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 Geynisman
M. sig
5-3-2004

Stephanie McDade
5/27/98

Endorsed by: Russ Rucinski
4/01/2004

Peer Review:
CASE 4: DUMPING OVERFILL

LIQ. NITROGEN DELIVERY TRUCKS HAVE RECENTLY BEEN UPGRADED TO DELIVER AT RATES UP TO 200 GPM AT 435 PSI G, WITH HIGH CAPACITY PUMPS.
[REFERENCE FERMILAB ES&H MESSAGE 960322-01]

THE RELIEVING REQUIREMENT FOR SUCH A LARGE FLOW RATE CANNOT BE MET BY CONVENTIONAL MEANS. THEREFORE, A SUITABLE ALTERNATIVE METHOD HAS BEEN CHOSEN.

VEssel OVERPRESSURE DUE TO FILLING IS PREVENTED BY AN AUTOMATIC SHUT OFF VALVE INSTALLED ON THE FILL LINE. A SIMPLIFIED SYSTEM SCHEMATIC IS SHOWN BELOW:

SKETCH 4.1 SIMPLIFIED SCHEMATIC OF AUTOMATIC FILL SHUT-OFF
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 (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 closes 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 commercially 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 0 ODH area.
**Reliability/Probability Analysis**

I will use a Probability Tree Diagram & Therp Model


**Filling Event**

- Operator shuts valve when full
- Pressure switch fails to operate
- Solenoid works properly
- Ball valve closes properly
- Failure = Relief Capacity is exceeded

**Probabilities**

<table>
<thead>
<tr>
<th>Event</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>.01</td>
</tr>
<tr>
<td>K'</td>
<td>.99</td>
</tr>
<tr>
<td>S</td>
<td>.00001</td>
</tr>
<tr>
<td>S'</td>
<td>.99999</td>
</tr>
<tr>
<td>T</td>
<td>.001</td>
</tr>
<tr>
<td>T'</td>
<td>.999</td>
</tr>
<tr>
<td>R</td>
<td>.0003</td>
</tr>
<tr>
<td>R'</td>
<td>.9997</td>
</tr>
</tbody>
</table>

Probability of Failure = 1

\[
Pr(\text{outcome}) = K + K'(S1K)(T1(S1K))(T1T1(S1K))
\]

\[
Pr(\text{outcome}) = .99 + .01(.99999)(.999)(.9997)
\]
Pr_{\text{fail}} (\text{outcome}) = .000013091687003

\text{CHECK: } Pr_{\text{safe}} (\text{outcome}) + Pr_{\text{fail}} (\text{outcome}) = 1.0

\frac{.9999869031 + .0000130969}{1.0000000000} \checkmark \text{checks ok.}

\left[ Pr_{\text{fail}} (\text{outcome}) \right]^{-1} = 76,354

\text{THERE IS A PROBABILITY OF 1 FAILURE OUTCOME IN 76,354 FILLING OPERATIONS, ASSUMING 3 FILLS/WEEK; THIS MEANS 1 FAILURE IN 4.39 YEARS. PUTTING THIS IN ODH PROBABILITY UNITS OF \text{yr}^{-1},}

Pr_{\text{fail}} (\text{outcome}) = .00001309637 \begin{align*}
\text{failures, } &3 \text{ events, } \frac{1}{\text{week}} \times \frac{1}{\text{day}} \\
\text{event } &7 \text{ days } 24 \text{ hrs,}
\end{align*}

= 2.34 \times 10^{-7} \text{ failures } \frac{1}{\text{yr}}

\text{A FAILURE OUTCOME JUST MEANS THE RELIEF CAPACITY WOULD BE EXCEEDED IF THE PUMPING RATE WAS GREATER THAN 110 \text{ gpm} (FROM CAPACITY CALLS, 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_{\text{fail}} F_1 = \left( 2.34 \times 10^{-7} \text{ failures } \frac{1}{\text{yr}} \right) \frac{1}{10 \text{ failures}} \times 2 \times 10^{-8} \text{ yr}^{-1}
FOR COMPARISON, THE ODH CLASS CRITERIA IS THAT $\phi < 10^{-7} \text{ m}^{-1}$ FOR AN ODH CLASS $\phi$ AREA.

