LN2 DEWAR 42

DELIVERY OVERFILL

INLET SOLUTION

Original: J. Wu and G.T. Mulholland, February 26, 1991

Amendment 1: S. McDade, R. Rucinski, May 7, 2004

D-ZERO ENGINEERING NOTE # 3740.214-EN-281, Amendment 1

Background:

Pressure vessels must be protected against overpressure scenarios. A scenario of particular concern is that from a high pressure LN2 pump, now standard on LN2 delivery trailers. A safety mechanism must be in place to prevent the overfilling, and subsequent overpressure from occurring because these pumps have a higher mass flow output than reasonably sized relief valves provide.

Original Solution:

The original solution to the problem was to close a valve on the fill line when a certain liquid level in the dewar is reached. The valve remains closed until the level drops below that threshold. The trigger level was about 13,000 gallons for the 20,000 gallon capacity dewar. The solution was in place from 1989 until present, 2004. (The original solution engineering note follows the Amendment 1 documents.)

Amendment 1:

In 2003, the Compressed Gas Association, CGA, issued a position statement (PS-8-2003) regarding the "protection of cryogenic storage tanks from overpressure during operator-attended refill". This position statement provided a list of possible solutions to the problem. The solution which included an automatically closing valve on the fill line, based on a "mechanical pressure sensing" device. A review of all Fermilab LN2 dewars was undertaken to check for compliance.

It is accepted within the cryogenic safety review panels, that the "liquid level" triggered solution is in compliance. I note that in fact, the "liquid level" trigger is obtained by a mechanical differential pressure sensor device.

In any case, I decided to change the solution to "pressure" to 1.) take advantage of being able to store more liquid inventory, and 2.) make the Dewar 42 solution the same as Dzero LN2 Dewar 39, with common logic, and spare parts. The pressure vessel engineering note was amended and reviewed. Installation and switch to the new overfill solution will take place in 2004.

Russell Rucinski, PPD/MD/D0 Ops

AMENDMENT #1

PUMPING OVERFILL PROTECTION FOR VESSEL RD.4004

DEWAR 42

Reviewed By: MICHAEL GEYANISMAN
M. Geyanisman
5-3-2004

Stephanie McDade
5/27/98

ENDORSED BY: RUSS RUCINSKI
4/01/2004

PEER REVIEW:

REVISION DATE

MATH CHECKED:
M. ZACZEK

SKETCH 4.1 SIMPLIFIED SCHEMATIC OF AUTOMATIC FILL SHUT-OFF

FERMILAB
ENGINEERING NOTE

SECTION

RD/DØ

PROJECT

LN₂
DEWAR

SERIAL-CATEGORY

3323.115

PAGE

A4.1

SUBJECT

LN₂ DEWAR RELIEF SIZING REQMTS.
PUMPING OVERTILL (CONT.)

NAME

RUSS RUCINSKI

DATE

11-5-96

REVISION DATE

MATH CHECKED:
M ZACZEL
11-8-96

SPECIFIC DETAILS, MODEL NUMBERS, ETC.
FOR THE COMPONENTS OF THE SYSTEM ARE ATTACHED.

THE NORMAL OPERATING PRESSURE OF THIS DEWAR IS 35 PSIG. DURING A NORMAL FILL THIS PRESSURE SHOULD NOT VARY MORE THAN 5 PSIG. FOR A FILLING ACCIDENT CASE (^{1st} DRIVER DISREGARDS LEVEL GAGE.) THE PRESSURE SWITCH, PS-576-N WILL TRIP AT A FIXED SET POINT OF 55 PSIG. WHEN TRIPPED, IT BREAKS THE CIRCUIT SUPPLYING POWER TO THE 4 WAY SOLENOID. THE 4 WAY SOLENOID BLOCKS AND VENTS THE AIR SUPPLY THAT HOLDS OPEN THE FILL VALVE PV-540 -N. THE FILL VALVE CLOSSES WHICH PROTECTS THE VESSEL FROM THE SOURCE OF OVERPRESSURE.

THE PRESSURE SWITCH IS PROVIDED WITH A LATCHING RESET BUTTON SO THAT MANUAL INTERVENTION IS NECESSARY TO RESUME FILLING OPERATIONS. ALL COMPONENTS ARE COMMERCIALY AVAILABLE, COMMON ITEMS WITH GOOD RELIABILITY. THE SYSTEM IS FAIL SAFE IN AS MUCH AS A LOSS OF EITHER ELECTRICAL POWER OR INSTRUMENT AIR WILL CLOSE THE FILL VALVE PV-540 -N.

A RELIABILITY ANALYSIS FOLLOWS AND SHOWS THAT THE SYSTEM IS AS SAFE AS A CLASS Ø ODH AREA.

SUBJECT

LN2 DEWAR RELIEF SIZING REQMTS
PUMPING OVERFILL (CONT.)

NAME
RUSS RUCINSKI

DATE
11-7-96

REVISION DATE

RELIABILITY / PROBABILITY ANALYSIS

FOR AUTO FILL
SHUT-OFF
ON OVERPRESSURE

I WILL USE A PROBABILITY TREE DIAGRAM & THERP MODEL
{ REF. "HUMAN FACTORS" BY KANTOWITZ & SORKIN, ISBN 0-471-09544-X }
PAGE 51

MATH CHECK
A. ZACZEK
11-8-96

PROBABILITIES

$$K = .01$$

$$K = .99$$

.01 PROBABILITY OF FAILURE TO RECOGNIZE
AN INCORRECT STATUS WHEN CHECKING
ITEM IN FRONT OF YOUR NOSE.
TABLE 2-2 P.53 "HUMAN FACTORS"

$$S = .00001$$

$$S = .99999$$

REF. FESHM 5064 TABLE 2

$$T = .001$$

$$t = .999$$

$$R = .0003$$

$$r = .9997$$

PROBABILITY OF = Pr

$$Pr(\text{SAFE outcome}) = K + K(S|K)(t|(S|K))(r|(t|(S|K)))$$

$$Pr(\text{SAFE outcome}) = .99 + .01(.99999)(.999)(.9997)$$

99% PROB. OPERATOR
SHUTS OFF FLOW

1% PROBABILITY
OPERATOR
SCREWS UP

PROB. P.S.
OPERATES
CORRECTLY

PROB. SOLENOID
WORKS COR.

PROB. BALL VALVE
ACTUATES

FERMILAB

ENGINEERING NOTE

SECTION

RD/DO

PROJECT

LN₂
DEWAR

SERIAL-CATEGORY

3823.115

PAGE

A4.3

SUBJECT

LN₂ DEWAR RELIEF SIZING REQ'T AT
PUMPING OVERFILL (CONT.)

NAME

RUSS RUCINSKI

DATE

11-7-96

REVISION DATE

MATH CHECKED
M. ZACZEK
11-8-96

$$Pr(\text{SAFE OUTCOME}) = .9999869031$$

$$Pr(\text{FAILURE OUTCOME}) = K(S|K) + K(S|K)(T1(S|K)) + \\ + K(S|K)(T1(S|K))(R(T1(S|K)))$$

$$Pr(\text{FAILURE OUTCOME}) = .01(.00001) + .01(.99999)(.001) + .01(.99999)(.999)(.0001)$$

$$Pr(\text{FAILURE OUTCOME}) = .00001309687003$$

$$\text{CHECK: } Pr(\text{SAFE OUTCOME}) + Pr(\text{FAILURE OUTCOME}) \stackrel{?}{=} 1.0$$

$$\begin{array}{r} .9999869031 \\ + .00001309687 \\ \hline 1.0000000000 \end{array} \quad \checkmark \text{ CHECKS O.K.}$$

WHAT THIS MEANS IN MORE TANGIBLE TERMS IS:

$$[Pr(\text{FAILURE OUTCOME})]^{-1} = 76,354$$

THERE IS A PROBABILITY OF 1 FAILURE OUTCOME IN 76,354 FILLING OPERATIONS. ASSUMING 3 FILLS/WEEK; THIS MEANS 1 FAILURE IN 439 YEARS. PUTTING THIS IN ODH PROBABILITY UNITS OF hr^{-1} ;

$$Pr(\text{FAILURE OUTCOME}) = .00001309687 \frac{\text{FAILURES}}{\text{EVENT}} \cdot \frac{3 \text{ EVENTS}}{\text{WEEK}} \cdot \frac{1 \text{ WEEK}}{7 \text{ DAYS}} \cdot \frac{1 \text{ DAY}}{24 \text{ hrs.}} \\ = 2.34 \times 10^{-7} \frac{\text{FAILURES}}{\text{HR}}$$

A FAILURE OUTCOME JUST MEANS THE RELIEF CAPACITY WOULD BE EXCEEDED IF THE PUMPING RATE WAS GREATER THAN 110 gpm (FROM CAPACITY CALCS. NOT PRESENTED.) DURING THAT FILL EVENT. JUST FOR DISCUSSION, ASSUME A ONE IN TEN FATALITY FACTOR FOR A FAILURE EVENT. THEN THE FATALITY RATE WOULD BE:

$$\phi = Pr \cdot F_1 = (2.34 \times 10^{-7} \frac{\text{FAILURES}}{\text{HR}}) \left(\frac{1 \text{ FATALITY}}{10 \text{ FAILURES}} \right) = 2 \times 10^{-8} \text{ hr}^{-1}$$

FERMILAB

ENGINEERING NOTE

SECTION

RD100

PROJECT

LN₂
DEWAR

SERIAL-CATEGORY

3823.115

PAGE

A4.4

SUBJECT

LN₂ DEWAR RELIEF SIZING REOMT
PUMPING OVERFILL (CONT.)

NAME

RUSS RUCINSKI

DATE

11-7-96

REVISION DATE

MATCH CHECKED
M. ZACZEK

FOR COMPARISON, THE ODH CLASS CRITERIA IS THAT 11-8-96

 $\phi < 10^{-7} \text{ hr}^{-1}$ FOR AN ODH CLASS ϕ AREA.

I CONCLUDE THAT IN GOOD ENGINEERING JUDGEMENT, THE
AUTO FILL SHUT-OFF SYSTEM ON OVERPRESSURE
IS RELIABLE ENOUGH TO REDUCE THE HAZARD
TO AN ACCEPTABLE LEVEL.

ID # 8351

PURCHASE REQUISITION

(SEE INSTRUCTIONS ON REVERSE SIDE - DO NOT WRITE IN SHADED AREAS)

DESIRED DELIVERY 12/9/96

REQUESTED BY Russ Rucinski		EMPLOYEE NO 8351	EXT.	ORGANIZATION UNIT RD/DO	MAIL STATION 357	REQUESTOR'S IDENTIFIER		REQ. DATE 11/5/96
SUGGESTED VENDOR B&B Instruments, Inc. 6444 Columbia Ave., PO box 4039 Hammond, IN 46324		PHONE NO 219-932-4474		PROJECT DESCRIPTION DØ Upgrade Solenoid DELIVER TO (INCLUDE NAME & BUILDING NO) Russ Rucinski, D-Zero Ass'y Bldg.		APPROVALS EMPLOYEE NO		
SHORT DESCRIPTION (30 CHARACTERS OR LESS) Pressure switches - LN2 dewar					PREVIOUS P.O.	DIR. OFFICE		
REC. AREA CODE	QUANTITY	ITEM DESCRIPTION				ESTIMATED UNIT PRICE	DO NOT USE UNIT PRICE DISCOUNT DEL. DATE	
	3	UE Electromechanical Products, Pressure switch. Model Number H100-270-1530.				\$138.00		
CHECK BOX IF CONFERENCE REQ.		CHECK BOX TO RECEIVE P.O. COPY VIA E-MAIL		TOTAL AMOUNT THIS REQUISITION				\$414.00
BUDGET CODE	PERCENTAGE	NEPA APPROVAL		DIVISION OFFICE APPROVAL		WBS NUMBER	PERCENTAGE	PURCHASING/CONTRACTS DEPT. STAMP
EEH	100					3.1.1.4.5	100%	
P.O. NUMBER		VENDOR CODE		BUYER		AT RIGHT INDICATE SPECIAL ORDER TYPE (SPARES/ISS/GSA/CAFE/AB/T&M)		GSA/FSS CONTRACT NO.
SEND P.O. TO ATTENTION OF		SHIP VIA		F.O.B. & POINT OF SHIPMENT FOR FB/FC/FD		TERMS	REPORTING CODE	COST ELEMENT
CONFIRMED TO & DATE								
CHECK IF P.O. FOR INTERNAL USE ONLY		CHECK IF REQUESTER TO APPROVE PAYMENT		BEGINNING STD. TEXT CODES		ENDING STD. TEXT CODES		REQUISITION NUMBER

DØ-8/29/96

A4.5

PAGE A4.6

UE Electromechanical Products

Pressure and Temperature Switches
Indicating Temperature Controls
Temperature Recorders

B&B Instruments, Inc.

