 8 - 0.307 sq. in. [198.0 sq. mm] 9 - 0.503 sq. in. [324.5 sq. mm]	1 - 1500 psig [103.42 barg] 2 - 2500 psig [172.36 barg] 3 - 5000 psig [344.74 barg]	1 - Metal 2 - BUNA-N 3 - Viton® 4 - Ethylene Propylene Rubber (EPR) 5 - Kalrez® 6 - TFE 7 - Other (Specify)	0 - Standard Materials Carbon Steel Cylinder 316 SS Base, Disc Insert, Disc Holder and Guide 17-7PH SS Spring -50F to +750F [-45.6C to +399C] 1 - All 316 SS Materials -450°F to +500°F [-268°C to +260°C] 2 - All 316 SS Materials Inconel® X750 Spring -450°F to +750°F [-268°C to +399°C] 3 - Carbon Steel Cylinder Monel® Base, Disc Insert, Disc Holder and Guide Inconel® X750 Spring Note[5] -50°F to +750°F [-45.6°C to +399°C] 4 - All Monel® Materials, Inconel® X750 Spring Note[5] -320°F to +750°F [-196°C to +399°C] 5 - Carbon Steel Cylinder Hastelloy® C Base, Disc Insert, Disc Holder and Guide Inconel® X750 Spring Note[5] -50°F to +750°F [-45.6°C to +399°C] 6 - All Hastelloy® C Materials Note[5] -320°F to +750°F [-196°C to +399°C] 7 - NACE MR-0175-2002[10] Carbon Steel Cylinder 316 SS Base, Disc Insert, Disc Holder & Guide Inconel® X750 Spring With 316 SS Washers -50°F to +750°F [-45.6°C to +399°C] 8 - Other (Specify)	0 - 1/2 x 1 1 - 3/4 x 1 2 - 1 x 1 3 - 1 x 1 1/2 4 - 1 1/2 x 1 1/2 5 - 1 1/2 x 2 6 - 2 x 2 7 - 1 1/2 x 2 1/2 9 - Other	M - MNPT x FNPT F - FNPT x FNPT 1 - 150# RF x 150# RF 2 - 300# RF x 150# RF 3 - 600# RF x 150# RF 4 - 1500# RF x 300# RF 5 - 2500# RF x 300# RF 7 - Other (Specify) 8 - Male SW x Male SW[9] 9 - MNPT x FNPT 3/4 x 1 Bolted Cylinder (951 Orifice only)	A - Standard Threaded Cap B - Threaded Cap with Test Rod D - Packed Lifting Lever E - Packed Lifting Lever with Test Rod

Caution!
Refer to Pages 14-17 for ensuring [illegible]

How to Order

Example 1: To specify a 3/4 x 1 MNPT x FNPT Series 900 valve with a 0.074 sq. in. [47.74 sq. mm] effective area, BUNA-N seats, all 316 stainless steel materials, standard threaded cap, process fluid operating temperature at 150°F [66°C], and set at 175 psig [12.07 barg], use the following style designation: **951211MA**

Example 2: To specify a 1 1/2 x 2 MNPT x FNPT Series 900 valve with a 0.307 sq. in. [198.0 sq. mm] effective area, metal seats, standard materials, packed lifting lever with test rod, for saturated steam service set at 200 psig [13.79 barg], use the following style designation: **981105ME-STM**

Notes

1. For steam service a 17-4PH disc holder is used. Add — STM after style designation.
2. Maximum set pressure for steam service is 1000 psig [68.95 barg].
3. See page 7 for complete listing of materials of construction.
4. Optional flange facings (such as ring type joint, 125-200RA), if required, must always be specified.
5. Optional flange materials (such as Monel® and Hastelloy®), if required, must always be specified.
6. See pages 14 - 17 for appropriate maximum set pressures.
7. See pages 14 - 17 for appropriate inlet and outlet sizes for each effective orifice area.
8. Consult Crosby for materials, and center to face and height dimensions for socket weld (SW) connections. Weights are the same as for threaded connections.
9. Not available with soft seats; contact the factory.
10. Contact factory for compliance to NACE MR-0175-2003 or later requirements.

System Venting Verification

The water/glycol coolant piping schematic is on page 9. The tank (bladder, hydro-pneumatic type) is on a dead-end line connected to the pump suction line. Coolant does not flow through the tank. The only movement of coolant between the system and the tank is the expansion or contraction volume caused when the coolant circulating in the system changes temperature. The compressed air system used to pressurize the tank for operation is discussed below.

Sources of overpressure are thermal expansion, fire and the compressed air system.

Thermal expansion is not a problem. The tank is at most half full. It can easily handle the system expansion/contraction volume of 10 gallons when half full. Expansion/contraction volume is calculated in PPD Mechanical Department Engineering Note MD-ENG-042 Section 25.4. It is included in Appendix AA. The Crosby 991307MD relief valve is large enough to handle thermal expansion because any thermal expansion rate will be lower than the relieving capacity calculated for the fire case.

The Crosby 991307MD relief valve is sized for displaced liquid relief from the bottom of the tank during a fire. The Control Devices Inc SCB7510-0A125 relief valve is sized for vapor relief from the top of the tank during a fire. For the fire calculations, it is assumed that the vessel is full and 100% of the external surface area is exposed to fire. The relief valve sizing calculations are in PPD Mechanical Department Engineering Note MD-ENG-042 Section 25.6. It is included in Appendix BB.

Some of the system piping is above the expansion/contraction tank. Thus, the tank must be pressurized to keep these sections of the system full of coolant. Compressed air is used to pressurize the tank. The compressed air system is described in the FESHM Chapter 5031 Pressure Vessel Engineering Note NMI-015. According to the EN, free air flow for the Ingersoll-Rand Model SS3L3 compressor at 90 psi is 11.3 cfm and is 10.3 cfm at the maximum pressure of 135 psi. Also, capacity of the relief valve that protects the air receiver is 129 scfm at a set pressure of 150 psi.

The Ingersoll-Rand specification sheet for the Model SS3L3 compressor is in Appendix CC. The flow is specified as 11.3 ACFM at 40 psi. This is equivalent to a standard flow rate of about [(40*1.1+15)/15]*11.3 = 45 scfm at a set pressure of 40 psi. The standard flow rate at a set pressure of 125 psi is [(125*1.1+15)/15]*11.3 = 115 scfm.

A relief valve, Control Devices Inc SCB7510-0A125, is installed at the top of the tank to protect it while using the air compressor to pressurize it to the operating pressure. Tank normal operating pressure is under 50 psi and the maximum operating pressure is 75 psi. A pressure gauge is installed to monitor tank pressure while it is being charged. Capacity of this relief valve is 496 scfm at a set pressure of 125 psi. Thus, this relief valve has 330% excess capacity above the air compressor flow rate of 115 scfm. Relief valve specs are in Appendix DD. As shown in Appendix DD, the SCB7510-0A125 has a steam capacity of 1,620 lbm/hr. Thus, this relief valve has 250% excess capacity for the fire case where steam is relieved from the top of the tank. A smaller relief valve can be used to protect the tank for the two cases discussed in this paragraph. However, the SCB7510-0A125 is the smallest valve I could find with a single outlet port. The outlet port will be used to direct relief valve discharge flow away from an area that can be occupied by people.

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE 1

SUBJECT: Water/glycol coolant piping ΔP calc. PPD Mechanical Dept Engineering Note MD-ENG-042 Section 25.1