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

\[ \text{Signature} \]

ID = 8351
**PURCHASE REQUISITION**

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

**REQUESTED BY**
Russ Rucinski

**EMPLLOYEE NO**
8351

**ORGANIZATION UNIT**
RD/DO

**MAIL STATION**
357

**REQUESTOR'S IDENTIFIER**

**APPROVED BY**

**PROJECT DESCRIPTION**
DØ Upgrade Solenoid

**DESIRED DELIVERY**
12/9/96

**REQUESTED BY**
Russ Rucinski

**ORGANIZATION UNIT**
RD/DO

**MAIL STATION**
357

**REQUESTOR'S IDENTIFIER**

**SUGGESTED VENDOR**
B&B Instruments, Inc.

**PHONE NO**
219-932-4474

**PROJECT DESCRIPTION**
DØ Upgrade Solenoid

**DELIVER TO**
(RIGHT NAME & BUILDING NO)
Russ Rucinski, D-Zero Ass'y Bldg.

**SHORT DESCRIPTION (30 CHARACTERS OR LESS)**
Pressure switches - LN2 dewar

**REQUISITION NUMBER**

**QUANTITY**
3

**ITEM DESCRIPTION**
UE Electromechanical Products, Pressure switch.

**ESTIMATED UNIT PRICE**
$138.00

**DISCOUNT**

**DEL DATE**

**TOTAL AMOUNT THIS REQUISITION**
$414.00

**BUDGET CODE**
EEH

**PERCENTAGE**
100

**NEPA APPROVAL**

**DIVISION OF OFFICE APPROVAL**

**WBS NUMBER**
3.1.1.4.5

**PERCENTAGE**
100%

**PURCHASING/CONTRACTS DEPT. STAMP**

**F.O.B. & POINT OF SHIPMENT FOR FED/FD**

**TERMS**

**REPORTING CODE**

**COST ELEMENT**

**CONFIRMED TO DATE**

**REQUISITION NUMBER**

**CHECK IF P.O. FOR INTERNAL USE ONLY**

**CHECK IF REQUESTER TO APPROVE PAYMENT**

**BEGINNING STD. TEXT CODES**

**ENDING STD. TEXT CODES**

**CONFIRMED TO DATE**

**REQUISITION NUMBER**

**INTERNAL USE ONLY**

**TO APPROVE PAYMENT**

**CHECK IF P.O. FOR**
• 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 160°F
Ambient Temperature limits: -40 to 160°F, except models 701-706. 0 to 160°F.
Shock: Set point typically shifts less than 1% of range for a 50°F (28°C) ambient temperature change.
Vibration: Set point repeats after 15 G. 10 millisecond duration.
Enclosure Classification: NEMA 4; (4X see 117 series)
Temperature Models ± 1% of adjustable range.
Pressure Models 701-706, 270-376 ± 1% of adjustable range. 190-194, 612-680 ± 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:
½"NPT (2) ½" diameter knockouts.
¼"NPTF except models 190-194 (¼"NPTF). 6 feet copper or 304 stainless steel models M9B. M9BB 347 stainless steel.
Temperature Assembly 6 feel copper or 304 stainless steel models M9B.
Bulb and Capillary: 347 stainless steel.
Immersed Stem Bulb and Capillary: 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 ½°F per minute change).
Deadband: Switches designed specifically for heat tracing and freeze protection applications.
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 via
calibrated dial
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. H100-706). 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).

PETROUSE Model Chart
Type H100

<table>
<thead>
<tr>
<th>Model</th>
<th>Stock numbers for Type H100</th>
<th>Adjustable Range (English)</th>
<th>Deadband Range span</th>
<th>Proof Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>190†</td>
<td>95303</td>
<td>5 to 30 PSI</td>
<td>35 to 200 kPa</td>
<td>2500 PSI</td>
</tr>
<tr>
<td>191†</td>
<td>95310</td>
<td>10 to 100 PSI</td>
<td>70 to 700 kPa</td>
<td>2500 PSI</td>
</tr>
<tr>
<td>192†</td>
<td>95317</td>
<td>30 to 300 PSI</td>
<td>200 to 2000 kPa</td>
<td>2500 PSI</td>
</tr>
<tr>
<td>193†</td>
<td>95324</td>
<td>50 to 500 PSI</td>
<td>0.35 to 3.5 MPa</td>
<td>2500 PSI</td>
</tr>
<tr>
<td>194†</td>
<td>95331</td>
<td>200 to 1700 PSI</td>
<td>1.4 to 11.7 MPa</td>
<td>2500 PSI</td>
</tr>
</tbody>
</table>

†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 ¼" NPTF pressure connection