8444 COLUMBIA AVE.

P.O. BOX 4039

HAMMOND, IN 46324

312-891-8840/219-932-4474/FAX: 219-932-5399

INDUSTRIAL GAUGES AND PROCESS CONTROLS

General Purpose Service

A4.7

- Introducing a family of low-cost pressure and temperature switches for the process plant or OEM
- Wide selection of adjustable ranges within 3-5000 psi and -180 to 1000°F
- Internal reference scales and adjustment lock
- Enclosure design permits safe and easy access for wiring
- Many models available from stock
- Factory setting

Specifications

Approvals:

UL listed
CSA certified.

Storage Temperature:

-65 to $\pm 160^{\circ}\text{F}$

Ambient Temperature limits:

-40 to $\pm 160^{\circ}\text{F}$, except models 701-706, 0 to 160°F .
Set point typically shifts less than 1% of range for a 50°F (28°C) ambient temperature change.

Shock:

Set point repeats after 15 G, 10 millisecond duration.

Vibration:

Set point repeats after 2.5 G, 5-500 CPS.

Enclosure Classification:

NEMA 4; (4X see 117 series).

Set point Repeatability:

Temperature Models $\pm 1\%$ of adjustable range.

Pressure Models 701-706, 270-376 $\pm 1\%$ of adjustable range.

190-194, 612-680 $\pm 1.5\%$ of adjustable range.

Switch Output:

1 SPDT. Switch may be wired "normally open" or "normally closed".

Electrical Rating:

15 amp 125/250/480 VAC resistive.

Enclosure:

Die cast aluminum, (max 0.6% copper)

Light grey aluminum lacquer finish, gasketed

Approx. 2 lbs.

Weight:

Electrical connection:

$\frac{1}{2}$ " NPT, (2) $\frac{3}{8}$ " diameter knockouts.

Pressure connection:

$\frac{1}{4}$ " NPTF except models 190-194 ($\frac{1}{2}$ " NPTF).

Temperature Assembly

6 feet copper or 304 stainless steel models M9B, M9BB 347 stainless steel.

Bulb and Capillary:

Immersion Stem

Brass

Fill:

Models 1BC, 1BS are solvent filled, models 2-8 are oil-filled and models M9B, M9BB are mercury filled.

Temperature

Typically 1% of range under laboratory conditions (70°F ambient circulating bath at rate of $\frac{1}{2}^{\circ}\text{F}$ per minute change).

Deadband:

Switches designed specifically for heat tracing and freeze protection applications.

HTFP Heat Tracing/ Freeze Protection:

Available with types B100 and E100. Specifications are the same as above except:
B100-13546 includes: 22 amp switch with a stainless steel immersion stem.
E100-13545 includes: 22 amp switch and 10 feet of stainless steel capillary.

Dimensions

How To Order

Follow Steps 1-4 to specify the 100 Series pressure and temperature switch for your application.

1 Specify Type

Pressure:

Type H100 - One SPDT output

Temperature:

Type C100 - Immersion stem, internal adjustment

Type B100 - Immersion stem,

internal adjustment via calibrated dial

Type F100 - Bulb and capillary, internal adjustment

Type E100 - Bulb and capillary, internal adjustment via calibrated dial

2 Select standard models in stock for fast delivery. Order by type and stock number (eg. H100-

95122). Be sure to check for stocked models with options. If your selection is not stock, go to step 3.

3 For models not in stock, specify type and model (eg. H100 model 706)

4 If an option is required, add code number from pages 46 and 47 to type and model (eg. H100-701*M201).

PRESSURE Model Chart Type H100

316 Stainless Steel diaphragm and 1/2" NPTF pressure connection.						
Model	Stock numbers for Type H100	Adjustable Range (English)	Adjustable Range (Metric)	Deadband		Proof Pressure
				Lower 75% range span	Top 25% range span	
190†	95303	5 to 30 PSI	35 to 200 kPa	1.0 to 3.0	6 max.	2500 PSI
191†	95310	10 to 100 PSI	70 to 700 kPa	1.0 to 8.0	15 max.	2500 PSI
192†	95317	30 to 300 PSI	200 to 2000 kPa	3.0 to 18	25 max.	2500 PSI
193†	95324	50 to 500 PSI	0.35 to 3.5 MPa	4.0 to 30	45 max.	2500 PSI
194†	95331	200 to 1700 PSI	1.4 to 11.7 MPa	5.0 to 120	150 max.	2500 PSI

†Deadband Note: Models 190-194 are expressed as the lower 75% and top 25% of the range span because of the operating characteristics of the diaphragm sensor and switch.

Phosphor bronze bellows and 1/4" NPTF brass pressure connection						
Model	Stock numbers for Type H100	Adjustable Range (English)	Adjustable Range (Metric)	Deadband		Proof Pressure
218	95704	30"Hg VAC to 0 PSI	-100 to 0 kPa	1 to 2"Hg		30 PSI
270	95166	20 to 200 PSI	140 to 1400 kPa	1 to 4.0 PSI		250 PSI
274		30 to 300 PSI	200 to 2000 kPa	1 to 5.0 PSI		350 PSI
316 Stainless steel bellows and 1/4" NPTF pressure connection						
358		20 to 200 PSI	140 to 1400 kPa	1 to 3.0 PSI		250 PSI
361		30 to 300 PSI	200 to 2000 kPa	1 to 1.4 PSI		350 PSI
376		50 to 500 PSI	0.35 to 3.5 MPa	1.5 to 5.0 PSI		575 PSI
316 Stainless steel bellows and 1/4" NPTF pressure connection						
680	95415	100 to 1700 PSI	7 to 11.7 MPa	9 to 23 PSI		2500 PSI
303 Stainless steel piston and Buna-N "O" ring 1/4" NPTF pressure connection, (not recommended for gas service since drying of the "O" ring can allow bleeding of medium into the atmosphere).						
610		100 to 1000 PSI	0.7 to 7MPa	30 to 150 PSI		10000PSI
612	95712	200 to 3000 PSI	1.4 to 20.0 MPa	40 to 250 PSI		10000 PSI
616		700 to 5000 PSI	4.8 to 35.0 MPa	40 to 375 PSI		10000 PSI
Buna-N diaphragm, "O" ring and 1/4" NPTF brass pressure connection. Buna-N diaphragm limited to process temperatures below 165°F.						
701	95122	3 to 30 PSI	20 to 200 kPa	1.0 to 2.0 PSI		600 PSI
702	95129	10 to 100 PSI	70 to 700 kPa	1.0 to 4.0 PSI		600 PSI
703	95136	30 to 300 PSI	200 to 2000 kPa	1.0 to 5.0 PSI		600 PSI
704	95142	50 to 500 PSI	0.35 to 3.5 MPa	2.0 to 8.0 PSI		2500 PSI
705	96149	100 to 1000 PSI	0.7 to 7.0 MPa	3.0 to 20.0 PSI		2500 PSI
706		200 to 1700 PSI	1.4 to 11.7 MPa	10.0 to 30.0 PSI		2500 PSI

*Stocked items with options.

Options

Many UE products with options are available from stock. These are indicated in model charts throughout the catalog by a stock number beginning with the number "9" (H100-95606, for example, refers to an H100 pressure switch with option M315). Order these by type and stock number (H100-9536, eg.). Switches listed below are UL listed, CSA approved. All switches are SPDT unless stated otherwise.

For products with options that are not in stock, follow 1-3.

1. Specify product type H100
2. Select model from chart H100-701
3. Select option from these pages after checking availability listed H100-701*0140*M201.

Optional Switches

Code	Description/availability
0140	1 amp 125 VAC res. gold flashed contact (dry circuit). Available: Types J400, J&H402, J403 (C400, 02, 03) (F400, 02, 03) Types J, C, F, 120; E, B, H122 series J6 and 100
0500	5 amp 125/250 VAC res. switch, close deadband. Available: Series 400, 120, 100, 6, 21K, 54, 55
1010	DPDT switch, 10 amp 125/250 VAC resistive 120 deadbands wider than standard. Available for certain models J120, J120K; all models F120, E121, H100, F100, C100
1070	10 amp 125 VDC switch. Available for the following: Types J, C, F 400, all type 402 Types C, F, J 120 Series J6, 100 and 54 Deadbands wider than standard.
1180	Hermetic Seal, SPDT, 11 amp 125/250 VAC, resistive UL, CSA listed. Available C, F, J120.
1190	DPDT, 11 amp Hermetic Seal. Available: 117, 120 Series.
1519	15 amp adjustable deadband 480 VAC res. max. Available: J120, J120K, C120, F120, C, F, H100.
1520	15 amp 277 VAC res. max., adjustable deadband. Available: Series J6 (126-S160, 218-230) Types J, C, F 400 and J, C, F 402 Types H 105, J54 and J54S Series J21K
1521	15 amp 277 VAC res. max., 2.40% of span adjustable deadband construction. Available: J6 (126-S160B) J400, (126-S164B, 451-454) J400K
→ 1530	15 amp 125/250 VAC res. external manual reset on increasing pressure and temperature. Types J, C, F 400; J, C, F 402 Series: J21K, J6 Types C, F, H 100; B, C, E, F, J54 Types C, F, J120*, E55, E55A
2000	20 amp 125/250 VAC res. switch. Available: Types J, C, F 400, 402, 403 Series 120 single switch only. Series 55, 100, J6, J21K, J27KB, 800, 820 Type E105, B105

Recorder options

Code	Description/availability
M002	60Hz, 115VAC, 7 day chart drive Available: 650 Series
M003	50 Hz, 115VAC, 7 day chart drive
M008	50Hz, 230VAC, 7 day chart drive
M009	60Hz, 230VAC, 24 hour rotation

Note: For celsius models, std. 24 hour rotation order option M270
For celsius models, 7 day rotation suffix "C" after option code (eg. M002C).

*Use of 1530 or M450 options provide CSA, Class I, Div. 1 group C & D only.

General Options

Code	Description/availability
M007	Drilled electrical opening 800 Series, right side.
M201	Set one switch; specify increasing or decreasing pressure or temperature and set point.
M202	Set two switches; specify increasing or decreasing pressure or temperature and set point.
M203	Set three switches; specify increasing or decreasing pressure or temperature and set point.
M210	Differential pressure indication Available: H122K, H121K, J400K, J402K (models 147-S157B)
M270	Metric calibrated dials (Celsius) Dual reference scales standard for many Series. Available: E54, E55, 650's only.
M300	NEMA 4 construction Available for the 800 Series Standard for many Series.
M315	Epoxy Polyamide coating of enclosure, external aluminum parts. Available: Types J, C, F 402 Series: 100 Series: Types C, F, J 120, B, E, H122 only.
M321	Gasketed Lexan® window Available on Types, B, E, H 400 Series.
Cenelec	Flameproof enclosure, BS5501, part 5, 1977, IP-66.
BASEEFA	CENELEC EN 50014/50018; EExd IIB T6. Approval available for the 120 Series only. Prefix model number with 'Q' eg. QF120-6BS (EExd IIC T6-Consult factory).
M410	CSA option Available for the following: J6, J40, 54.
M411	Compliance to NACE std. MR-01-80, 120, 100; 117 Series pressure models 190-193. Consult factory.
M444	Paper ID tag
M446	Stainless steel ID tag & wire attachment (attachment will vary depending on product)
M449	Mounting hardware 800 Series
M450	Breather drain Available for certain 120 Series models only. Consult factory
M540	Viton construction (deadbands may increase slightly) H100, H100D, H117, H117D and 120 Series models 700-713, wetted parts include Viton diaphragm and "O" ring plus 303 St/St, 1/4" NPTF pressure connection. 120 Series models 450-454, 400 Series models 448-454, 54 Series models 22-28 plus 120K, 400K, and 105K models 455-457: wetted parts include Viton diaphragm and "O" ring plus standard connection material. All products within models 610-618 and 50-55: "O" ring (only) is changed to Viton.
M550	Oxygen service cleaning. Internal construction may change, consult UE. Available for: Pressure controls (H60, 100, 105, 120, 400 Series). Not available: J400-614, J402-610. Differential pressure controls (120K, 105K, 400K)
M900	Watertight conduit fitting. Converts 7/8" hole to 1/2" NPT. Available for the following: 400 Series 800 Series 117 Series 650 Series 100 Series
M901	Watertight conduit fitting. Converts 1/2" NPT to 3/4" NPT. (117 Series).