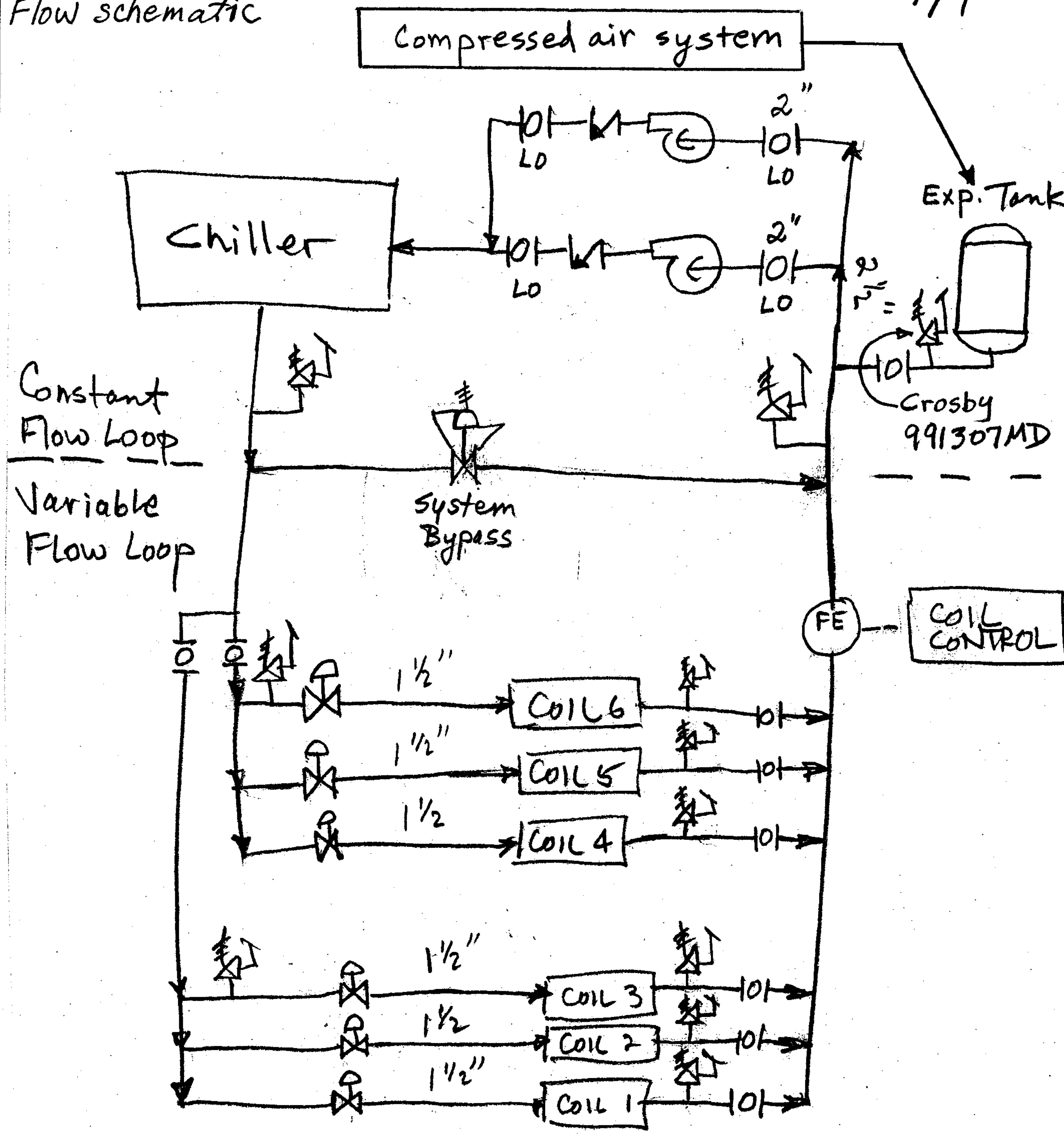
NAME: AMS

DATE: 7/2/04

REVISION DATE:

9/9

1.0 Flow schematic



Appendix AA

Fermilab

Particle Physics Division
Mechanical Department Engineering Note

Number:	MD-ENG-042 Section 25.4
Date:	October 29, 2004
Project Reference:	Design/Integration of Target Pile Cooling, WBS 1.1.2.1.8.5, UID 74239
Project:	NuMI
Title:	Size coolant expansion tank
Author:	Andy Stefanik AMS
Reviewer:	
Key Words:	expansion, contraction, chilled water, chiller, pump, coolant, glycol
Abstract Summary:	An ASME, bladder, hydro-pneumatic tank is used. An expansion/contraction volume of 10 gallons is enough to handle the system temperature range. A 130 gallon tank is used to minimize the variation in system pressure as the coolant volume changes.
Applicable Standard:	

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE 1

SUBJECT: Size Expansion Tank

NAME: AMS

DATE: 10/29/04

REVISION DATE:

1.0 System Volume

Piping – Follow water/glycol coolant piping ΔP calc.

- 2" copper tube: $350\ ft \cdot \frac{12\ in}{ft} \cdot 3\ in^2 = 12,600\ in^3 = 7.3\ ft^3$

- 1½" copper tube: $\left(50\ ft \cdot \frac{12\ in}{ft} \cdot 1.72\ in^2\right)6 = 6,192\ in^3 = 3.6\ ft^3$

- 2½ copper tube: $240\ ft \cdot \frac{12\ in}{ft} \cdot 4.66\ in^2 = 13,421\ in^3 = 7.8\ ft^3$

- Cooling coils: $\left[184\ Lbs \times \frac{ft^3}{62.4\ Lbs}\right]2 = 6\ ft^3$

  (184 Lbs: Weight of water in a coil. Vendor dwg 37082B0100.)

- Chiller & pumps (Bob Rowald's estimate) (10 gallons max) $\doteq 2\ ft^3$

$\Sigma = 26.7\ ft^3$

$= 200$ gals

2.0 Volume change

Use 250 gallons = 33.4 ft^3

Low temp = 30°F

High temp = 50°F process, 100°F max shutdown

Density ≐ 64.4 Lbm/ft^3 @ 30°F = ρ_1

Density ≐ 63.3 Lbm/ft^3 @ 100°F = ρ_2

3.0 Expansion tank volume for open tank

$$V_{t_o} = 2\{ V_s [(\rho_1/\rho_2)-1] - \cancel{3\alpha\Delta t} \}$$

$$= 2\{ 250 \text{ gals} [(64.4/63.3)-1] \}$$

$$= 8.7 \text{ gallons}$$

4.0 Expansion tank volume for diaphragm tank

$$V_{t_D} = \frac{V_s [(\rho_1/\rho_2)-1] - \cancel{3\alpha\Delta t}}{1-(P_1/P_2)} = \frac{V_{to}/2}{1-(P_1/P_2)}$$

$$1-(P_1/P_2) = \frac{V_{to}}{2 V_{tD}} \Rightarrow 1 - \frac{V_{to}}{2V_{tD}} = \frac{P_1}{P_2}$$

$$\Rightarrow P_2 = P_1 \Big/ \left[1 - \frac{V_{to}}{2V_{tD}}\right]$$

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE 3

SUBJECT

NAME AMS

DATE 10/29/04

REVISION DATE

For this system:

$$P_2 = \frac{P_1}{1 - \frac{8.7}{2 \cdot V_{tD}}} = \frac{P_1}{1 - \frac{4.35}{V_{tD}}}$$

$P_1 = 5$ psi $\doteq$ 19.3 psia

V_{tD}	P_2
10	34.2 psia = 19.9 psig
50	21.1 psia = 6.8 psig
100	20.2 psia = 5.9 psig

Appendix BB

Relief valve calculations for Coolant Expansion/ Tank start on page 4.

Fermilab

Particle Physics Division
Mechanical Department Engineering Note

Number:	MD-ENG-042 Section 25.6
Date:	December 14, 2004
Project Reference:	Design/Integration of Target Pile Cooling, WBS 1.1.2.1.8.5, UID 74239
Project:	NuMI
Title:	Water/glycol coolant system relief valves
Author:	Andy Stefanik AMS
Reviewer:	Rafael Silva
Key Words:	relief valve, chilled water, chiller, pump, coolant, glycol
Abstract Summary:	The relief valves are sized. Only two conditions need be considered to size all of the relief valves in the water/glycol coolant system: fire and thermal relief. Copper tube dimensions can be found in MD-ENG-042 Section 25.2.
Applicable Standard:	ANSI/API Recommended Practice 520 – Recommended Practice for the Design and Installation of Pressure-Relieving Systems in Refineries Part 1 Sizing and Selection, and ANSI/API Recommended Practice 521 – Guide for Pressure Relief and Depressuring Systems.

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			1

SUBJECT: Size pressure relief valves for 75% water/25% propylene glycol piping

NAME: AMS

DATE: 12/14/04

REVISION DATE:

1.0 Air coil piping

- Line size: 1½" nominal diameter copper tube

  OD = 1.625", Type K.

- Surface area exposed to a fire & heating rate

  Length is < 25'.

  $A_s = \pi (OD) L = \pi (1.625/12) ft (25 ft) \doteq 11 \, ft^2$

  Q ≡ heating due to fire = $21{,}000 A^{0.82}$ (API-520)

  $Q = 21{,}000 (11)^{0.82} = 150{,}000$ Btu/hr

- Relief valve flow rate

  Set pressure = 200 psi

  Relieving pressure = 200(1.2) = 240 psig = 254 psia

  Latent heat = 823 Btu/Lbm @ 255 psia → T_s = 403 °F
  = 863 °R

  $\dot{m} = 150{,}000 \frac{Btu}{hr} \cdot \frac{Lbm}{823 \, Btu} = 185 \, Lbm/hr$

- Size relief valve (API-520)

  $$A = \frac{W\sqrt{TZ}}{CKP_1\sqrt{M}} = \frac{185 \frac{Lbm}{hr} \sqrt{(863°R)(1)}}{347(0.8)(254 \, psia)\sqrt{18}} = 0.018 \, in^2$$

  ⇒ Use API-4 orifice, A = 0.049 in², or larger

2.0 RAW room supply piping

- Line size: 2½" nominal diameter copper tube

  OD = 2.625" Type K

- Surface area exposed to a fire & heating rate

  Length < 50'

  $A_s = \pi (2.625/12)(50) = 35 \text{ ft}^2$

  $Q = 21{,}000 (35)^{0.82} = 390{,}000 \text{ Btu/hr}$

- Relief valve flow rate

  Set pressure = 200 psi on supply piping.