<table>
<thead>
<tr>
<th>Model</th>
<th>Stock numbers for Type H100</th>
<th>Adjustable Range (English)</th>
<th>Deadband</th>
<th>Proof Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>218</td>
<td>95704</td>
<td>30°Hg VAC to 0 PSI</td>
<td>1 to 2°Hg</td>
<td>30 PSI</td>
</tr>
<tr>
<td>270</td>
<td>95166</td>
<td>20 to 200 PSI</td>
<td>140 to 1400 kPa</td>
<td>250 PSI</td>
</tr>
<tr>
<td>274</td>
<td>30 to 300 PSI</td>
<td>200 to 2000 kPa</td>
<td>1 to 5.0 PSI</td>
<td>350 PSI</td>
</tr>
<tr>
<td>318</td>
<td>30 Stainless steel bellows and ¼&quot; NPTF pressure connection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>358</td>
<td></td>
<td>20 to 200 PSI</td>
<td>140 to 1400 kPa</td>
<td>250 PSI</td>
</tr>
<tr>
<td>361</td>
<td></td>
<td>30 to 300 PSI</td>
<td>200 to 2000 kPa</td>
<td>350 PSI</td>
</tr>
<tr>
<td>376</td>
<td></td>
<td>50 to 500 PSI</td>
<td>0.35 to 3.5 MPa</td>
<td>575 PSI</td>
</tr>
<tr>
<td>316</td>
<td>30 Stainless steel bellows and ¼&quot; NPTF pressure connection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>680</td>
<td>95415</td>
<td>100 to 1700 PSI</td>
<td>7 to 11.7 MPa</td>
<td>2500 PSI</td>
</tr>
<tr>
<td>303</td>
<td>Stainless steel piston and Buna-N &quot;O&quot; ring ¼&quot; NPTF pressure connection (not recommended for gas service since drying of the &quot;O&quot; ring can allow bleeding of medium into the atmosphere)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>610</td>
<td>100 to 1000 PSI</td>
<td>0.7 to 7MPa</td>
<td>30 to 150 PSI</td>
<td>100000 PSI</td>
</tr>
<tr>
<td>612</td>
<td>95712</td>
<td>200 to 3000 PSI</td>
<td>1.4 to 20.0 MPa</td>
<td>10000 PSI</td>
</tr>
<tr>
<td>616</td>
<td>700 to 5000 PSI</td>
<td>4.8 to 35.0 MPa</td>
<td>40 to 375 PSI</td>
<td>100000 PSI</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Buna-N diaphragm, &quot;O&quot; ring and ¼&quot; NPTF brass pressure connection. Buna-N diaphragm limited to process temperatures below 165°F.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>701 95122</td>
<td>3 to 30 PSI</td>
<td>20 to 200 kPa</td>
<td>2 to 1.0 PSI</td>
</tr>
<tr>
<td></td>
<td>702 95129</td>
<td>10 to 100 PSI</td>
<td>70 to 700 kPa</td>
<td>1.0 to 4.0 PSI</td>
</tr>
<tr>
<td></td>
<td>703 95136</td>
<td>30 to 300 PSI</td>
<td>200 to 2000 kPa</td>
<td>1.0 to 5.0 PSI</td>
</tr>
<tr>
<td></td>
<td>704 95142</td>
<td>50 to 500 PSI</td>
<td>0.35 to 3.5 MPa</td>
<td>2.0 to 8.0 PSI</td>
</tr>
<tr>
<td></td>
<td>705 96149</td>
<td>100 to 1000 PSI</td>
<td>0.7 to 7.0 MPa</td>
<td>3.0 to 20.0 PSI</td>
</tr>
<tr>
<td></td>
<td>706 200 to 1700 PSI</td>
<td>1.4 to 11.7 MPa</td>
<td>10.0 to 30.0 PSI</td>
<td>2500 PSI</td>
</tr>
</tbody>
</table>

*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" (H100-95505, 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 SPOT 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 pages after checking availability listed.

### Optional Switches

<table>
<thead>
<tr>
<th>Code</th>
<th>Description/availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>0140</td>
<td>1 amp 125 VAC res. gold flashed contact (dry circuit) Available: Types J400, J404, J406, J407 (C400, C402, C403)</td>
</tr>
<tr>
<td>0500</td>
<td>5 amp 125/250 VAC res. switch, close deadband. Available: Series 400, 402, 450, 454, 455, 456, 457</td>
</tr>
<tr>
<td>1070</td>
<td>10 amp 125 VDC switch. Available for the following: Types J, C, F, 400, all type 402</td>
</tr>
<tr>
<td>1519</td>
<td>15 amp adjustable deadband 48 VAC res. max. Available: J120, J120K, C120, F120, C, F, H100</td>
</tr>
</tbody>
</table>