Fermilab

PURCHASE REQUISITION

(SEE INSTRUCTIONS ON REVERSE SIDE - DO NOT WRITE IN SHADED AREAS)

[illegible]

4.4A

A 4.11

General Description

Parker Gold Ring™ 2 position 4-way solenoid valves are available in brass with 1/4 inch N.P.T. They can be used for media flow control in systems used to control small double acting cylinders not larger than 4" in diameter.

Series 48 solenoid valves require a minimum 10 psi operating pressure for acceptable system operation. Avoid exhaust flow restriction.

Applications

Series 48 Gold Ring™ solenoid valves are ideal for the control of a variety of media including gases, fluid light oils and other clean flowing media compatible with brass. This valve can be used in the following applications:

- Pilots
- Air motors
- Air vises
- Dampers

Operating Specifications

De-energized: Pressure to "A"; "B" to exhaust.

Energized: Pressure to "B"; "A" to exhaust.

Installation

- For proper operation, solenoid valves should be mounted vertical and upright
- See mounting dimensions (nominal) shown here
- For certified dimensions consult factory

Approvals

Standard valves with general purpose or explosion proof solenoid enclosures are U.L. Listed and CSA Certified. For details, consult factory.

Wetted Materials

Valve body:	Brass
Seals:	Buna-N
Plunger and Pole Piece:	430FR S.S.
Plunger Tube:	305 S.S.
Springs:	302 S.S.
Shading Coil:	Copper (Brass Bodiés)
Disc Holder:	Celcon

Solenoid Types

Open Frame:	Open Frame (O)
Type 1:	General Purpose (G), Splice Box (S) or Conduit Hub (T)
Type 2, 3, 3R:	Rainproof (R), Explosion Proof (E), S.S. Explosion Proof (M), S.S. or Standard Submersible (U or W)
Type 4, 4X:	Gold Ring II™ totally encapsulated (4)
Type 6:	Submersible Splice Box (W)
Type 7, 9:	Explosion Proof (E), S.S. Explosion Proof (M)
D.I.N.:	ISO 4400 & DIN 43650 (P)

Electrical

24/60, 110/120-50/60, 220/240-50/60, 440/480-50/60 volts A.C.
6, 12, 24, 120, 125 volts D.C. Other voltages as requested.

Coil

Class F, Standard. Class H Available.

Temperature Ratings

Media as listed

• A.C. voltages: 180°F max. • D.C. voltages: 104°F max.

Ambient: 32-77°F (standard)

For temperature variations, consult factory.

Series 48
AC & DC

Gold Ring™ Solenoid Valves

Material & Trim: Brass & Buna N

A4.12

AC Valve Specifications											AC Solenoid Specifications					
NPT	ORIFICE INLET EXH	Cv INLET EXH	Oper. Press. Differential			° F MAX TEMP	AC WATT	DWG NO	VALVE PART NUMBER	Select One Code From Each Column						
			MIN PSI	Max (MOPD) PSI						ENCLOSURE	COIL TERMINATION	VOLTAGE				
				AIR INERT GAS	WATER							LIGHT OIL 300SSU				
Operation: Universal (Pressure at P)											Strain Relief	C	Screw	K	AC	
1/4	1/16 3/32	.09 .09	10	150	150	150	180	11.0	83	04F48S2106ACF	Explosion Proof Watertight	E	Spade D.I.N.	S H	24/60 24/50	01 02
											General Purpose	G	Leads 6"	B	120/60 110/50	05
											316 SS Explosion Proof Watertight	M	18" 24" 36"	C D E	208/60 240/60 220/50	10 15
											Open Frame D.I.N.	O P			480/60 440/50	20
											Rainproof Splice Box	R S			120- 240/60	51
											Conduit Hub 316 SS	T U			240/60	53
											Submersible Submersible Splice Box	W			240- 480/60	
											Explosion Proof Watertight With Ground Lead	Y			DC	
											M. With Ground Lead	Z			6 12	70 75
											Gold Ring II™ Totally Encapsulated	4			24 120 125	80 90 95

Drawing 83

Explosion-Proof/Watertight
Shown in Outline

Series C4 and C51 Ball Valves for Cryogenic Service

High performance, shutoff valves for intermittent and continuous flow applications with temperatures to -425°F .

SB-442-11

WORCESTER PRESENTS THE QUALITY SOLUTION TO PROBLEMS OF MANUAL AND AUTOMATIC CONTROL OF CRYOGENS

Worcester Controls has the quality solution for tough applications involving all types of cryogenics; oxygen, hydrogen, methane, ammonia, nitrogen, fluorine, LNG and deuterium. Our complete line of cryogenic valves backed by years of successful field experience, incorporates superior technology and design. This means automatic or manual control of cryogenic fluids with no contamination, no fluid degradation and no waste while assuring safety to human life, property and the environment. The wrong specs here can turn an inferior valve into a time bomb. Tough applications demand Worcester Controls' special service cryogenic valves. Here's why:

Positive Ball Cavity Relief - An upstream relief hole in the ball prevents dangerous overpressure due to thermal expansion. On extended stem valves through 2", a one-piece stem with alignment pin assures proper orientation of the ball.

Blowout-Proof Stem - Both single piece and two-piece, assembled-inside-the-body stems are blowout-proof and are supported inside the body with Polyfill thrust-washers.

Zero Leak Packing - Belleville live loaded TFE packing rings and stem centering followers assure zero leakage through the toughest, high cycle applications.

Bonnet Extensions That Work - The stem extensions of Worcester Controls' cryogenic valves conform to ISA Standard SP79. That means wall thickness and lengths that keep heat transfer down, the packing frost free, operational torques low, and actuators solidly supported.

High Performance/Low Thermal Stress - The special "part compatibility" design of valve parts, Polyfill seats and body seals assure tight shutoff, zero body leakage and low torque through large thermal excursions from ambient to -425°F .

Valves Designed for Automation - Approximately 40% of cryogenic installations require fail-safe operation or automatic control. Worcester Controls has the pneumatic and electronic, computer compatible controls for your installation.

NO LEAK SEATS AND SEALS

Fully adjustable TFE, high cycle, zero leak chevron packing (stem seals). This is a Belleville live loaded design incorporated into 1/4"-2" three-piece and diverter valves. Wafer and flanged valves use 15% glass filled solid ring stem seals.

The heart of the Worcester cryogenic design is a rugged, one-piece, blowout-proof stem with a Polyfill thrustbearing and stainless steel split ring. You get design safety and low operational torque. Polyfill seats give you tight shutoff throughout the temperature range. With orientation controlled stem/ball connection and upstream hole in the ball, you get positive overpressure protection. All parts are oxygen compatible.

C4

C4 Diverter

C4 Wafer

C51 Flanged

VALVES WITHOUT STEM EXTENSIONS

CRYOGENIC VALVE CONFIGURATIONS

Worcester Controls cryogenic valves are available in four basic body configurations; C4 (1/4" 2"), C4 Diverter (1/2" 2"), C4 Wafer (3/6"), and C51 Flanged (3/6"). All four valve styles offer the same features; exclusive "Polyfill" seats, all stainless steel construction, blowout-proof stem, extension bonnet lengths to ISA SP79 Standards, positive, ball cavity relief and low operational torques.

C4 - The Worcester cryogenic valve incorporates many of the features of the rugged "Mizer" line of valves. Three-piece construction makes it easy to install, versatile in application and simple to maintain. By removing three of the body bolts and loosening the fourth, the valve may be swung out of line. In welded or soldered piping systems, all four body bolts may be removed and the center section lifted out for maintenance or replacement. A variety of connections are available; screwed end, socket weld, butt weld and solder/sweat ends.

C4 Diverter - The cryogenic diverter valve accepts media through the bottom inlet port and directs it to one of two side ports. There are two ball porting configurations; Porting No. 1 directs flow from one outlet port to the other through a 90° rotation. The flow cannot be shut off, only diverted to either port. Porting No. 2 diverts media from one outlet port to the other through a 180° rotation. With Porting No. 2, the flow can be shut off by positioning the valve at 90° rotation. A Porting No. 1 diverter valve can be automated pneumatically or electrically. A Porting No. 2 valve may be operated by a Series 75 electric actuator. Bottom connection options are the same as standard valves (except butt weld).

C4 Wafer - The Worcester wafer is a flangeless cryogenic valve that mounts between ANSI Class 150 or 300 flanges. The extension construction is slightly different than the smaller C4 valves and includes a two-piece pinned stem extension and solid ring 15% glass filled TFE stem seals and virgin TFE body seal.

C51 Flanged - The C51 is identical in internal construction to the wafer cryogenic valve. The body is cast with ANSI Class 150 flanges.

Valves Without Stem Extensions

Valves in all four configurations are available without stem extensions for intermittent cryogenic service.

Codes and Standards:

ISA SP79 Cryogenic Valve Design, Linde Division Spec. GS-38, ANSI B31.10 Cryogenic Piping, ANSI B31.5 Refrigeration Piping, ANSI B31.4 Liquid Petroleum Transportation Piping, Applicable ANSI Dimensional Design and Materials Standards, Applicable MSS Standards, Flanged Valves meet ANSI B16.5 and B16.10, MSS-SP6

CLEAN ROOM ASSEMBLY

ENVIRONMENT CONTROL

Worcester assembles all clean service and cryogenic valves in a Class 100 work area. Before final assembly, valve components are cleaned and rinsed or vapor degreased with Inhibited 1, 1, 1-Trichloroethane or Gene Solv-D. Cleaning and tagging procedures for Worcester cryogenic valves are based on Linde Division Specification GS-38.

Stainless Steel Passivation - Worcester engineering specifications strictly define procedures for cleaning, descaling and passivating stainless steel parts. Inspection is performed with a copper sulfate test per ASTM A380.

Wipe Test - All wetted components are wipe tested using Whatman #44 paper. Performed on application.

Helium Leak Test - Valves are dry tested, internally pressurized with 80 psi helium and checked with a helium leak detector (Helium Mass Spectrometer sensitive to 1×10^{-6} cc/sec.).

Vacuum Sealed - After all testing has been completed, cryogenic valves are capped with protective plastic end caps, stamped, tagged and heat sealed in 4 mil polyethylene bags. This ensures valve integrity up to the point of installation.

Custom Testing - On request, special material, valve integrity, tightness and operational testing can be performed. This includes tightness per ISA SP79 with valves submerged in liquid nitrogen.

AUTOMATION PNEUMATIC AND ELECTRIC CONTROLS

Easy automation is assured by our Series 39 pneumatic or Series 75 electric actuators. Both are backed by our exclusive two-year warranty. The Series 39 actuator is the toughest and most versatile rotary actuator available. Positioners (including electro-pneumatic), fail-safe feature, and mechanical and proximity limit switches provide ON/OFF or proportional control to your system with the feedback you require. Refer to Bulletin No. PB302.