  Relieving pressure = 200 (1.2) = 240 psig = 254 psia

  $\dot{m} = \frac{390{,}000}{823} = 475 \text{ Lbm/hr}$

- Size relief valve

  $A = \frac{475\sqrt{(863)(1)}}{347(0.8)(254)\sqrt{18}} = 0.047 \text{ in}^2$

⇒ Use API-4 orifice, $A = 0.049 \text{ in}^2$, or larger

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			3

SUBJECT

NAME: AMS

DATE: 12/14/04

REVISION DATE:

3.0 RAW Room return piping – Same line size as § 2.0.

- From § 2.0: $Q = 390{,}000$ Btu/hr
- Relief value flow rate

Set pressure = 125 psi on return piping

Relieving pressure = 125 (1.2) = 150 psi = 164 psia

Latent heat = 857 Btu/Lbm @ 164 psia → $T_s = 366°F$
$= 826°R$

$$\dot{m} = \frac{390{,}000}{857} = 455 \text{ Lbm/hr}$$

- Size relief valve

$$A = \frac{455\sqrt{826(1)}}{347(0.8)(164)\sqrt{18}} = 0.068 \text{ in}^2$$

⇒ Use API D-orifice, $A = 0.11 \text{ in}^2$ or larger

SUBJECT

NAME AMS

DATE 12/14/04 REVISION DATE

4.0 Expansion Tank in RAW Room

- Tank dimensions: See page 5.
- Total surface = $\pi DL + 2$ (surface area of 1 head - page 5)

$$= \pi\left(\frac{30}{12}\right)\left(\frac{82}{12}\right) + 2(6.75) = 21 + 13.5 = 34.5\ ft^2$$

Use total surface area = 36.2 ft^2 from preliminary calcs.

- Surface area exposed to a fire and heating rate

Set wetted surface area equal to total surface area. Note: This is conservative because the wetted surface area is at most ½ to ⅔ of the total surface area.

$$Q = 21{,}000\,(36.2)^{0.82} = 398{,}500\ Btu/hr$$

- Relief valve flow rate

Set pressure = 125 psi

Relieving pressure = 125 (1.2) = 150 psi = 164 psia

$$\dot{m} = \frac{398{,}500}{857} = 465\ Lbm/hr$$

- Size relief value – vapor relief (Relief valve mounted on top of the vessel.)

$$A = \frac{465\sqrt{826(1)}}{347(0.8)(164)\sqrt{18}} = 0.07\ in^2$$

⇒ Use API D-orifice, $A = 0.110\ in^2$

Thrush Company, Inc.

Page 5
AMS
12/14/04

ASME TANKS

Bladder Hydro-Pneumatic Tanks 125, 175, & 250 PSI ASME

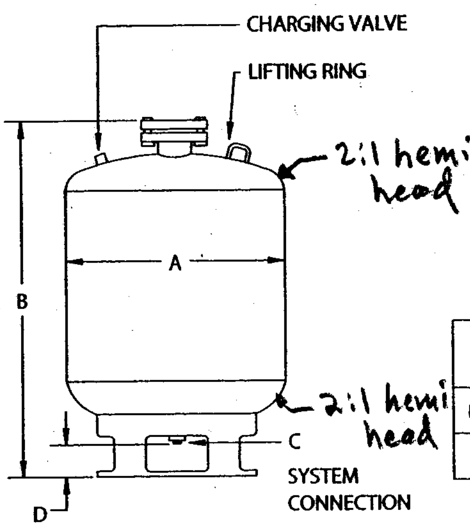
For Well & Booster Systems

MAXIMUM OPERATING CONDITIONS

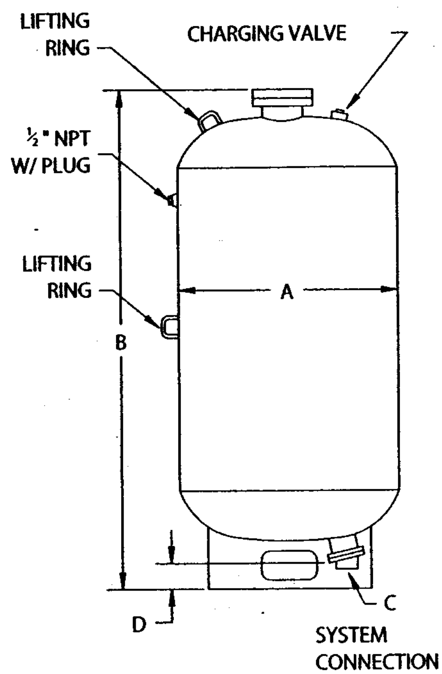
Working Temp.	240 Deg F
Working Pres. (PSI)	125 ____
	175 ____
	250 ____

MATERIALS OF CONSTRUCTION

Shell	Carbon Steel (with epoxy wetted parts)
Bladder	Butyl (FDA Listed)
Finish	Primer Painted Exterior



W-447C THRU W-451C



W-452C THRU W-457C

Shell length = 31½" (measured)

ASME FIXED BLADDER

Model	Gal.	Accept.	DRAWDOWN 20/40	DRAWDOWN 30/50	DRAWDOWN 40/60	"A" (inches)	"B" (inches)	"C" (inches)	"D" (inches)	Shipping Weight 125 PSI (Lbs.)	Shipping Weight 175 PSI (Lbs.)	Shipping Weight 250 PSI (Lbs.)
W - 447C	53	37	19	16	14	24	43			210	230	270
W - 448C	80	56	29	25	21		55	1-1/2	5-1/4	225	270	340
W - 449C	106	74	39	33	28		49			300	370	455
→ W - 450C	132	92	48	41	35	30	57			330	420	515
W - 451C	158	111	58	49	42		65	2	4-3/4	360	575	780
W - 452C	211	148	77	65	57		63			475	680	900
W - 453C	264	185	97	82	71	36	87			735	790	1050
W - 454C	317	222	116	98	85		98		8-1/2	745	910	1200
W - 455C	370	259	135	114	99		111	3		900	1020	1350
W - 456C	422	295	154	130	113	48	84		8-3/4	1210	1360	1790
W - 457C	528	370	193	163	142		96			1305	1600	2100

Notes: Tanks are factory pre-charged at 30 PSIG Charging Valve: .302"-32NC

Surface area of 2:1 hemi-ellipsoidal head $= \pi R^2 [1 + K^2(2-K)]$ {APP. A}

$= \pi (1.25)^2 [1 + (\frac{1}{2})^2 (2 - \frac{1}{2})]$

$= 6.75 \text{ ft}^2$

$R = \frac{30}{2(12)} = 1.25 \text{ ft}$; $K = \frac{1}{2}$ (2:1)

- Size relief valve – displaced liquid relief

Saturated vapor density at relieving conditions = 0.36 $\frac{\text{Lbm}}{\text{ft}^3}$

Volumetric displacement rate = $465 \frac{\text{Lbm}}{\text{hr}} \frac{\text{ft}^3}{0.36\ \text{Lbm}} * \frac{\text{hr}}{60\ \text{min}}$

$* 7.481 \frac{\text{gal}}{\text{ft}^3} = 161$ gpm

See Appendix B

Per Kunkle rating chart for liquid relief, use a G-orifice. The liquid flow is 175(1.045) = 183 gpm at 20% accumulation.

- Size relief valve – flashing flow

In the two previous calcs, the relief valve was sized on the basis of vapor relief only and also liquid relief only. Now it's time to consider flashing flow through the relief valve, where the valve will be relieving both vapor and liquid at the same time.

Follow the recommended practice in API-521, Guide for Pressure-Relieving and Depressuring Systems, § 3.17.1. See Appendix C.

Calculate the critical pressure, p^*:

$$\frac{p^*}{p_o} = \left(\frac{2}{k+1}\right)^{\frac{k}{k-1}} = \left(\frac{2}{1.33+1}\right)^{\frac{1.33}{1.33-1}} = 0.54$$

$$p^* = 0.54\, p_o = 0.54\,(164 \text{ psia}) \doteq 89 \text{ psia}$$

Note: p_o is the relieving pressure. $p^* >$ back pressure.

$$\text{Vapor fraction} = \left(h_{\text{sat liq @ relieving pressure}} - h_{\text{sat liq @ critical pressure}}\right) \Big/ h_{fg \text{ @ critical pressure}}$$

$$\text{Vapor fraction} = \frac{338.2 - 289.9}{895.2} = 0.05$$

$$\text{Liquid fraction} = 1 - 0.05 = 0.95$$

So, 5% of the mass flowrate flashes to vapor as it passes through the relief valve.

Calculate the orifice area required to relieve the vapor flow:

$$\dot{m}_{vapor} = 0.05\left(161 \frac{\text{gal}}{\text{min}}\right) * \frac{\text{ft}^3}{7.481 \text{ gal}} * 60 \frac{\text{min}}{\text{hr}} * 0.36 \frac{\text{Lbm}}{\text{ft}^3}$$
$$= 23 \text{ Lbm/hr}$$

$$A_{vapor} = \frac{23\sqrt{826(1)}}{347(0.8)(164)\sqrt{18}} = 0.004 \text{ in}^2$$

Calculate the orifice area required to relieve the liquid flow:

Liquid flow rate = 0.95 (161 gpm) = 153 gpm

Per Kunkle rating chart for liquid relief, use a G-orifice.

The liquid flow rate is 175 (1.045) = 183 gpm at 20% accumulation. The required orifice area is

$$\frac{153}{183} * 0.553\ in^2 = 0.462\ in^2$$

Total required orifice area:

$$0.004 + 0.462 = 0.466\ in^2$$

Conclusion for § 4.0 for Kunkle relief valve:

⇒ Use Kunkle G-orifice, $A = 0.553\ in^2$ or larger

Note

The liquid sizing calculation is based on the orifice area and the corresponding letter designation for a Kunkle relief valve. If a different brand of relief valve is purchased, a different letter designation might be needed to obtain the minimum required orifice area.