Mount a Series 75 electric actuator and you have a high performance control valve package specifically designed for computer or PLC control. For ON/OFF or proportional control, the Series 75 can take a timed pulse or analog signal. A variety of options allow you to select the performance criteria and feedback information you desire. The Series 75 is available with NEMA I, IV, VII or IX enclosures. Refer to Bulletin No. PB730

APPLICATIONS

- Over the Road LNG-LPG Trailers
- Terminal Unloading Stations
- High Purity Cryogenic/Gas Systems
- LNG Storage and Distribution
- CO₂ and Nitrogen Injection for Enhanced Oil Recovery
- Over the Road CO₂, LN₂ Food Carriers
- Petroleum Refining Unleaded Gasoline (Gas Treatment Skids)
- Lyophilization Systems
- Air Separation Plants
- Liquid and Gaseous Oxygen for Steel Production
- Inerting and Heat Treatment

SPECIFICATIONS

C4 and C4 Diverter Valves with Stem Extensions

Valve Sizes:	1/4", 3/8", 1/2", 3/4", 1" 1/2" and 2" (Diverter Not Available in 1/4" and 3/8")
Styles:	Unidirectional Flow, Three-Piece Design Extended, One-Piece, Blowout-Proof Stem Diverter-V1, V2 Porting
Body:	ASTM A743 CF3M, 316L Stainless Steel ASTM B283 C37700, Brass
Pipe Ends:	ASTM A743 CF3M, (316L) Stainless Steel ASTM A743 CF8M, (316) Stainless Steel ASTM B283 C37700, Brass
Ball:	ASTM A276 316 Stainless Steel, Condition A ASTM B16 H02 Upstream relief hole (V3) in ball to relieve cavity pressure. Slot in top of ball for insertion of stem alignment pin to insure proper orientation in valve. Gives external positive indication of ball position.
Stem:	ASTM A479 316L or ASTM A276, 316L Condition A solution annealed. One-piece stem with alignment pin in bottom and arrow on top for proper orientation of ball in valve. Gives positive external indication of ball position.
Seats:	Polyfill
Body Seals:	"S" Gaskets (Teflon Coated 316 Stainless Steel)
Stem Packing:	Chevron Packing (Teflon Style C-VH Rings)
Packing Followers:	ASTM A479 316L
Split Ring:	ASTM A479 316L
Split Thrustbearing:	Polyfill (1"-2"), PBI (1/2"-3/4")
Externals:	300 Series Stainless Steel
End Connections:	SE - Screwed Pipe Ends (NPT) (Dimensions to ANSI B1.20.1) SW - Socket Weld Ends (Diameter and Depth of Bore to ANSI B16.11) SW0 - Socket Weld Ends for O.D. Tubing to ASTM A269 (Stainless Steel Only) BW1 - Butt Weld Ends for Schedule 10 Pipe (Dimensions to ANSI B16.25) (Stainless Steel Only) TE - Tube Ends (Sweet Ends for Type K, L and M Copper Tubing to ASTM B88) (Brass Only)
Temperature Range:	-425°F to +500°F
Maximum Pressure:	1500 psi 1000 psi (1 1/2" & 2" Brass)

Wafer Valves and Flanged Valves with and without Extensions

Valve Sizes:	3", 4" and 6"
Style:	Unidirectional Flow, Wafer/Flangeless and flanged Design Blowout-Proof Stem
Valve Ratings:	Wafer - Fits between ANSI Class 150 and 300 Flanges Flanged - ANSI Class 150
Body and End Plug:	ASTM A351 CF8M Stainless Steel ASTM B584 C83600 Brass (Water Only)
Ball:	ASTM A240-316 or ASTM A312 GR TP-316 Stainless Steel ASTM B584 C83600 Brass (Water Only)
Stem:	ASTM A276 316 Stainless Steel Condition A
Seats:	Polyfill
Body Seal:	TFE-Virgin
Stem Seals:	TFE - 15% Glass Filled
Centering Washers:	AISI 316 Stainless Steel ASTM B121 C34200 Brass (Water Only)
Thrustbearing:	TFE - 15% Glass Filled
Follower:	AISI - 304 Stainless Steel
Externals:	300 Series Stainless Steel

C4 and C4 Diverter Valves without Extensions

Valve Sizes:	1/4", 3/8", 1/2", 3/4", 1" 1/2" and 2" (Diverter Not Available in 1/4" and 3/8")
Styles:	Unidirectional Flow, Three-Piece Design Top Entry Extended, One-Piece, Blowout-Proof Stem Diverter - V1, V2 Porting
Body:	ASTM A743 CF3M, 316L Stainless Steel ASTM B283 C37700, Brass
Pipe Ends:	ASTM A743 CF3M, (316L) Stainless Steel ASTM A743 CF8M, (316) Stainless Steel ASTM B283 C37700, Brass
Seats:	Polyfill
Body Seals:	"S" Gaskets (Teflon Coated 316 Stainless Steel)
Externals:	300 Series Stainless Steel
End Connections:	SE - Screwed Pipe Ends (NPT) (Dimensions to ANSI B1.20.1) SW - Socket Weld Ends (Diameter and Depth of Bore to ANSI B16.11) SW0 - Socket Weld Ends for O.D. Tubing to ASTM A269 (Stainless Steel Only) BW1 - Butt Weld Ends for Schedule 10 Pipe (Dimensions to ANSI B16.25) (Stainless Steel Only) TE - Tube Ends (Sweet Ends for Type K, L and M Copper Tubing to ASTM B88) (Brass Only)
Ball:	ASTM A276 316 Stainless Steel, Condition A ASTM B16 H02 Upstream relief hole (V3) in ball to relieve cavity pressure.
Stem:	ASTM A276 316 Stainless Steel, Condition A ASTM B16 H02
Packing Follower:	AISI 316L Stainless Steel
Stem Seal:	TFE - 15% Glass Filled
Thrustbearing:	Polyfill

General Specifications

Shutoff:	The valve exceeds the tightness requirements of ISA SP79 for Level II (.10 SCFH per inch of valve @ 100 psi Helium and -320°F maximum leakage.)
Packaging:	End connections are capped or plugged, and valves are placed in 4 mil thick (minimum) polyethylene bags and heat sealed.
Operation:	Lever handle, pneumatic or electric actuators.
Cleaning:	Cleaning for all valves is based on the oxygen cleaning procedures of Linde Division Spec. GS38. Body, ball, stem and pipe ends degreased.
Lubrication:	Molycoat 321FL
Assembly:	Assembled in a Class 100 environment per Federal Standard 209B.
Testing:	Valves are dry tested, internally pressurized with 80 psi Helium, checked with hand-held helium leak detector (Helium Mass Spectrometer) sensitive to 1×10^{-8} cc/sec.

Body Temperature vs Bonnet Temperature 1/4"-2" 3 Piece and Diverter Valves with Extension Ambient Temperature 75°F

Pressure/Temperature Ratings

Pressure Torque Curves - Polyfill Seats 1/4" - 2" C4 and C4 Diverter Valves

Pressure Torque Curves - Polyfill Seat 3"-6" Wafer and Flanged Valves

Flow Coefficient

Cv values and equivalent lengths of pipe

Valve Size	Cv	Eq. Length (ft)	Eq. Length (m)	Cv	Eq. Length (ft)	Eq. Length (m)	Cv	Eq. Length (ft)	Eq. Length (m)
1/4"-1/2"	8	3		3.1	19.6				
3/4"	12	5		6.3	30.4				
1"	32	10		3.1	27.8				
1 1/2"	82	24		4.3	43.5				
2"	120	36		7.5	22.7				
3"			350				7.1	7.1	
4"			720				6.9	6.9	
6"			1020				20.4	20.4	

PARTS IDENTIFICATION

1/4" - 2" Cryogenic C4 and C4 Diverter Valves with Extension

1/4" - 2" Cryogenic C4 and C4 Diverter Valves without Extension

3" - 6" Cryogenic C4 Wafer and C51 Flanged Valves with Extension

3" - 6" Cryogenic C4 Wafer and C51 Flanged Valves without Extension

Dimensions

1/4" - 2" Cryogenic C4 Ball Valves
Extended and non-extended bonnets

1/4", 1/2", 3/4"	2.57 (65.28)	2.50 (63.50)	7.86 (199.6)	5.53 (140)	3.97 (101)	8.02 (204)	1.73 (43.9)	1.75 (44.4)	.44 (11.8)	3.0 (1.4)	1.2 (0.5)
1"	2.79 (70.87)	2.73 (69.34)	7.96 (202.2)	5.53 (140)	3.97 (101)	8.12 (206)	1.80 (45.7)	2.00 (50.8)	.56 (14.22)	3.5 (1.6)	1.7 (0.8)
1 1/2"	3.69 (93.73)	3.62 (91.95)	8.91 (226.3)	5.53 (140)	5.56 (141)	9.09 (231)	2.35 (59.7)	2.38 (60.4)	.81 (20.57)	5.0 (2.3)	3.0 (1.4)
2"	4.53 (115.1)	4.47 (113.5)	10.23 (259.8)	6.72 (171)	6.75 (172)	10.27 (261)	3.08 (78.2)	3.20 (81.3)	1.25 (31.75)	10.9 (4.9)	6.0 (2.7)
2"	4.98 (126.5)	4.90 (124.5)	10.41 (264.4)	6.72 (171)	6.75 (172)	10.46 (261)	3.27 (83.0)	3.57 (90.7)	1.50 (38.10)	12.9 (5.9)	8.0 (3.6)

1/2" - 2" Cryogenic C4 Diverter Ball Valves
Extended and non-extended bonnets

1/2"	2.57 (65.28)	2.50 (63.50)	7.86 (199.6)	5.53 (140)	3.97 (101)	8.02 (204)	1.73 (43.9)	1.75 (44.4)	2.25 (51.0)	.44 (11.8)	.34 (8.64)	3.2 (1.5)	1.6 (0.7)
3/4"	2.79 (70.87)	2.73 (69.34)	7.96 (202.2)	5.53 (140)	3.97 (101)	8.12 (206)	1.80 (45.7)	2.00 (50.8)	2.50 (63.5)	.56 (14.22)	.51 (12.95)	3.8 (1.7)	2.0 (0.9)
1"	3.69 (93.73)	3.62 (91.95)	8.91 (226.3)	5.53 (140)	5.56 (141)	9.09 (231)	2.35 (59.7)	2.38 (60.4)	3.07 (77.9)	.81 (20.57)	.72 (18.29)	5.3 (2.4)	3.6 (1.5)
1 1/2"	4.53 (115.1)	4.47 (113.5)	10.23 (259.8)	6.72 (171)	6.75 (172)	10.27 (261)	3.08 (78.2)	3.20 (81.3)	3.56 (90.4)	1.25 (31.75)	1.12 (28.45)	11.5 (5.2)	7.6 (3.0)
2"	4.98 (126.5)	4.90 (124.5)	10.41 (264.4)	6.72 (171)	6.75 (172)	10.46 (261)	3.27 (83.0)	3.57 (90.7)	3.95 (100.3)	1.50 (38.10)	1.38 (35.05)	13.7 (5.4)	9.2 (3.6)

3" - 6" Cryogenic C4 Wafer Ball Valves

Extended and non-extended bonnets

Valve Size	A	B	C	Weight Without Bonnet	Weight With Bonnet	Weight Without Bonnet	Weight With Bonnet	Weight Without Bonnet	Weight With Bonnet	Weight Without Bonnet	Weight With Bonnet	Approx. Weight Without Bonnet	Approx. Weight With Bonnet
3"	4.50 (114.3)	5.31 (135)	15.38 (391)	3.88 (98.5)	18.72 (475)	7.22 (183.4)	17.68 (449)	6.18 (157)	22.0 (559)	5.88 (149)	2.50 (63.5)	27 (12.2)	21 (21)
4"	5.81 (147.6)	6.81 (173)	15.98 (406)	4.48 (114)	19.34 (491)	7.84 (199.1)	18.30 (464.8)	6.80 (172.7)	22.0 (559)	7.50 (190)	3.25 (82.5)	41 (18.6)	34 (15.4)
6"	7.38 (187.5)	8.69 (221)	18.0 (457)	6.19 (157)	23.02 (585)	11.21 (284.7)	21.63 (549.4)	9.82 (249.4)	26.0 (660)	9.88 (251)	4.38 (111.2)	94 (42.6)	64 (29)

3" - 6" Cryogenic C51 Flanged Ball Valves

Extended and non-extended bonnets

Valve Size	A	B	C	Weight Without Bonnet	Weight With Bonnet	Weight Without Bonnet	Weight With Bonnet	Weight Without Bonnet	Weight With Bonnet	Weight Without Bonnet	Weight With Bonnet	Approx. Weight Without Bonnet	Approx. Weight With Bonnet
3"	8.00 (203.2)	3.62 (91.9)	3.06 (77.7)	15.38 (391)	3.88 (98.6)	18.72 (475)	7.22 (183)	17.68 (449)	6.18 (157)	22.0 (559)	2.50 (63.5)	46 (20.9)	39.5 (17.9)
4"	9.00 (228.6)	4.00 (101)	4.03 (102)	15.98 (406)	4.48 (114)	19.34 (491)	7.84 (199)	18.30 (464.8)	6.80 (172.7)	22.0 (559)	3.25 (82.5)	69 (31.3)	62 (28)
6"	10.50 (266.7)	4.25 (108)	6.06 (154)	18.0 (457)	6.19 (157)	23.02 (585)	11.2 (285)	21.63 (549.4)	9.82 (249.4)	26.0 (660)	4.38 (111.2)	139 (63.1)	125 (56.5)

HOW TO ORDER

	<u>3/4"</u>	<u>C4</u>	<u>6</u>	<u>6</u>	<u>P</u>	<u>M</u>	<u>SE</u>	<u>N</u>	
1/4" 3/8" 1/2" 3/4" 1" 1 1/2" 2"	C4	1-Brass 6-316 Stainless Steel	1-Brass 6-316 Stainless Steel	P-Polyfill	M-TFE Coated S.S.	SE- Screw End any Sch. pipe† Brass + 316 S.S. SW- Socket Weld any Sch. pipe † Brass + 316L S.S. SWO- Socket Weld OD Tube 316L S.S. only** BW1- Butt Weld Sch. 10- 316L S.Ss. only TE- Solder/Sweat Ends Brass only Type K, L, or M Copper Tube	Blank-with Stem Extension N*-without Stem Extension		
3/4" 1" 1 1/2" 2"	C4-(Diverter)	1-Brass 6-316 Stainless Steel	1-Brass 6-316 Stainless Steel	P-Polyfill	M-TFE Coated S.S.	SE- Screw End any Sch. pipe† Brass + 316 S.S. SW- Socket Weld any Sch. pipe† Brass + 316L S.S. TE- Solder/Sweat Ends Brass only Type K, L, or M Copper Tubur	Blank-with Stem Extension N*-without Stem Extension	V1-Porting 1 V2-Porting 2	
3" 4" 6"	C4-(Wafer)	1-Brass 6-316 Stainless Steel	1-Brass 6-316 Stainless Steel	P-Polyfill	TTFE	151- ANSI 150 301- ANSI 300	Blank-with Stem Extension N*-without Stem Extension		
3" 4" 6"	C51-(Flanged)	6-316 Stainless Steel	6-Stainless Steel	P-Polyfill	TTFE	150- ANSI 150 (ANSI 300 available as a custom product)	Blank-with Stem Extension N*-without Stem Extension		

* Non-extended stem valves are designed for intermittent cryogenic service (drains, vents, sampling and small Dewar drain & fill).

**SWO - not available in $\frac{1}{4}$ ", $\frac{3}{8}$ ".

† All IPS schedules of stainless steel pipe, S.P.S. copper pipe and red brass pipe.

Ordering Example above is a $\frac{3}{4}$ " 3-piece cryogenic ball valve with stainless steel body, pipe ends, ball and stem, polyfill seats, TFE coated SS body seal, screw ends with no extension.

†† All stems are S.S. with brass or S.S. balls.

Caution: Ball Valves can retain pressurized media in the body cavity when closed. Use care when disassembling. Always open valve to relieve pressure prior to disassembly. Due to continuous development of our product range, we reserve the right to alter the information contained in this leaflet as required.

CAUTION: CRYOGENS CAN CAUSE SEVERE BURNS, SUFFOCATION OR OTHER SERIOUS INJURIES. ENVIRONMENTS CONTAINING CRYOGENIC VALVES NEED PROPER VENTILATION AND LOW OXYGEN WARNING DEVICES.

Worcester Controls

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The Overfill Problem

Experiments that receive large, and especially frequent, LN₂ deliveries are subject to "overfill" problems at the time of each delivery in which the trailer liquid volume (to 6,000 gls.) is greater than the receiving dewar gas space. Transfer pumping of LN₂ to fill stationary dewars, attended only by the trailer driver, has become the standard delivery practice for all large (more than 1,000 gls.) deliveries at Fermilab. Both contractors, Union Carbide-Linde (for the CHL) and Liquid Carbonic (balance of the Laboratory), have high flow and high pressure, (relative to the typical tank MAWP) centrifugal delivery pumps to fill customer fill stations at 250 psig. The concern is for the transfer that fills the dewar and continues to deliver product at pressures well in excess of the MAWP of the receiving dewar. The typical, standard equipment, LN₂ dewar relief valve(s) is not nearly large enough to handle the flow these pumps can deliver. That puts the rupture disk at risk for each loading that approaches "full" for all dewars with MAWP's less than the pump maximum and may lead to a major liquid spill.

There are a number of very different ways to go about solving this problem. This note describes the problem and a solution that acts to isolate the dewar from the trailer on overfill, the *inlet solution*, as currently installed¹ and operating on the D0, 65 psig, 20,000 gls. LN₂ dewar.

Pump Capacities

The trailer mounted pump capacities of the current LN₂ vendors are shown in Figure 1, Union Carbide-Linde, and Figure 2, Liquid Carbonic. The Liquid Carbonic delivery trailer schematic is found in Figure 3. The limiting values for LN₂ are listed in Table 1.

Table 1. Transfer Pump Limiting values.

<u>Vendor</u>	<u>Where used</u>	<u>Max. Press.</u>	<u>Max. Flow</u>
Union Carbide	only CHL	460 psig	240 gpm @ 275 psig
Liquid Carbonic	bal. Fermilab ²	220 psig	180 gpm @ 150 psig

Note first, that these vendors may not always be the Laboratory's suppliers. "Overfill" considerations (limiting parameters and procedures) should be a specific matter for the LN₂ Vendor specification and contract in the future. Any design solution must address the largest of the current or future pump parameters that might be encountered.

¹ See drawing 3740-ME-222394

² D0 currently receives nitrogen under this contract.

Overfill Solutions Considered

Outlet solutions that address the overfill problem by escalating or augmenting the standard relief device capacities; 1) are very costly, 2) are typically provided in duplicate, 3) affect the process by increasing the dewar operating pressure beyond the normal range or to, or approaching, the MAWP, and 4) spill large quantities liquid (to 6,000 gals.) as a direct consequence of protecting the dewar. Inlet solutions close a valve in the source line, and keep it closed until it is manually reset and spill nothing.

Inlet solutions of two generic types were considered; inlet shutoff on overfill and inlet flow restricting. Flow restricting elements are a half way measure (neither inlet or outlet) that would be designed to limit the flow values reliefs must handle. They suffer from the outlet solutions problems 3) and 4), immediately above, and were not pursued for those reasons.

The inlet shutoff solutions, once the failsafe shutoff valve³ was sized, become a choice among piloting valve closure schemes. There are two overfill sense parameter approaches; A) dewar pressure and B) dewar level.

The first, (A), allows any and all variations on pilot loaders that are common to large relief valves. When the dewar pressure rises to a preset value, comfortably above the normal dewar operating pressure range (to preclude premature operation), the pilot vents a dome loaded, normally open valve, and it closes. A separate latch must be provided to keep the valve closed and guard against chattering.

The second, (B), requires a differential pressure sensing element that is activated by a preset dewar level comfortably above the dewar operating level and exceeding a fixed threshold value. Although less obvious here than in the pressure sensed solution, a valve latching or dead band function is still required.

Although both pressure and level sensor piloting were studied initially, the matter quickly converged to the level sensor solution for two reasons; 1) the process is either not affected at all, or minimally affected if the level rises above a nominal operating value for a properly sized dewar (pressure activation would clearly affect the process), and 2) there are a large number of accurate and versatile low pressure differential latching devices readily available. The level sensor unit selected, a Snap Action Relay⁴, is a high flow, high accuracy, repeatable differential pneumatic pressure switch. The schematic for the installed overfill solution is found in Figure 4.

³ Worcester, 1", C-4 valve with a Worcester Controls series 37 pneumatic actuator, valve Model C416PM-SW, Actuator 153375, see Appendix, A-1.

⁴ Fairchild Model 24-243142T, range 1-60 psig, resolution 0.2 psig, see Appendix, A-2.

Other Provisions

It was immediately recognized that either very high pressure dewars (or alternately limited pump pressures) and large gas spaces were potential solutions. The high pressure solution is prohibitively expensive⁵ and given the 6,000 gls. size of the trailers the large gas space solution is only possible in the case of the largest installed dewars. D0 is fortunate to be in the dewar size class that can, and has, taken advantage of the latter provision. It has, and preserves, a 6,000 gls. gas space.

Overfill Solution; Description of Operation

The installed solution operates by sensing the liquid head in the storage dewar with 1/4" lines connected to the *Dewar Bottom* and the *Dewar Top* as indicated, see figure 4. This differential pressure is compared with the manual, locked, set point of a *Differential Pressure Relay*, the Fairchild model 24-243142T, system tag number DPR576N. The normally open *DPR* functions as a pilot to hold the fill permit valve, PV540N, open as long as the dewar level is below the *DPR* set point. When the dewar level exceeds the set point the *DPR* changes state, vents the pneumatic actuator of the normally closed PV540N, and stops the flow of cryogen from the trailer to the dewar.

Stopping the flow dead heads the trailer transfer pump, P-1, and stops the flow, see figure 3. The pump pressure rises to its 275 psig maximum, does not lift the local 350 psig relief valve, SV-3, may momentarily lift the suction relief, SV-2, and the pump quickly (seconds) loses its net positive suction head (NPSH) and the pressure decays to the trailer pressure, ca. 25 psig (reliefs, SV-1, SV-1 are set to 33psig).

The authors are indebted to Liquid Carbonic for their interest and participation in a test of this overfill solution. The overfill protection functioned exactly as described above (SV-3 did relieve momentarily) and the Liquid Carbonic representatives, as represented by Customer Service Manager Steve Dolan, accepted the solution as one their equipment and drivers could accomodate.

Summary and Conclusion

The overfill problem is real, typically affects operation through the loss of delivery pressure by blown rupture disks, and can be addressed at a reasonable cost⁶. Any installation for which the reliability of the LN₂ source is crucial, and D0 is such an example, should consider the overfill question and a technical response to the level demonstrated here.

⁵ See Appendix, A-3

⁶ See Appendix, A-4

VARIOUS SPEEDS

Figure 1
Union Carbide
Linde
Pump
Curve

CRYOGENIC MACHINERY CO.7306 GREENBUSH AVENUE
NO. HOLLYWOOD, CA 91605

CURVE NO. 1531 - RPM 6

**Figure 2 - Liquid Carbonic
Nitrogen Pump Curve**

Note: See reverse side
for Piping Legend.

Figure 3 - Liquid Carbonic Trailer Piping Schematic

Piping Legend

V-1	Bottom fill and drain valve - 3"	SV-1	Inner vessel safety set 33 psig
V-2	Vapor return - 1 1/2"	SV-2	Pump inlet safety relief set 50 psig
V-3	Liquid to PB coil - 1"	SV-3	Pump discharge safety relief set 350 psig
V-4	Pump inlet - 2 1/2"	SV-4	Fill line safety relief set 350 psig
V-5	Top fill valve - 2"	CV-1	Swing check valve - 1 1/2"
V-6	Pump recycle - 1 1/2"	S-1	Pump inlet strainer
V-7	Meter discharge - 1 1/2"	PI-1	Inner vessel pressure gauge (0-100 psig)
V-8	Meter discharge line drain - 3/8"	PI-3	Pump discharge pressure gauge (0-400 psig)
V-9	Main fill line drain - 3/8"	SD-1	Inner vessel rupture disc (2-2") (50-58 psi)
V-10	Liquid level gauge equalizer - 1/4"	SD-2	Outer (jacket) vessel relief device (6")
V-11	Liquid level gauge gas phase isolation - 1/4"	PCV-1	In-transit road relief pressure regulator set 15 psig
V-12	Liquid level gauge liquid phase isolation - 1/4"	LI-1	Liquid level indicator barton 227 (0-100")
V-14	Empty trycock - 3/8"	P-1	Pump belt driven (90-120 gpm)
V-15	Full trycock - 3/8"	PB-1	Pressure build 140 gpm loxfin
V-16	Manual vent - 2 1/2"	M-1	Flow meter (40-120 gpm)
V-17	Pump discharge pressure gauge isolation - 1/4"	DC-1	Discharge flex hose with 1-1/2" union connector
V-18	In-transit relief valve isolation - 1/2"	DC-2	Fill and drain connection with 3" union hose connector
V-19	Rupture disc selector valve - 2"	DC-3	Vapor recovery connection with 1-1/2" union hose connector
VV-1	Main vacuum valve - 2"	DC-4	Gas sample - quick disconnect
VV-2	Vacuum probe isolation - 1/8"	DC-5	Liquid sample - quick disconnect
VP-1	Vacuum probe - 1/8"		

GTM 3/89
J. Wu 2/7/91

Appendix, A1

Specifications for Worcester Series C4 Ball Valve and Series 37 Pneumatic Actuator

Series C4 and C51 Ball Valves for Cryogenic Service

High performance, shutoff valves for intermittent and continuous flow applications with temperatures to -425°F .