- Redo the two-phase flow case using a Crosby OMNI-TRIM relief valve.

$A_{vapor} = 0.004\ in^2$ – Same as for the Kunkle valve, page 6.

See Appendix D for the formulas to size a Crosby relief valve for liquid relief.

$$A = \frac{GPM\sqrt{G}}{28.14\ K_w K_v \sqrt{\Delta P}}$$

$K_w = 1.0$ (Negligible back pressure)

$K_v = 1.0$ (For non-viscous fluid)

$$G = \frac{\text{Saturated liquid density at relieving conditions}}{62.4}$$

$$= \frac{55}{62.4} = 0.88$$

$$A = \frac{153\sqrt{0.88}}{28.14(1)(1)\sqrt{125(1.2)}} = 0.416\ in^2$$

Total required orifice area $= 0.004 + 0.416$

$= 0.42\ in^2$

Conclusion for § 4.0 for Crosby relief valve:

⇒ Use Crosby -9 orifice, $A = 0.503\ in^2$ or larger.

Note: API G-orifice area is $0.503\ in^2$.

Appendix A

AMS
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MISCELLANEOUS FORMULAS

1. Area of Roofs.

Umbrella Roofs:

D = diameter of tank in feet.

Surface area in square feet $\begin{cases} = 0.842\,D^2 \text{ (when radius = diameter)} \\ = 0.882\,D^2 \text{ (when radius = 0.8 diameter)} \end{cases}$

Conical Roofs:

Surface area in square feet $\begin{cases} = 0.787\,D^2 \text{ (when pitch is } \tfrac{3}{4} \text{ in 12)} \\ = 0.792\,D^2 \text{ (when pitch is } 1\tfrac{1}{2} \text{ in 12)} \end{cases}$

2. Average weights.

Steel —490 pounds per cubic foot—specific gravity 7.85

Wrought iron —485 pounds per cubic foot—specific gravity 7.77

Cast iron —450 pounds per cubic foot—specific gravity 7.21

1 cubic foot air or gas at 32° F., 760 m.m. barometer = molecular weight x 0.0027855 pounds.

3. Expansion in steel pipe = 0.78 inch per 100 lineal feet per 100 degrees Fahrenheit change in temperature = 0.412 inch per mile per degree Fahrenheit temperature change.

4. Linear coefficients of expansion per degree increase in temperature:

	Per Degree Fahrenheit	Per Degree Centigrade
STRUCTURAL STEEL—A-7		
70° to 200° F.	0.0000067	—
21.1° to 93° C.	—	0.0000121
STAINLESS STEEL—TYPE 304		
32° to 932° F.	0.0000102	—
0° to 500° C.	—	0.0000184
ALUMINUM		
−76° to 68° F.	0.0000120	—
−60° to 20° C.	—	0.0000216

5. To determine the net thickness of shells for horizontal cylindrical pressure tanks:

$$T = \frac{6\,PD}{S}$$

P = working pressure in pounds per square inch

D = diameter of cylinder in feet

S = allowable unit working stress in pounds per square inch

T = Net thickness in inches

Resulting net thickness must be corrected to gross or actual thickness by dividing by joint efficiency.

6. To determine the net thickness of heads for cylindrical pressure tanks:

(6a) Ellipsoidal or Bumped Heads:

$$T = \frac{6\,PD}{S}$$

T, P and D as in formula 5

(6b) Dished or Basket Heads:

$$T = \frac{10.6P(MR)}{S}$$

T, S and P as in formula 5

MR = principal radius of head in feet

Resulting net thickness of heads is both net and gross thickness if one piece seamless heads are used, otherwise net thickness must be corrected to gross thickness as above.

Formulas 5 and 6 must often be modified to comply with various engineering codes, and state and municipal regulations. Calculated gross plate thicknesses are sometimes arbitrarily increased to provide an additional allowance for corrosion.

7. Heads for Horizontal Cylindrical Tanks:

Hemi-ellipsoidal Heads have an ellipsoidal cross section, usually with minor axis equal to one half the major axis—that is, depth = ¼ D, or more.

Dished or Basket Heads consist of a spherical segment normally dished to a radius equal to the inside diameter of the tank cylinder (or within a range of 6 inches plus or minus) and connected to the straight cylindrical flange by a "knuckle" whose inside radius is usually not less than 6 per cent of the inside diameter of the cylinder nor less than 3 times the thickness of the head plate. Basket heads closely approximate hemi-ellipsoidal heads.

Bumped Heads consist of a spherical segment joining the tank cylinder directly without the transition "knuckle." The radius = D, or less. This type of head is used only for pressures of 10 pounds per square inch or less, excepting where a compression ring is placed at the junction of head and shell.

Surface Area of Heads:

(7a) Hemi-ellipsoidal Heads:

$$S = \pi R^2 \,[1 + K^2(2-K)]$$

S = surface area in square feet

R = radius of cylinder in feet

K = ratio of the depth of the head (not including the straight flange) to the radius of the cylinder

The above formula is not exact but is within limits of practical accuracy.

(7b) Dished or Basket Heads:
Formula (7a) gives surface area within practical limits.

(7c) Bumped Heads:

$$S = \pi R^2 \,(1 + K^2)$$

S, R, and K as in formula (7a)

Volume of Heads:

(7d) Hemi-ellipsoidal Heads:

$$V = \tfrac{2}{3}\,\pi K R^3$$

R = radius of cylinder in feet

K = ratio of the depth of the head (not including the straight flange) to the radius of the cylinder

(7e) Dished or Basket Heads:
Formula (7d) gives volume within practical limits.

(7f) Bumped Heads:

$$V = \tfrac{1}{2}\,\pi K R^3 \,(1 + \tfrac{1}{3} K^2)$$

V, K and R as in formula (7d)

Note: K in above formulas may be determined as follows:
Hemi-ellipsoidal heads—K is known

Dished Heads—$K = M - \sqrt{(M-1)\,(M+1-2m)}$

Bumped Heads—$K = [M - \sqrt{M^2-1}]$

MR = principal radius of head in feet

mR = radius of knuckle in feet

R = radius of cylinder in feet

$$M = \frac{MR}{R} \qquad m = \frac{mR}{R}$$

For bumped heads, m = o

8. Total volume or length of shell in cylindrical tank with ellipsiodal or hemispherical heads:

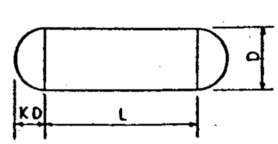
V = Total volume

L = Length of cylindrical shell

KD = Depth of head

$$V = \frac{\pi D^2}{4}\,(L + 1\tfrac{1}{3}\,KD)$$

$$L = (V \div \frac{\pi D^2}{4}) - 1\tfrac{1}{3}\,KD$$



Appendix B

AMS
12/14/04

Model 900

Capacities - Models 910, 911, 912, 913, 916, 917, 918 and 919

ASME VIII Liquid (English, GPM) - Flow Coefficient = 0.710

Set Pressure (psig)	D (0.1213)	E (0.2157)	F (0.3369)	G (0.553)	H (0.864)	J (1.415)
	Orifice Area, in^2					
15	14	25	39	63	99	162
25	17	31	[illegible]	[illegible]	[illegible]	[illegible]
35	20	36	56	93	145	237
[illegible]	23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
55	26	45	71	116	181	297
65	28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
75	30	53	83	136	212	347
[illegible]	32	56	88	[illegible]	225	[illegible]
95	34	60	93	153	238	390
100	[illegible]	[illegible]	[illegible]	156	[illegible]	400
125	38	68	107	175	273	448
[illegible]	[illegible]	[illegible]	[illegible]	192	[illegible]	490
175	45	81	126	207	323	530
200	[illegible]	[illegible]	[illegible]	221	[illegible]	[illegible]
225	52	92	143	235	367	601
250	54	97	151	247	387	633
275	57	101	158	259	405	664
300	60	106	165	[illegible]	[illegible]	[illegible]
325	62	110	172	282	441	722
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	457	[illegible]
375	67	118	185	303	473	775
[illegible]	[illegible]	122	[illegible]	[illegible]	[illegible]	[illegible]
425	71	126	197	323	504	825
450	73	129	202	332	519	849
475	75	133	208	341	533	873
500	77	136	[illegible]	350	[illegible]	895
550	81	143	224	367	—	—
600	84	150	234	383	—	—
650	88	156	—	—	—	—
700	91	161	—	—	—	—
750	94	167	—	—	—	—
800	97	172	—	—	—	—
850	100	178	—	—	—	—
900	103	183	—	—	—	—

Notes

1. No code stamp or 'NB' on nameplate below 15 psig set.
2. Pressure Limitations
   Model 910, 916: 3 to 900 psig
   Model 911, 917: 3 to 900 psig
   Model 912, 918: 3 to 300 psig
   Model 913, 919: 3 to 900 psig
3. Liquid conversion factors to determine liquid capacity at other than 10% accumulation, multiply by the following:
   1.022 = 15% accumulation
   1.045 = 20% accumulation
   1.066 = 25% accumulation (see page 20)

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t = depressuring time interval, in hours (usually assumed as 0.25 hour).
V = volume available for the vapor, in cubic feet (cubic meters).
W = vapor flow rate per unit of time, in pounds per hour (kilograms per hour).
Wt = weight of liquid or vapor, in pounds (kilograms).
X = weight fraction of the initial liquid in the system vaporized due to depressuring (dimensionless).
z = compressibility factor (dimensionless).
Δ = difference, for example, $\Delta T_n = T_{n-1} - T_n$.
λ = average latent heat of the liquid, in British thermal units per pound (kilojoule per kilogram).