SB-442-11

WORCESTER PRESENTS THE QUALITY SOLUTION TO PROBLEMS OF MANUAL AND AUTOMATIC CONTROL OF CRYOGENS

Worcester Controls has the quality solution for tough applications involving all types of cryogenics; oxygen, hydrogen, methane, ammonia, nitrogen, fluorine, LNG and deuterium. Our complete line of cryogenic valves backed by years of successful field experience, incorporates superior technology and design. This means automatic or manual control of cryogenic fluids with no contamination, no fluid degradation and no waste while assuring safety to human life, property and the environment. The wrong specs here can turn an inferior valve into a time bomb. Tough applications demand Worcester Controls' special service cryogenic valves. Here's why:

Positive Ball Cavity Relief - An upstream relief hole in the ball prevents dangerous overpressure due to thermal expansion. On extended stem valves through 2", a one-piece stem with alignment pin assures proper orientation of the ball.

Blowout-Proof Stem - Both single piece and two-piece, assembled-inside-the-body stems are blowout-proof and are supported inside the body with Polyfill thrust-washers.

Zero Leak Packing - Belleville live loaded TFE packing rings and stem centering followers assure zero leakage through the toughest, high cycle applications.

Bonnet Extensions That Work - The stem extensions of Worcester Controls' cryogenic valves conform to ISA Standard SP79. That means wall thickness and lengths that keep heat transfer down, the packing frost free, operational torques low, and actuators solidly supported.

High Performance/Low Thermal Stress - The special "part compatibility" design of valve parts, Polyfill seats and body seals assure tight shutoff, zero body leakage and low torque through large thermal excursions from ambient to -425°F .

Valves Designed for Automation - Approximately 40% of cryogenic installations require fail-safe operation or automatic control. Worcester Controls has the pneumatic and electronic, computer compatible controls for your installation.

NO LEAK SEATS AND SEALS

Fully adjustable TFE, high cycle, zero leak chevron packing (stem seals). This is a Belleville live loaded design incorporated into 1/4"-2" three-piece and diverter valves. Wafer and flanged valves use 15% glass filled solid ring stem seals.

The heart of the Worcester cryogenic design is a rugged, one-piece, blowout-proof stem with a Polyfill thrustbearing and stainless steel split ring. You get design safety and low operational torque. Polyfill seats give you tight shutoff throughout the temperature range. With orientation controlled stem/ball connection and upstream hole in the ball, you get positive overpressure protection. All parts are oxygen compatible.

C4

C4 Diverter

C4 Wafer

C51 Flanged

VALVES WITHOUT STEM EXTENSIONS

CRYOGENIC VALVE CONFIGURATIONS

Worcester Controls cryogenic valves are available in four basic body configurations; C4 (1/4" 2"), C4 Diverter (1/2" 2"), C4 Wafer (3" 6"), and C51 Flanged (3" 6"). All four valve styles offer the same features; exclusive "Polyfill" seats, all stainless steel construction, blowout-proof stem, extension bonnet lengths to ISA SP79 Standards, positive, ball cavity relief and low operational torques.

C4 - The Worcester cryogenic valve incorporates many of the features of the rugged "Mizer" line of valves. Three-piece construction makes it easy to install, versatile in application and simple to maintain. By removing three of the body bolts and loosening the fourth, the valve may be swung out of line. In welded or soldered piping systems, all four body bolts may be removed and the center section lifted out for maintenance or replacement. A variety of connections are available; screwed end, socket weld, butt weld and solder/sweat ends.

C4 Diverter - The cryogenic diverter valve accepts media through the bottom inlet port and directs it to one of two side ports. There are two ball porting configurations; Porting No. 1 directs flow from one outlet port to the other through a 90° rotation. The flow cannot be shut off, only diverted to either port. Porting No. 2 diverts media from one outlet port to the other through a 180° rotation. With Porting No. 2, the flow can be shut off by positioning the valve at 90° rotation. A Porting No. 1 diverter valve can be automated pneumatically or electrically. A Porting No. 2 valve may be operated by a Series 75 electric actuator. Bottom connection options are the same as standard valves (except butt weld).

C4 Wafer - The Worcester wafer is a flangeless cryogenic valve that mounts between ANSI Class 150 or 300 flanges. The extension construction is slightly different than the smaller C4 valves and includes a two-piece pinned stem extension and solid ring 15% glass filled TFE stem seals and virgin TFE body seal.

C51 Flanged - The C51 is identical in internal construction to the wafer cryogenic valve. The body is cast with ANSI Class 150 flanges.

Valves Without Stem Extensions

Valves in all four configurations are available without stem extensions for intermittent cryogenic service.

Codes and Standards:

ISA SP79 Cryogenic Valve Design, Linde Division Spec. GS-38, ANSI B31.10 Cryogenic Piping, ANSI B31.5 Refrigeration Piping, ANSI B31.4 Liquid Petroleum Transportation Piping, Applicable ANSI Dimensional Design and Materials Standards, Applicable MSS Standards, Flanged Valves meet ANSI B16.5 and B16.10, MSS-SP6.

CLEAN ROOM ASSEMBLY

ENVIRONMENT CONTROL

Worcester assembles all clean service and cryogenic valves in a Class 100 work area. Before final assembly, valve components are cleaned and rinsed or vapor degreased with Inhibited 1, 1, 1-Trichloroethane or Gene Solv-D. Cleaning and tagging procedures for Worcester cryogenic valves are based on Linde Division Specification GS-38.

Stainless Steel Passivation - Worcester engineering specifications strictly define procedures for cleaning, descaling and passivating stainless steel parts. Inspection is performed with a copper sulfate test per ASTM A380.

Wipe Test - All wetted components are wipe tested using Whatman #44 paper. Performed on application.

Helium Leak Test - Valves are dry tested, internally pressurized with 80 psi helium and checked with a helium leak detector (Helium Mass Spectrometer sensitive to 1×10^{-6} cc/sec).

Vacuum Sealed - After all testing has been completed, cryogenic valves are capped with protective plastic end caps, stamped, tagged and heat sealed in 4 mil polyethylene bags. This ensures valve integrity up to the point of installation.

Custom Testing - On request, special material, valve integrity, tightness and operational testing can be performed. This includes tightness per ISA SP79 with valves submerged in liquid nitrogen.

AUTOMATION PNEUMATIC AND ELECTRIC CONTROLS

Easy automation is assured by our Series 39 pneumatic or Series 75 electric actuators. Both are backed by our exclusive two-year warranty. The Series 39 actuator is the toughest and most versatile rotary actuator available. Positioners (including electro-pneumatic), fail-safe feature, and mechanical and proximity limit switches provide ON/OFF or proportional control to your system with the feedback you require. Refer to Bulletin No. PB302.

Mount a Series 75 electric actuator and you have a high performance control valve package specifically designed for computer or PLC control. For ON/OFF or proportional control, the Series 75 can take a timed pulse or analog signal. A variety of options allow you to select the performance criteria and feedback information you desire. The Series 75 is available with NEMA I, IV, VII or IX enclosures. Refer to Bulletin No. PB730.

APPLICATIONS

- Over the Road LNG-LPG Trailers
- Terminal Unloading Stations
- High Purity Cryogenic/Gas Systems
- LNG Storage and Distribution
- CO₂ and Nitrogen Injection for Enhanced Oil Recovery
- Over the Road CO₂, LN₂ Food Carriers
- Petroleum Refining Unleaded Gasoline (Gas Treatment Skids)
- Lyophilization Systems
- Air Separation Plants
- Liquid and Gaseous Oxygen for Steel Production
- Inerting and Heat Treatment

SPECIFICATIONS

C4 and C4 Diverter Valves with Stem Extensions

Valve Sizes:	1/4", 3/8", 1/2", 3/4", 1", 1 1/2" and 2" (Diverter Not Available in 1/4" and 3/8")
Styles:	Unidirectional Flow, Three-Piece Design Extended, One-Piece, Blowout-Proof Stem Diverter-V1, V2 Porting
Body:	ASTM A743 CF3M, 316L Stainless Steel ASTM B283 C37700, Brass
Pipe Ends:	ASTM A743 CF3M, (316L) Stainless Steel ASTM A743 CF8M, (316) Stainless Steel ASTM B283 C37700, Brass
Ball:	ASTM A276 316 Stainless Steel, Condition A ASTM B16 HO2 Upstream relief hole (V3) in ball to relieve cavity pressure. Slot in top of ball for insertion of stem alignment pin to insure proper orientation in valve. Gives external positive indication of ball position.
Stem:	ASTM A479 316L or ASTM A276, 316L Condition A solution annealed. One-piece stem with alignment pin in bottom and arrow on top for proper orientation of ball in valve. Gives positive external indication of ball position.
Seats:	Polyfill
Body Seals:	"S" Gaskets (Teflon Coated 316 Stainless Steel)
Stem Packing:	Chevron Packing (Teflon Style C-VH Rings)
Packing Followers:	ASTM A479 316L
Split Ring:	ASTM A479 316L
Split	
Thrustbearing:	Polyfill (1" - 2"), PBI (1/2" - 3/4")
Externals:	300 Series Stainless Steel
End Connections:	SE - Screwed Pipe Ends (NPT) (Dimensions to ANSI B1.20.1) SW - Socket Weld Ends (Diameter and Depth of Bore to ANSI B16.11) SW0 - Socket Weld Ends for O.D. Tubing to ASTM A269 (Stainless Steel Only) BW1 - Butt Weld Ends for Schedule 10 Pipe (Dimensions to ANSI B16.25) (Stainless Steel Only) TE - Tube Ends (Sweat Ends for Type K, L and M Copper Tubing to ASTM B88) (Brass Only)
Temperature Range:	-425°F to +500°F
Maximum Pressure:	1500 psi 1000 psi (1 1/2" & 2" Brass)

Wafer Valves and Flanged Valves with and without Extensions

Valve Sizes:	3", 4" and 6"
Style:	Unidirectional Flow, Wafer/Flangeless and flanged Design Blowout-Proof Stem
Valve Ratings:	Wafer - Fits between ANSI Class 150 and 300 Flanges Flanged - ANSI Class 150
Body and End Plug:	ASTM A351 CF8M Stainless Steel ASTM B584 C83600 Brass (Wafer Only)
Ball:	ASTM A240-316 or ASTM A312 GR TP-316 Stainless Steel ASTM B584 C83600 Brass (Wafer Only)
Stem:	ASTM A276 316 Stainless Steel Condition A
Seats:	Polyfill
Body Seal:	TFE/Virgin
Stem Seals:	TFE - 15% Glass Filled
Centering Washers:	AISI 316 Stainless Steel ASTM B121 C34200 Brass (Wafer Only)
Thrustbearing:	TFE - 15% Glass Filled
Follower:	AISI - 304 Stainless Steel
Externals:	300 Series Stainless Steel

C4 and C4 Diverter Valves without Extensions

Valve Sizes:	1/4", 3/8", 1/2", 3/4", 1", 1 1/2" and 2" (Diverter Not Available in 1/4" and 3/8")
Styles:	Unidirectional Flow, Three-Piece Design Top Entry Extended, One-Piece, Blowout-Proof Stem Diverter - V1, V2 Porting
Body:	ASTM A743 CF3M, 316L Stainless Steel ASTM B283 C37700, Brass
Pipe Ends:	ASTM A743 CF3M, (316L) Stainless Steel ASTM A743 CF8M, (316) Stainless Steel ASTM B283 C37700, Brass
Seats:	Polyfill
Body Seals:	"S" Gaskets (Teflon Coated 316 Stainless Steel)
Externals:	300 Series Stainless Steel
End Connections:	SE - Screwed Pipe Ends (NPT) (Dimensions to ANSI B1.20.1) SW - Socket Weld Ends (Diameter and Depth of Bore to ANSI B16.11) SW0 - Socket Weld Ends for O.D. Tubing to ASTM A269 (Stainless Steel Only) BW1 - Butt Weld Ends for Schedule 10 Pipe (Dimensions to ANSI B16.25) (Stainless Steel Only) TE - Tube Ends (Sweat Ends for Type K, L and M Copper Tubing to ASTM B88) (Brass Only)
Ball:	ASTM A276 316 Stainless Steel, Condition A ASTM B16 HO2 Upstream relief hole (V3) in ball to relieve cavity pressure.
Stem:	ASTM A276 316 Stainless Steel, Condition A ASTM B16 HO2
Packing Follower:	AISI 316L Stainless Steel
Stem Seal:	TFE - 15% Glass Filled
Thrustbearing:	Polyfill

General Specifications

Shutoff:	The valve exceeds the tightness requirements of ISA SP79 for Level II (.10 SCFH per inch of valve @ 100 psi Helium and -320°F maximum leakage.)
Packaging:	End connections are capped or plugged, and valves are placed in 4 mil thick (minimum) polyethylene bags and heat sealed.
Operation:	Lever handle, pneumatic or electric actuators.
Cleaning:	Cleaning for all valves is based on the oxygen cleaning procedures of Linde Division Spec. GS38. Body, ball, stem and pipe ends degreased.
Lubrication:	Molycoat 321R.
Assembly:	Assembled in a Class 100 environment per Federal Standard 209B.
Testing:	Valves are dry tested, internally pressurized with 80 psi Helium, checked with hand-held helium leak detector (Helium Mass Spectrometer) sensitive to 1×10^{-3} cc/sec.