3.16.3.1 Superscript

m = total number of vessels in the depressuring system.

3.16.3.2 Subscripts

a = original condition at the start of the depressuring time interval, assumed to be the saturated vapor-liquid equilibrium condition with respect to temperature and pressure.
b = depressured condition at the end of the depressuring time interval.
d = relating to the density change of the vapor due to pressure reduction.
f = relating to vaporization from the fire.
i = individual vessel of the system if more than one vessel is involved and needs to be considered separately because of differing fluid properties, insulation for fire effect, or related factors.
L = liquid.
n = depressuring step of many steps between the original condition and the depressured condition.
$n - 1$ = depressuring step preceding Step n.
v = relating to liquid flash or vapor generated from pressure reduction.

3.17 Special Considerations for Individual Valves

Sizing procedures for pressure safety valves are covered in API Recommended Practice 520, Part I, Section 2 and Appendix C [1], with the exception of the following circumstances.

3.17.1 LIQUID-VAPOR MIXTURE AND SOLIDS FORMATION

A pressure relief valve handling a liquid at vapor-liquid equilibrium or a mixed-phase fluid will produce flashing with vapor generation as the fluid moves through the valve. The vapor generation may reduce the effective mass flow capacity of the valve and must be taken into account. The quantity of flash vapor is commonly calculated based on adiabatic flashing from the relieving condition—either to the critical downstream pressure (the critical drop across the valve orifice) or to the back pressure, whichever is higher—and on an orifice area calculated for that vapor flow using the same pressure drop. An area is also calculated for the remaining liquid quantity (after flash) under relieving conditions using the total pressure drop (the relieving pressure minus the back pressure). The orifice selected should have an area equal to or greater than the sum of the individual areas previously calculated. The designer is cautioned to investigate the effects of flow reduction or choking. Choking occurs at a point in any flowing compressible or flashing fluid where the available pressure drop increment is totally used up by accelerating the flashing fluid. Therefore, no additional pressure difference is available to overcome the friction in the incremental line length.

Calculations for determining properties and for handling liquid-vapor phases, as well as their use in sizing relieving devices, are cited in 6.4 and 6.5. If manufacturers' charts or tables are used, the same overpressure should be used for both sizings because vapor capacities are normally tabulated at 10 percent overpressure, whereas liquid capacities are usually tabulated at 25 percent overpressure. Since the percentage of flash across the valve is indirectly a function of the size of the discharge line, the effects of vapor suppression should be considered. The use of a balanced safety relief valve is suggested to minimize the effects of flashed vapor on the valve capacity.

Generally, the most economical valve size (for balanced safety relief valves) is one that occurs at approximately 30 percent back pressure (see API Recommended Practice 520, Part I, Appendix C [1]). Further suppression of flash by reducing the size of the discharge piping (never less than the size of the valve outlet) may be more economical, although the effect of such changes on the performance of the relief device must be considered.

Some fluids, for example, carbon dioxide and wet propane, may form solids when discharged through the relieving device. There is no uniformly accepted method for reducing the possibility of plugging.

3.17.2 LOCATION OF A PRESSURE-RELIEVING DEVICE IN A NORMALLY LIQUID SYS

Where valves or other devices are sized to relieve vapors caused by vapor entry or generation of vapor in a normally all-liquid system (see 3.7, 3.9, 3.10, and 3.16), care must be taken to locate the device so that it

Liquid Sizing

Spring Loaded Valves

Styles JLT-JOS, JLT-JBS, Series 900 and Series BP

The following formula has been developed for valve Styles JLT-JOS, JLT-JBS, Series 900 and Series BP pressure relief valves using valve capacities certified by the National Board of Boiler and Pressure Vessel Inspectors in accordance with the rules of the ASME Boiler and Pressure Vessel Code, Section VIII. This formula applies to, and is to be used exclusively for, sizing Crosby Styles JLT, Series 900 and Series BP pressure relief valves for liquid service applications. Valve sizing using this formulation is not permitted for overpressures less than 10%.

$$A = \frac{GPM \sqrt{G}}{28.14 K_w K_v \sqrt{\Delta P}}$$

Where:

- A = Minimum required effective discharge area, square inches.
- G = Specific gravity of the liquid at flowing conditions.
- GPM = Required relieving capacity, U.S. gallons per minute at flowing temperature.
- ΔP = Differential pressure (psi). This is the set pressure (psig) + overpressure (psi) - back pressure (psig). Pressures expressed, psi.
- K_v = Flow correction factor due to viscosity of the fluid at flowing conditions (see page 7-7).
- K_w = Capacity correction factor due to back pressure on bellows or Series BP valves on liquid service. Refer to Figure F7-3 on page 7-5.

Note: See page 7-25 for information on two phase flow.

EXAMPLE #1
Liquid, gpm

Fluid:	Sodium Trisulfate
Relieving Capacity:	125 gpm
Set Pressure:	100 psig
Overpressure:	10%
Back Pressure:	0-30 psig (built-up)
Relieving Temperature:	60F
Specific Gravity:	1.23

$$A = \frac{GPM \sqrt{G}}{28.14 K_v K_w \sqrt{\Delta P}}$$

Where:

- A = Minimum required effective discharge area, square inches
- GPM = 125 gallons per minute
- G = 1.23
- K_w = .866 (Figure F7-3 on page 7-5)
- K_v = 1.0 for non-viscous fluid
- ΔP = 100 psig + 10 psi - 30 psig = 80 psi

$$A = \frac{125 \sqrt{1.23}}{28.14(1)(.866) \sqrt{80}} = 0.636 \text{ sq. in.}$$

An "H" orifice valve with an effective area of 0.785 square inches is the smallest standard size valve that will flow the required relieving capacity. Since the built-up back pressure exceeds 10% a bellows style valve, Style JBS, is required. From Crosby Catalog No. 310, standard materials were selected. Therefore, Model Number is 1-1/2H3 Style JLT-JBS-15 valve with a Type J cap.

EXAMPLE #2
Liquid, gpm

Fluid:	Castor Oil
Relieving Cap:	100 gpm
Set Pressure:	210 psig
Overpressure:	10%
Back Pressure:	35 psig (constant)
Relieving Temperature:	60F
Specific Gravity:	0.96

$$A = \frac{GPM \sqrt{G}}{28.14 K_w K_v \sqrt{\Delta P}}$$

Where:

- A = Minimum required effective discharge area, square inches
- GPM = 100 gallons per minute
- G = 0.96
- K_w = 1.0 (Page 7-5)
- K_v = 1.0 for non-viscous fluid
- ΔP = 210 psig + 21 psi - 35 psig = 196 psi

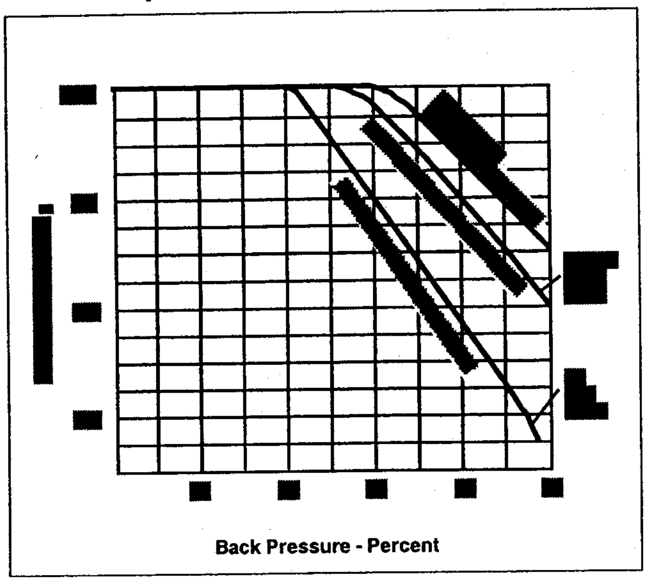
$$A = \frac{100 \sqrt{0.96}}{28.14 (1)(1) \sqrt{196}} = 0.249 \text{ sq.in.}$$

A number "8" orifice with an effective area of 0.307 sq.in. is the smallest Series 900 OMNI-TRIM valve that will flow the required relieving capacity. Since the back pressure is constant a conventional Style JOS or Series 900 valve can be used. Therefore, from Crosby Catalog No. 902, select a 981105M-A.

D.2
AMS
12/14/04

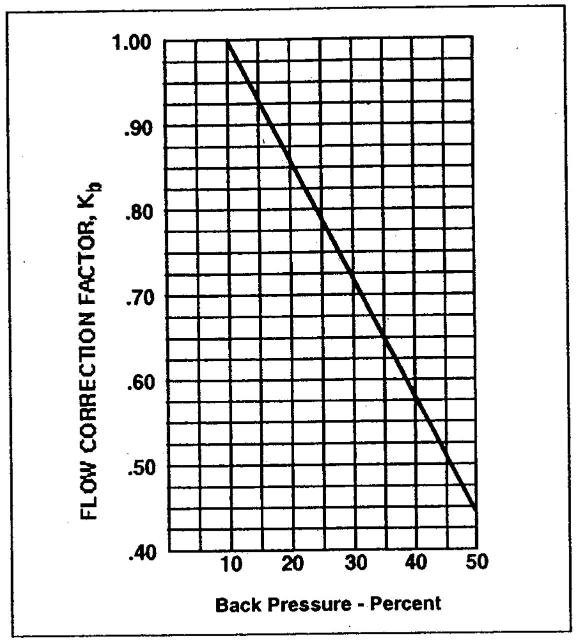
Correction Factor for Vapors and Gases, K_b

Figure F7-2A
Style JBS Valves - 10% Overpressure



$\frac{\text{Back Pressure (gage)}}{\text{Set Pressure (gage)}} \times 100$

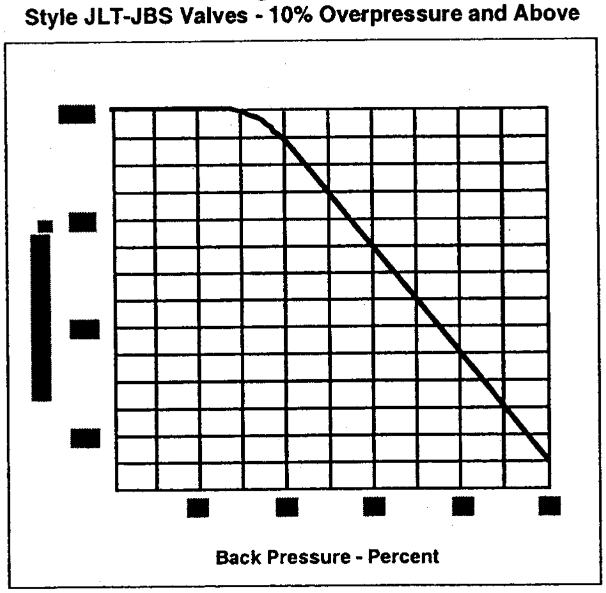
Figure F7-2B
Series BP Valves - 10% Overpressure



$\frac{\text{Back Pressure (gage)}}{\text{Set Pressure (gage)}} \times 100$

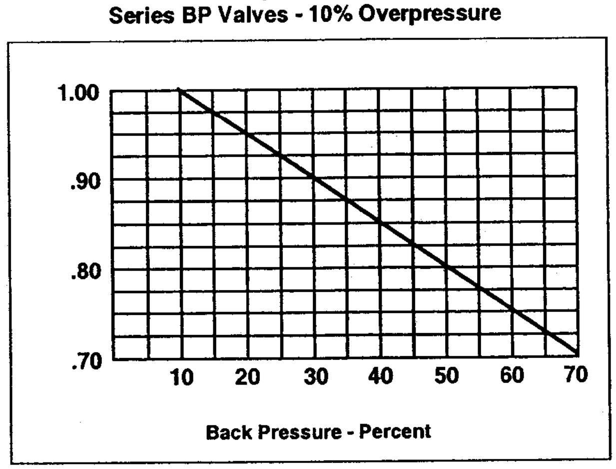
Correction Factor for Liquids, K_w

Figure F7-3A
Style JLT-JBS Valves - 10% Overpressure and Above



$\frac{\text{Back Pressure (gage)}}{\text{Set Pressure (gage)}} \times 100$

Figure F7-3B
Series BP Valves - 10% Overpressure



$\frac{\text{Back Pressure (gage)}}{\text{Set Pressure (gage)}} \times 100$

Capacity Correction Factor for Viscosity, K_v

When a relief valve is sized for viscous liquid service, it is suggested that it be sized first as for nonviscous-type application in order to obtain a preliminary required effective discharge area, A. From Crosby's standard effective orifice sizes select the next larger orifice size and calculate the Reynolds' number, R, per the following formula:

U.S.C.S. Units:

$$R = \frac{GPM(2800G)}{\mu \sqrt{A}} \qquad R = \frac{12700\,GPM}{U \sqrt{A}}$$

Metric Units:

$$R = \frac{Q(18800)G}{\mu \sqrt{A'}} \qquad R = \frac{85225Q}{U \sqrt{A'}}$$

Where:

GPM = Flow rate at the flowing temperature, U.S. gallons per minute.

G = Specific gravity of the liquid at the flowing temperature referred to water = 1.00 at 70F (21C).

A = Effective discharge area, square inches (from manufacturers' standard orifice areas).

U = Viscosity at the flowing temperature, Saybolt Universal Seconds (SSU).

μ = Absolute viscosity at the flowing temperature, centipoises.

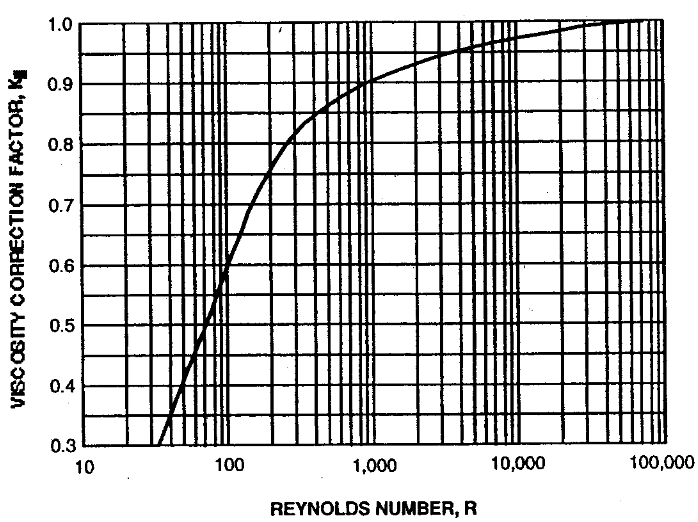
Q = Flow rate at the flowing temperature, liters per minute.

A' = Effective discharge area, sq. mm.

After the value of R is determined, the factor K_v is obtained from the graph. Factor K_v is applied to correct the "preliminary required discharge area." If the corrected area exceeds the "chosen effective orifice area," the above calculations should be repeated using the next larger effective orifice size as the required effective orifice area of the valve selected cannot be less than the calculated required effective area.

Figure F7-5

Correction Factor for Viscosity, K_v



D.4
AMS
12/14/04

Water Capacities Series 900 OMNI-TRIM® Valves - USCS (U.S. Customary System) Units

Note: USCS Units for water and liquids are U.S. gallons per minute (1 U.S. gallon equals .833 Imperial gallon).

Water Capacities - Differential Pressures Δ P[1] 5-5500 psi[2]

Diff. Pressure Δ P[1] (psi)	Effective Area (sq. in.)				
	0.074	0.110	0.196	0.307	0.503
5	4.6	6.9			
10	6.5	9.7	17.4		
15	8.0	11.9	21.3	33.4	54.8
20	9.3	13.8	24.6	38.6	63.3
40	13.1	19.5	34.8	54.6	89.5
60	16.1	23.9	42.7	66.9	109
80	18.6	27.6	49.3	77.2	126
100	20.8	30.9	55.1	86.3	141
120	22.8	33.9	60.4	94.6	155
140	24.6	36.6	65.2	102	167
160	26.3	39.1	69.7	109	179
180	27.9	[illegible]	73.9	115	189
200	29.4	43.7	78.0	122	200
220	30.8	45.9	81.8	128	209
240	32.2	47.9	85.4	133	219
260	33.5	49.9	88.9	139	228
280	34.8	51.7	92.2	144	236
300	36.0	53.6	95.5	149	245
320	37.2	55.3	98.6	154	253
340	38.3	57.0	101	159	260
360	39.5	58.7	104	163	268
380	40.5	60.3	107	168	275
400	41.6	61.9	110	172	283
420	42.6	63.4	113	177	290
440	43.6	64.9	115	181	296
460	44.6	66.3	118	185	303
480	45.6	67.8	120	189	310
500	46.5	69.2	123	193	316
520	47.4	70.5	125	196	322
540	48.3	71.9	128	200	328
560	49.2	73.2	130	204	334
580	50.1	74.5	132	208	340
600	51.0	75.8	135	211	346
620	51.8	77.0	137	215	352
640	52.6	78.3	139	218	358
660	53.4	79.5	141	221	363
680	54.3	80.7	143	225	369
700	55.0	81.8	145	228	374
720	55.8	83.0	147	231	379
740	56.6	84.2	150	235	385
760	57.4	85.3	152	238	390
780	58.1	86.4	154	241	395
800	58.8	87.5	156	244	400
820	59.6	88.6	157	247	405
840	60.3	89.7	159	250	410
860	61.0	90.7	161	253	415
880	61.7	91.8	163	256	419
900	62.4	92.8	165	259	424
920	63.1	93.8	167	262	429