Body Temperature vs Bonnet Temperature
 $\frac{1}{4}$ "-2" 3 Piece and Diverter Valves with Extension
 Ambient Temperature 75°F

Pressure/Temperature Ratings

Pressure Torque Curves - Polyfill Seats
 $\frac{1}{4}$ " - 2" C4 and C4 Diverter Valves

Pressure Torque Curves - Polyfill Seat
 3"-6" Wafer and Flanged Valves

Flow Coefficient

Cv values and equivalent lengths of pipe

Valve Size	Cv	Eq. Length (ft)	Eq. Length (ft)	Cv	Cv	Eq. Length (ft)	Eq. Length (ft)
$\frac{1}{4}$ "- $\frac{1}{2}$ "	8	3		3.1	19.6		
$\frac{3}{4}$ "	12	5		6.3	30.4		
1"	32	10		3.1	27.8		
1"	82	24		4.3	43.5		
2"	120	36		7.5	22.7		
3"			350			7.1	7.1
4"			720			6.9	6.9
6"			1020			20.4	20.4

PARTS IDENTIFICATION

1/4" - 2" Cryogenic C4 and C4 Diverter Valves with Extension

1/4" - 2" Cryogenic C4 and C4 Diverter Valves without Extension

3" - 6" Cryogenic C4 Wafer and C51 Flanged Valves with Extension

3" - 6" Cryogenic C4 Wafer and C51 Flanged Valves without Extension

Dimensions

1/4" - 2" Cryogenic C4 Ball Valves Extended and non-extended bonnets

	1/4"	3/8"	1/2"	3/4"	1"	1 1/2"	2"
1/4"	2.57 (65.28)	2.50 (63.50)	7.86 (199.6)	5.53 (140)	3.97 (101)	8.02 (204)	1.73 (43.9)
3/8"	2.79 (70.87)	2.73 (69.34)	7.96 (202.2)	5.53 (140)	3.97 (101)	8.12 (206)	1.80 (45.7)
1"	3.69 (93.73)	3.62 (91.95)	8.91 (226.3)	5.53 (140)	5.56 (141)	9.09 (231)	2.35 (59.7)
1 1/2"	4.53 (115.1)	4.47 (113.5)	10.23 (259.8)	6.72 (171)	6.75 (172)	10.27 (261)	3.08 (78.2)
2"	4.98 (126.5)	4.90 (124.5)	10.41 (264.4)	6.72 (171)	6.75 (172)	10.46 (261)	3.27 (83.0)

1/2" - 2" Cryogenic C4 Diverter Ball Valves Extended and non-extended bonnets

	1/2"	3/4"	1"	1 1/2"	2"
1/2"	2.57 (65.28)	2.50 (63.50)	7.86 (199.6)	5.53 (140)	3.97 (101)
3/4"	2.79 (70.87)	2.73 (69.34)	7.96 (202.2)	5.53 (140)	3.97 (101)
1"	3.69 (93.73)	3.62 (91.95)	8.91 (226.3)	5.53 (140)	5.56 (141)
1 1/2"	4.53 (115.1)	4.47 (113.5)	10.23 (259.8)	6.72 (171)	6.75 (172)
2"	4.98 (126.5)	4.90 (124.5)	10.41 (264.4)	6.72 (171)	6.75 (172)

3" - 6" Cryogenic C4 Wafer Ball Valves

Extended and non-extended bonnets

Valve Size	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Approx. Weight (kg)
	Valve	Flange	Flange	Flange	Flange	Flange	Flange	Flange	Flange	Flange	Flange	Flange	Flange	Flange	Flange	Flange	Flange
3"	4.50 (114.3)	5.31 (135)	15.38 (391)	3.88 (98.5)	18.72 (475)	7.22 (183.4)	17.68 (449)	6.18 (157)	22.0 (559)	5.88 (149)	2.50 (63.5)	27 (12.2)	21 (21)				
4"	5.81 (147.6)	6.81 (173)	15.98 (406)	4.48 (114)	19.34 (491)	7.84 (199.1)	18.30 (464.8)	6.80 (172.7)	22.0 (559)	7.50 (190)	3.25 (82.5)	41 (18.6)	34 (15.4)				
6"	7.38 (187.5)	8.69 (221)	18.0 (457)	6.19 (157)	23.02 (585)	11.21 (284.7)	21.63 (549.4)	9.82 (249.4)	26.0 (660)	9.88 (251)	4.38 (111.2)	94 (42.6)	64 (29)

3" - 6" Cryogenic C51 Flanged Ball Valves

Extended and non-extended bonnets

Valve Size	A	B	C	D		E		F		H	Port Dia	Approx. Weight (kg)	
				With Seal	Without Seal	With Seal	Without Seal	With Seal	Without Seal			With Seal	Without Seal
3"	8.00 (203.2)	3.62 (91.9)	3.06 (77.7)	15.38 (391)	3.88 (98.6)	18.72 (475)	7.22 (183)	17.68 (449)	6.18 (157)	22.0 (559)	2.50 (63.5)	46 (20.9)	39.5 (17.9)
4"	9.00 (228.6)	4.00 (101)	4.03 (102)	15.98 (406)	4.48 (114)	19.34 (491)	7.84 (199)	18.30 (464.8)	6.80 (172.7)	22.0 (559)	3.25 (82.5)	69 (31.3)	62 (28)
6"	10.50 (266.7)	4.25 (108)	6.06 (154)	18.0 (457)	6.19 (157)	23.02 (585)	11.2 (285)	21.63 (549.4)	9.82 (249.4)	26.0 (660)	4.38 (111.2)	139 (63.1)	122 (55)

HOW TO ORDER

	3/4"	C4	6	6	P	M	SE	N	
1/4" 3/8" 1/2" 3/4" 1" 1 1/2" 2"	C4	1-Brass 6-316 Stainless Steel	1-Brass 6-316 Stainless Steel	P-Polyfill	M-TFE Coated S.S.	SE- Screw End any Sch. pipe† Brass + 316 S.S. SW- Socket Weld any Sch. pipe † Brass + 316L S.S. SWO- Socket Weld OD Tube 316L S.S. only** BW1- Butt Weld Sch. 10- 316L S.Ss. only TE- Solder/Sweat Ends Brass only Type K, L, or M Copper Tube	Blank-with Stem Extension N*-without Stem Extension		
3/4" 1" 1 1/2" 2"	C4-(Diverter)	1-Brass 6-316 Stainless Steel	1-Brass 6-316 Stainless Steel	P-Polyfill	M-TFE Coated S.S.	SE- Screw End any Sch. pipe† Brass + 316 S.S. SW- Socket Weld any Sch. pipe† Brass + 316L S.S. TE- Solder/Sweat Ends Brass only Type K, L, or M Copper Tuber	Blank-with Stem Extension N*-without Stem Extension	V1-Porting 1 V2-Porting 2	
3" 4" 6"	C4-(Wafer)	1-Brass 6-316 Stainless Steel	1-Brass 6-316 Stainless Steel	P-Polyfill	TFE	151- ANSI 150 301- ANSI 300	Blank-with Stem Extension N*-without Stem Extension		
3" 4" 6"	C51-(Flanged)	6-316 Stainless Steel	6-Stainless Steel	P-Polyfill	TFE	150- ANSI 150 (ANSI 300 available as a custom product)	Blank-with Stem Extension N*-without Stem Extension		

* Non-extended stem valves are designed for intermittent cryogenic service (drains, vents, sampling and small Dewar drain & fill).

**SWO - not available in $\frac{1}{4}$ ", $\frac{3}{8}$ ".

†† All stems are S.S. with brass or S.S. balls.

† All IPS schedules of stainless steel pipe, S.P.S. copper pipe and red brass pipe.

Ordering Example above is a $\frac{3}{4}$ " 3-piece cryogenic ball valve with stainless steel body, pipe ends, ball and stem, polyfill seats, TFE coated SS body seal, screw ends with no extension.

Caution: Ball Valves can retain pressurized media in the body cavity when closed. Use care when disassembling. Always open valve to relieve pressure prior to disassembly. Due to continuous development of our product range, we reserve the right to alter the information contained in this leaflet as required.

CAUTION: CRYOGENS CAN CAUSE SEVERE BURNS, SUFFOCATION OR OTHER SERIOUS INJURIES. ENVIRONMENTS CONTAINING CRYOGENIC VALVES NEED PROPER VENTILATION AND LOW OXYGEN WARNING DEVICES.

P.O. BOX 538, 33 LOCKE DRIVE
MARLBOROUGH, MA 01752
(508) 481-4800 TELEX 6817563
FAX (508) 481-4454

A BTR Company

20 MID-DOMINION ACRES
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Distributed by:

Series 37 Pneumatic Actuator

Aluminum rack and pinion actuator
for dependable ON/OFF operation
in general service applications.

PB 37A-5

The series 37 aluminum pneumatic actuator

FROM **Worcester Controls**

Characterized by features that give you rugged, reliable performance at the right price, the Series 37 is one of the most unique quarter-turn on/off actuators on the market today, and here's why...

The Aluminum 37 Actuator combines all the engineered advantages that a simplified rack and pinion design offers with the lower cost and weight advantages that an anodized aluminum body can provide.

Small in size and engineered simple with only 6 major parts, the Series 37 is like no other actuator on the market today. It features a rack and pinion design and packs a lot of torque output into a small, compact package—up to 450 in.-lbs. at 80 PSI air supply.

The unique totally internal system of air passages leave no external plumbing to corrode or damage.

There is no pressurized air in the center chamber so safety is increased because there is no possibility of the center pinion being ejected.

CLT, Center Line Thrust design means the pistons won't cock or tilt. A balanced force system is created within the actuator preventing "piston walk" down the cylinder. Piston motion is smooth and even.

Gearing side-loads are born by bearing surfaces in the body. The result is high specific torque and very long seal life.

Self-centering end-caps are easily reassembled and inserted after routine maintenance.

Female drive pinion. The female drive output shaft is standard and allows direct mounting on Worcester's 1/2"-2" valves, eliminating the need for a shaft coupling. Making a compact valve actuator package, the Series 37 fits easily into pipe line configurations with limited space.

Modular spring pack with multi-spring format. In spring-return Series 37's, multiple spring design allows custom adjustment to available air supply for maximum performance.

The spring pack is self-contained for easy and safe assembly or disassembly. "Fail close" or "fail open" operation is easily achieved by simply switching the spring pack from one end of the actuator to the other.

Solenoid Block

Body halves of each actuator are pre-drilled to allow rapid attachment of either double-acting or spring return solenoid control blocks.