Diff. Pressure Δ P[1] (psi)	Effective Area (sq. in.)				
	0.074	0.110	0.196	0.307	0.503
940	63.8	94.9	169	264	433
960	64.5	95.9	170	267	438
980	65.1	96.9	172	270	443
1000	65.8	97.8	174	273	447
1100	69.0	102	182	286	469
1200	72.0	107	191	299	490
1300	75.0	111	198	311	510
1400	77.9	115	206	323	529
1500	80.6	119	213	334	548
1600	83.2	123	220	345	566
1700	85.8	127	227		
1800	[illegible]	[illegible]	234		
1900	90.7	134	240		
2000	93.1	138	246		
2100	95.4	141	252		
2200	97.6	145	258		
2300	99.8	148	264		
2400	102	151	270		
2500	104	154	275		
2600	106	157	281		
2700	108	160	286		
2800	110	163			
2900	112	166			
3000	114	169			
3100	115	172			
3200	117	175			
3300	119	177			
3400	121	180			
3500	123	183			
3600	124	185			
3700	126	188			
3800	128	190			
3900	130	193			
4000	131	195			
4100	133	198			
4200	134	200			
4300	136	202			
4400	138	205			
4500	139	207			
4600	141	209			
4700	142	212			
4800	144	214			
4900	145	216			
5000	147	218			
5100	148	221			
5200	150	223			
5300	151	225			
5400	153	227			
5500	154	229			

Notes

1. Differential Pressure (Δ P) equals inlet pressure (set pressure plus overpressure) at flowing conditions minus back pressure.

See pages 12 and 13 for Minimum and Maximum Set Pressure Limits.

3. To determine capacities on liquids other than water or for fluid temperatures other than 70°F, use the liquid sizing formula in the Crosby Engineering Handbook.

4. The scope of the ASME Code, Section VIII, does not include pressures below 15 psig and therefore pressure relief valves set below 15 psig are not stamped with the ASME Code Symbol.

[illegible]

Capacities certified by the National Board of Boiler and Pressure Vessel Inspectors and in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII.

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Electric-Driven Single Stage

- [x] Peak HP
- [x] HP
- [x] Voltage
- [x] Tank
- [x] ACFM @ 40 PSI
- [x] Max PSI
- [x] NPT Outlet (in)
- [x] Package Dimensions (L x W x H
- [x] Net Weight (lbs)

Specifications

Model	Tank	ACFM @ 40 PSI	Max PSI	NPT Outlet (in)
SS3L3	60-gal vert	11.3	135	3/8
SS5L5	60-gal vert	18.1	135	1/2

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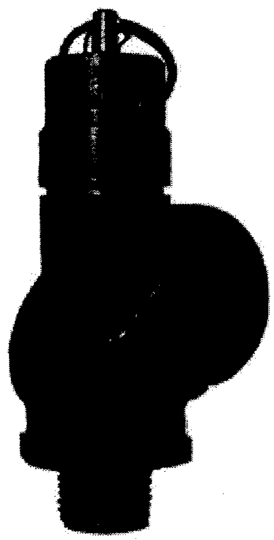
Appendix DD

SW12	1-1/4" NPT	SW12_Layout.pdf	25 - 300	2 lb.



SCB5075/SCB5010

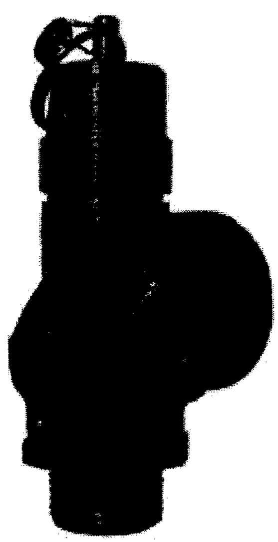
Model "SCB"

Model "SCB" ASME safety valves are designed for applications where a piped or directed discharge is required. Unique O-ring seal insures valve is bubbl tight to within 10% of set pressure.

1/2" NPT and 3/4" NPT inlets available. Outlet size are available in 3/4" NPT and 1" NPT.

Precision machined cast brass body with brass construction and stainless steel springs. O-ring sea available in silicone or fluorocarbon rubber.

Stamped with "UV" and "NB" symbols. Available se pressure range 25 PSI to 300 PSI. Set pressure tolerance ±3% of set pressure. 250°F max. temperature.



SCB7575/SCB7510

Flow Capacity Chart

Part Number	Inlet Size	Outlet Size	Dimensions (PDF File)	Set Pressure (Range - PSIG)	Approx. Shipping Wei
SCB5075	1/2" NPT	3/4" NPT	SCB5075_Layout.pdf		

SCB5010	1/2" NPT	1" NPT	SCB5010_Layout.pdf	25 - 300	1-1/2 lb.
SCB7575	3/4" NPT	3/4" NPT	SCB7575_Layout.pdf		
SCB7510	3/4" NPT	1" NPT	SCB7510_Layout.pdf		

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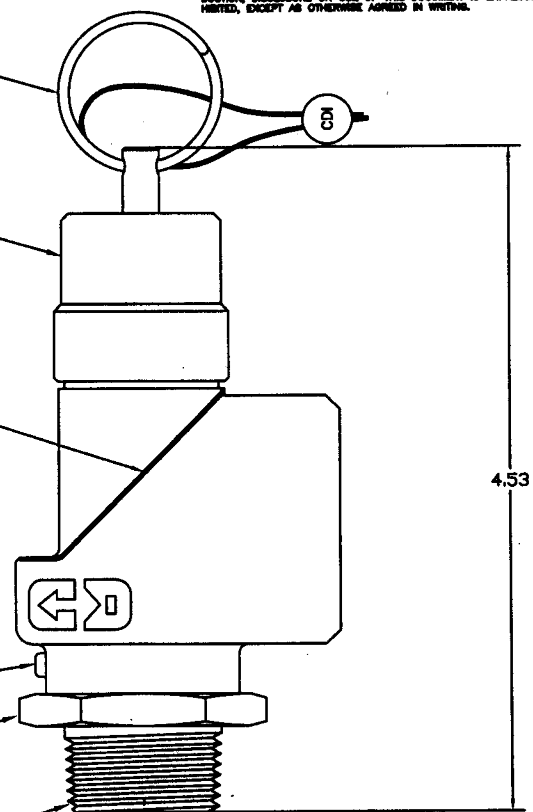


DATE	SYM	REVISION RECORD	ECN NO.	CK.

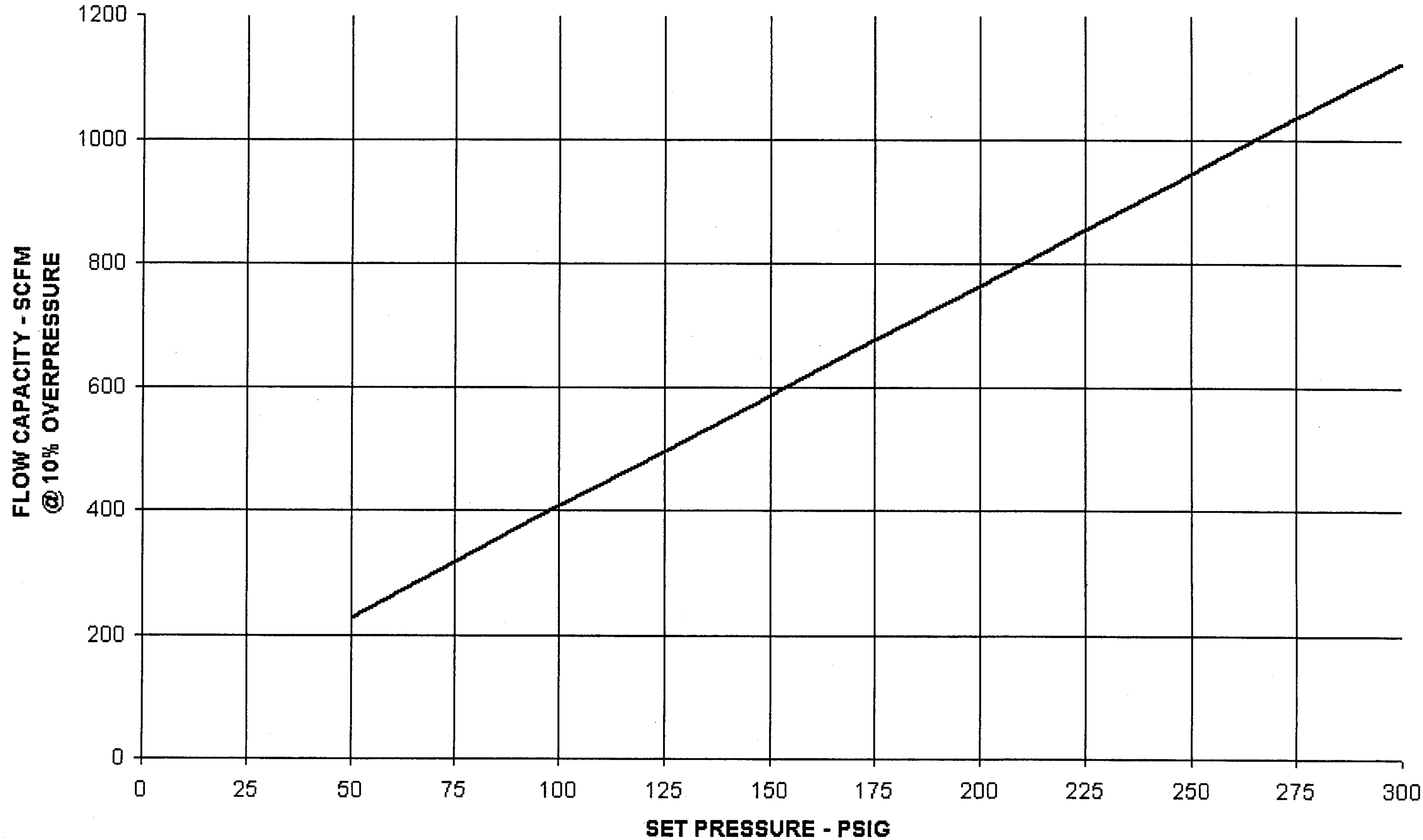
NOTES:

1. SET PRESSURE RANGE 50 TO 300 PSI
2. CERTIFIED RELIEF CAPACITY IS GIVEN BY THE EQUATION
   Q = 3.26 (1.1P + 14.7), WHERE
   Q = RELIEF CAPACITY IN SCFM, AND
   P = SET PRESSURE IN PSI
3. MATERIALS OF CONSTRUCTION:
   BODY, ROD, DISK, ADJUSTMENT
   SPRING, PULL RING – STAINLESS STEEL
   O-RING – SILICONE OR FLUOROCARBON RUBBER
   SEAL – LEAD

ALL DIMENSIONS ARE IN INCHES.

TOLERANCES (EXCEPT AS NOTED)	control devices inc. 711 HANLEY INDUSTRIAL COURT ST. LOUIS, MISSOURI 63144
DECIMAL ±	MATERIAL: — SCALE: 1:1 SIZE: B DRAWN BY: RMH APPROVED BY:
FRACTIONAL ±	
ANGULAR ±	TITLE: SAFETY VALVE, 3/4 NPT OUTLET
DATE: 7/29/98	CAD FILE: Q:\ENGR\PARTDWGS\SCB7575.DWG DRAWING NUMBER: SCB7575

Model SCB Safety Valves



FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE

SUBJECT: Appendix DD - Check steam capacity of CDI safety relief valve SCB7510-0A125

NAME: AMS

DATE: 2/22/05

REVISION DATE:

for the fire case where only steam is relieved (Relief valve mounted on top of the vessel).

Steam relieving capacity for tank fire case = 465 Lbm/hr from page 4 of the relief valve sizing calculations in MD-ENG-042 Section 25.6.

Relief valve capacity at the set pressure of 125 psi and with 10% overpressure:

$$Q = 3.26\,(1.1P + 14.7)$$ Formula from CDI drawing.

$$Q = 3.26(1.1(125) + 14.7) = 496 \text{ scfm air}$$

Back-calculate KA for this relief valve using the formula in Appendix 11 of ASME Section VIII Div 1.

$$KA = \frac{W_a}{CP}\sqrt{\frac{T}{M}}$$

$$W_a = 496\ \frac{\text{scf}}{\text{min}} * 0.075\ \frac{\text{Lbm}}{\text{scf}} * \frac{60\ \text{min}}{\text{hr}} = 2{,}232\ \frac{\text{Lbm}}{\text{air}}$$

$$KA = \frac{2{,}232}{356\,(125*1.1)}\sqrt{\frac{460+60}{28.97}} = 0.193$$

Steam relieving capacity at 164 psia is:

$$W = CKAP\sqrt{\frac{M}{T}} = 347(0.193)(164)\sqrt{\frac{18}{826}} = 1{,}620\ \frac{\text{Lbm}}{\text{hr}}$$

$$1{,}620\ \frac{\text{Lbm}}{\text{hr}} > 465\ \frac{\text{Lbm}}{\text{hr}}$$

Capacity > Design relieving flow rate

ok

APPENDIX 11
CAPACITY CONVERSIONS FOR SAFETY VALVES

11-1

The capacity of a safety or relief valve in terms of a gas or vapor other than the medium for which the valve was officially rated shall be determined by application of the following formulas:[1]

For steam,

$$W_s = 51.5KAP$$

For air,

$$W_a = CKAP\sqrt{\frac{M}{T}}$$

$$C = 356$$

$$M = 28.97$$

$T = 520$ when W_a is the rated capacity

For any gas or vapor,

$$W = CKAP\sqrt{\frac{M}{T}}$$

where

W_s = rated capacity, lb/hr of steam

W_a = rated capacity, converted to lb/hr of air at 60°F, inlet temperature

W = flow of any gas or vapor, lb/hr

C = constant for gas or vapor which is function of the ratio of specific heats, $k = c_p/c_v$ (see Fig. 11-1)

K = coefficient of discharge [see UG-131(d) and (e)]

A = actual discharge area of the safety valve, sq in.

P = (set pressure × 1.10) plus atmospheric pressure, psia

M = molecular weight

T = absolute temperature at inlet (°F + 460)

These formulas may also be used when the required flow of any gas or vapor is known and it is necessary to compute the rated capacity of steam or air.

Molecular weights of some of the common gases and vapors are given in Table 11-1.

For hydrocarbon vapors, where the actual value of k is not known, the conservative value, $k = 1.001$ has been commonly used and the formula becomes

$$W = 315KAP\sqrt{\frac{M}{T}}$$

When desired, as in the case of light hydrocarbons, the compressibility factor Z may be included in the formulas for gases and vapors as follows:

$$W = CKAP\sqrt{\frac{M}{ZT}}$$

Example 1

GIVEN: A safety valve bears a certified capacity rating of 3020 lb/hr of steam for a pressure setting of 200 psi.

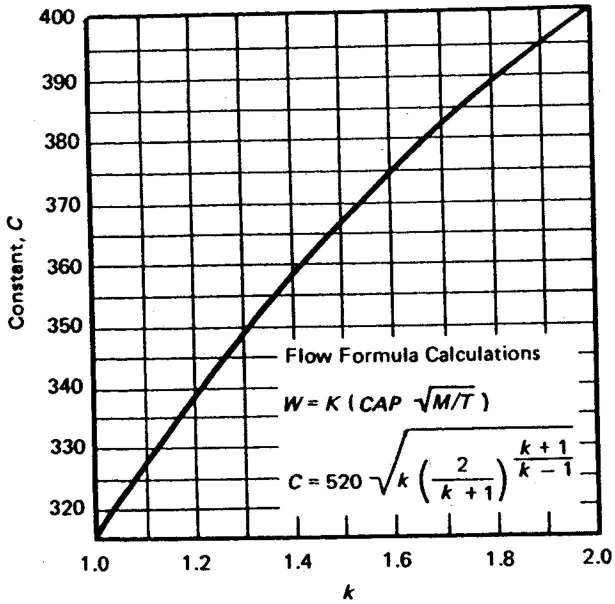
PROBLEM: What is the relieving capacity of that valve in terms of air at 100°F for the same pressure setting?

[1] Knowing the official rating capacity of a safety valve which is stamped on the valve, it is possible to determine the overall value of KA in either of the following formulas in cases where the value of these individual terms is not known:

Official Rating in Steam: $KA = \dfrac{W_s}{51.5P}$

Official Rating in Air: $KA = \dfrac{W_a}{CP}\sqrt{\dfrac{T}{M}}$

This value for KA is then substituted in the above formulas to determine the capacity of the safety valve in terms of the new gas or vapor.



k	Constant C	k	Constant C	k	Constant C
1.00	315	1.26	343	1.52	366
1.02	318	1.28	345	1.54	368
1.04	320	1.30	347	1.56	369
1.06	322	1.32	349	1.58	371
1.08	324	1.34	351	1.60	372
1.10	327	1.36	352	1.62	374
1.12	329	1.38	354	1.64	376
1.14	331	1.40	356	1.66	377
1.16	333	1.42	358	1.68	379
1.18	335	1.44	359	1.70	380
1.20	337	1.46	361	2.00	400
1.22	339	1.48	363	2.20	412
1.24	341	1.50	364	...	...

FIG. 11-1 CONSTANT C FOR GAS OR VAPOR RELATED TO RATIO OF SPECIFIC HEATS ($k = c_p/c_v$)

SOLUTION:

For steam

$$W_s = 51.5KAP$$

$$3020 = 51.5KAP$$

$$KAP = \frac{3020}{51.5} = 58.5$$

For air

$$W_a = CKAP\sqrt{\frac{M}{T}}$$

$$= 356\ KAP\sqrt{\frac{28.97}{460 + 100}}$$

$$= (356)(58.5)\sqrt{\frac{28.97}{560}}$$

$$= 4750 \text{ lb/hr}$$

Example 2

GIVEN: It is required to relieve 5000 lb/hr of propane from a pressure vessel through a safety valve set to relieve at a pressure of P_s, psi, and with an inlet temperature at 125°F.

PROBLEM: What total capacity in pounds of steam per hour in safety valves must be furnished?

SOLUTION:

For propane,

$$W = CKAP\sqrt{\frac{M}{T}}$$

The value of C is not definitely known. Use the conservative value, $C = 315$.

$$5000 = 315\ KAP\sqrt{\frac{44.09}{460 + 125}}$$

$$KAP = 57.7$$