A double-acting solenoid control block provides extremely fine and independent adjustments for speed control on the opening and closing strokes of a double-acting actuator.

A spring-return solenoid control block provides an adjustment for speed control on the spring stroke of a spring-return actuator.

Solenoids are available in the following types: General Purpose, NEMA I; Splash-proof, NEMA III; Hazardous Environment, NEMA VII (UL & CSA listed for Class I, Group D) and NEMA IX (UL & CSA listed for Class II, Groups E, F & G).

Available voltages are 24, 115 and 230V AC, or 6, 12 and 24V DC.

Sizing:

Determine appropriate valve torque requirements from valve literature. For double-acting actuators, select the actuator whose torque output at available air supply exceeds break-away torque requirements of the valve.

For fail-closed, spring-return actuators, select the appropriate size actuator whose torque output at end of spring stroke (at available air supply) is sufficient to close the valve.

For fail-open spring-return actuators, select appropriate actuator whose torque output at the end of the air-stroke at available air supply is sufficient to close the valve. For fail-open actuators, it is also necessary to determine that the torque output at the start of the spring stroke exceeds break-away requirements of the valve.

Operating Sequence

Parts Identification

Materials of Construction

Actuator		
Part	Qty.	Material
Body	2	Aluminum Black Anodized
Piston	1	Delrin
Output Shaft	1	Stainless Steel (304)
End Cap	2	Stainless Steel (304)
Bearings	2	Delrin
"O" Rings	6	Buna-N
Fasteners	4	Stainless Steel (304)
Spring Pack		
Part	Qty.	Material
Springs	6	Chrome Silicon Spring Wire
End Cap	1	Stainless Steel (304)
Spring Support Plate	1	Stainless Steel (304)
Retention Tube	1	Stainless Steel (304)
Cam Assembly	1	Delrin

NOTE: The spring pack can be fitted to either end of the actuator to give fail open or fail close.

How To Order

	05	3		37		115A
Size	Body Material	Special Services	Series	Modifications/ Solenoid	Solenoid Voltage	
05 15	3—Aluminum Body	Blank—In Line Mount 9—Cross-Line Mount	37	Blank—General Purpose Solenoid (NEMA I) S—Spring Return W—Splashproof Solenoid (NEMA III) X—Hazardous Locations Solenoid (NEMA VII & IX) N—No Solenoid (No Block)	6, 12, 24 DC; 24, 115, 230 AC (60 cycle)	
NOTE: Double acting solenoid is supplied if S or N not indicated						

NOTE: Code shows a size 05 double acting aluminum Series 37 actuator with a double acting General Purpose 115 volt AC Solenoid.

Due to continuous development of our product range, we reserve the right to alter the dimensions and information contained in this leaflet as required.

A BTR Company

33 LOCKE DRIVE, PO BOX 538
MARLBOROUGH, MA 01752-9906
(508) 481 4800 TELEX 92 0415
TELECOPY (508) 481 4454

MIDLAND PIPE & SUPPLY CO.

2829 South 61st Court
Cicero, IL 60650
Phone 312 - 656-4200

Printed in USA 5-87 10M

Appendix, A2

Specifications for Fairchild Model 24 Snap Acting Relay

FAIRCHILD

SNAP ACTING RELAY

MODEL 24

APPLICATIONS

The Model 24 Snap Acting Relay functions as a highly accurate, repeatable differential pressure switch. This precision control, available in eight configurations, may be set up to operate with one signal, or may be biased to respond to a pneumatic set point.

The Model 24, which provides true snap action, is recommended for a variety of high flow control applications, including emergency shutdown, level control or alarm on tank or bubbler systems, and leak detection.

MAJOR FEATURES

- Near zero throttling band.
- Pneumatic or mechanical control point.
- High forward and exhaust capacity — up to 14 SCFM.
- Available in normally closed or open valve.
- Pilot staged.

BENEFITS

- Results in true snap action.
- Permits operation from a remote location.
- Meets requirements for high flow applications.
- Meets industrial control requirements.
- Allows precise control of snap action operation.

SPECIFICATIONS

Capacity (100 psig supply) 14 SCFM (25 m³/HR)
 Exhaust capacity (100 psig drop) .. 14 SCFM (25 m³/HR)
 Maximum supply pressure 120 psig (800 kPa)
 Minimum supply pressure 10 psig (70 kPa)
 (use separate supply option if inlet
 pressure is less than 10 psig)
 Signal range 2" (5 cm) W.C.
 -120 psig (800 kPa)
 Change in signal to operate see chart
 Repeatability 2" (5 cm) W.C.
 CV Rating 0.23
 Mounting any position — pipe or bracket
 -40°F to +200°F
 Temperature limits (-40°C to +95°C)
 Air consumption less than .015 SCFM (.03 m³/HR)
 for 100 psig (690 kPa) inlet

Materials of Construction

Body Aluminum casting
 Trim Stainless steel and
 cadmium-plated steel
 Diaphragms Buna N and Dacron

Range	Inlet and Outlet	Change in Signal to Operate
2"W.C.-10 psig	1/4"	0.2" W.C.
2"W.C.-10 psig	3/8"	0.2" W.C.
.5-30 psig	1/4"	0.1 psig
.5-30 psig	3/8"	0.1 psig
1.0-60 psig	1/4"	0.2 psig
1.0-60 psig	3/8"	0.2 psig
2.0-120 psig	1/4"	0.5 psig
2.0-120 psig	3/8"	0.5 psig

OUTLINE DIMENSIONS

MODEL 24 SNAP ACTING RELAY

CROSS-SECTIONS

Model 24

PRINCIPLES OF OPERATION

The Model 24 employs a control diaphragm, positive bias spring, and an accurate flapper nozzle arrangement to establish set point. When this is achieved, the output of the device changes in a digital fashion (snap action). With supply pressure turned off and the control screw turned to allow the positive bias spring to be expanded, the upward force of the supply valve spring causes the supply valve to seat. Supply air entering the inlet port flows through the orifice to the top of the control diaphragm and vents through the nozzle.

The negative bias spring exerts force against the pilot diaphragm and opposes the positive bias spring.

The ball presses against the nozzle. With the nozzle flow restricted its back pressure increases, causing the control diaphragm to move downward, forcing the supply valve down against the force of the supply valve spring and opening a path to the outlet port. When the control knob is adjusted to a specific set point, and with no signal present, the positive bias spring exerts a force against the top of the diaphragm assembly, which is connected to the sensing diaphragm via the yoke.

The sensing diaphragm moves upward, moving the ball away from the nozzle and allowing back pressure to vent through the nozzle. Pressure is thus reduced over the control diaphragm.

The control diaphragm moves upward and the supply valve is forced closed by the supply valve spring. A pneumatic signal at A exerts pressure on the underside of the sensing diaphragm, which is connected via the yoke to the upper diaphragm and positive bias spring, moving the ball closer to the nozzle.

As signal pressure increases toward and eventually reaches set point, nozzle back pressure increases on top of the control diaphragm until it exceeds the supply valve spring forces, initiating snap action to open the valve. Back pressure buildup occurs over a relatively short signal change near set point so that snap action, rather than throttling, is achieved. The flapper nozzle in the Model 24 has a larger diameter than a proportionally piloted device such as the Model 85D. When the pneumatic signal at A drops below set point, reduced pressure on the underside of the sensing diaphragm causes the ball to move away from the nozzle. This action reduces back pressure on the top of the control diaphragm, allowing the supply valve spring to close the supply valve. The reduction of back pressure occurs over a relatively short signal change near set point, causing snap action rather than throttling.

A pneumatic signal introduced at B may be used in conjunction with, or in place of, the positive bias spring, since it exerts pressure on top of the control diaphragm. Thus, signal B becomes a remote set point capable of controlling the pressure at which signal A causes snap action.

TYPICAL APPLICATIONS

Snap Acting Relay with Pneumatic Set Point and Manual Bias

Figure 1 illustrates a configuration which uses a pneumatic signal for set point which may or may not be biased by the adjusting screw. In this case, the adjustment adds to the pneumatic signal. Should the set point and the operating signal be switched, the bias adjustment would subtract from the set point signal. To determine whether a Normally Open or Normally Closed valve is required, note that when "B" plus spring bias is greater than signal at "A" port, a Normally Open unit has an output, while a Normally Closed unit does not.

In Figure 2 the unit is shown with a separate supply option (SS) to indicate use of the unit when the input is a control signal such as 3-15 psig.

ORDERING INFORMATION

When ordering the Model 24, please refer to the following example, choosing the basic catalog number which represents the range and inlet and outlet size needed for your application. Further specify "Normally Open" or "Normally Closed" unit. Order any desired options by adding the appropriate suffix from the table below to the basic catalog number.

Catalog Number 243132 (T)

Catalog Number Norm Open	Catalog Number Norm Closed	Range	Inlet and Outlet	Change in Signal to Operate
243122	243222	2" W.C.-10 psig (5cm-70 kPa)	1/4"	0.2" W.C. .5 cm
243123	243223	2" W.C.-10 psig (5cm-70 kPa)	3/8"	0.2" W.C. .5 cm
243132	243232	.5-30 psig (3.5-200 kPa)	1/4"	0.1 psig .7 kPa
243133	243233	.5-30 psig (3.5-200 kPa)	3/8"	0.1 psig .7 kPa
243142	243242	1.0-60 psig (7-420 kPa)	1/4"	0.2 psig 1.4 kPa
243143	243243	1.0-60 psig (7-420 kPa)	3/8"	0.2 psig 1.4 kPa
243162	243262	2.0-120 psig (14-840 kPa)	1/8"	0.5 psig 3.5 kPa
243163	243263	2.0-120 psig (14-840 kPa)	3/8"	0.5 psig 3.5 kPa

Option	Suffix
Separate supply to pilot	SS
Knob adjustment	K
Tamper proof cap	T

Optional Mounting Bracket: EB-09921

SERVICE INFORMATION

Under current circumstances, it is not economically feasible to repair the Model 24.

FAIRCHILD
INDUSTRIAL PRODUCTS COMPANY
NEW ADDRESS AS OF JULY 9, 1990:
3920 West Point Blvd.
Winston-Salem, NC 27103
Phone: (919) 659-3400 Sales: (919) 659-FIPC
Fax: Sales (919) 659-9323 Purch. (919) 659-9358

Appendix, A3

Solving LN2 'Overfill' with 250 psig Dewars

If dewars of a MAWP greater than the delivery trailer pump dead headed pressure are utilized, delivery 'overfill' concerns do not require relief system based solutions. The following 20,000 gal. inner vessel material cost increment analysis (@ \$2/SS lb.) is based on existing information and data made available by Scott Nason of Process Engineering.

Dewar Pressure	Material Wt. Heads & Shells	Shell Thickness	Mat'l Cost Increment
65 psig + Vacuum	12,660# 1	0.228" 2	\$ base 5
150 psig + Vacuum	28,000#	----- 3	\$30,680
250 psig + Vacuum	43,200#	0.778"	\$61,080

Notes:

1. Scaled by the thickness from the 250 psig vessel. Total material weight will be slightly higher because of the greater use of stiffening rings on the low pressure tanks and fixed support requirements.

2. The actual thickness of a delivered 20,000 gal. SS dewar from LOX.

3. Value not supplied.

4. Does not include the additional thickness costs of welding (varies as the square of t) or other costs dependent on material thickness.

5. The base price can be lower if the inner vessel is aluminum. Process Engineering does not make the higher pressure tanks in Aluminum. Recent (1987 quotes, 1988 delivery) 20,000 gal., 65 psig, dewars have been quoted in the range \$102,000 to \$110,000. 304 SS and 5083 Al were quoted at the manufacturer's option. The Al bid accepted was lower by a few thousand dollars than all other SS bids.

6. A significant savings may be possible with 9% Ni steel for, especially, the high pressure tanks.

GTM 2/25/90

Appendix, A4

The Costs of the D0 Overfill Solution

<u>Parts</u>	<u>'89 Cost</u>
1. Worcester C4, 1", Cryogenic ball valve	\$850
2. Worcester series 37 valve actuator	\$350
3. Fairchild Model 24 Snap Action Relay	\$187
4. Miscellany	<u>\$100</u>
 SUB-TOTAL	 \$1487
 Installation	
 P/O normal install	 <u>\$000</u>
 TOTAL	 \$1487

GTM 2/91