### Recorder Options

<table>
<thead>
<tr>
<th>Code</th>
<th>Description/availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>M002</td>
<td>60Hz, 115VAC, 7 day chart drive Available: 650 Series</td>
</tr>
<tr>
<td>M003</td>
<td>50Hz, 115VAC, 7 day chart drive Available: 650 Series</td>
</tr>
<tr>
<td>M008</td>
<td>50Hz, 230VAC, 7 day chart drive Available: 650 Series</td>
</tr>
<tr>
<td>M009</td>
<td>60Hz, 230VAC, 24 hour rotation Available: 650 Series</td>
</tr>
</tbody>
</table>

Note: For Celsior models, std. 24 hour rotation order option M270. For Celsior models, 7 day rotation suffix "C" after option code (eg. M002S/C).

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

*SEE INSTRUCTIONS ON REVERSE SIDE - DO NOT WRITE IN SHAD ED AREAS*

<table>
<thead>
<tr>
<th>QUANTITY</th>
<th>ITEM DESCRIPTION</th>
<th>ESTIMATED UNIT PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>PARKER GOLD KING SOLENOID VALVE</td>
<td><strong>$1,12.71</strong></td>
</tr>
<tr>
<td></td>
<td>2 position, 4way, 100 psi, max pressure.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24V DC Coil, Outdoor Type 4 Enclosure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PART # 04F48S210G A3F 4 C 80</td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL AMOUNT OF THIS REQUISITION**: **$338.13**

**PURCHASING/CONTRACTS DEPT. STAMP**

** фл - 29 REV 6/93**
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

<table>
<thead>
<tr>
<th>Part</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve body</td>
<td>Brass</td>
</tr>
<tr>
<td>Seals</td>
<td>Buna-N</td>
</tr>
<tr>
<td>Plunger and Pole Piece</td>
<td>430FR S.S.</td>
</tr>
<tr>
<td>Plunger Tube</td>
<td>305 S.S.</td>
</tr>
<tr>
<td>Springs</td>
<td>302 S.S.</td>
</tr>
<tr>
<td>Shading Coil</td>
<td>Copper (Brass Body)</td>
</tr>
<tr>
<td>Disc Holder</td>
<td>Celcon</td>
</tr>
</tbody>
</table>

Solenoid Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Frame</td>
<td>Open Frame (O) General Purpose (G), Splice Box (S) or Conduit Hub (T)</td>
</tr>
<tr>
<td>Type 1</td>
<td>Rainproof (R), Explosion Proof (E), S.S. Explosion Proof (M), S.S. or Standard</td>
</tr>
<tr>
<td>Type 2, 3, 3R</td>
<td>Submersible (U or W)</td>
</tr>
<tr>
<td>Type 4, 4X</td>
<td>Gold Ring II™ totally encapsulated (4)</td>
</tr>
<tr>
<td>Type 6</td>
<td>Submersible Splice Box (W) Explosion Proof (E), S.S. Explosion Proof (M)</td>
</tr>
<tr>
<td>Type 7, 9</td>
<td>ISO 4400 &amp; DIN 43650 (P)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Media as listed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient: 32-77°F (standard)</td>
</tr>
</tbody>
</table>

For temperature variations, consult factory.
**Gold Ring™ Solenoid Valves**

**Material & Trim: Brass & Buna N**

<table>
<thead>
<tr>
<th>AC Valve Specifications</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NPT</strong></td>
<td><strong>ORIFICE INLET EXH</strong></td>
</tr>
<tr>
<td>1/4</td>
<td>1/16</td>
</tr>
</tbody>
</table>

**Operation: Universal (Pressure at P)**

<table>
<thead>
<tr>
<th>DC Valve Specifications</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NPT</strong></td>
<td><strong>ORIFICE INLET EXH</strong></td>
</tr>
<tr>
<td>1/4</td>
<td>1/16</td>
</tr>
</tbody>
</table>

**Operation: Universal (Pressure at P)**

<table>
<thead>
<tr>
<th>AC Solenoid Specifications</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Select One Code From Each Column</strong></td>
<td><strong>VOLTAGE</strong></td>
</tr>
<tr>
<td><strong>ENCLOSURE</strong></td>
<td><strong>COIL TERMINATION</strong></td>
</tr>
<tr>
<td>Strain Relief</td>
<td>C</td>
</tr>
<tr>
<td>Explosion Proof Watertight</td>
<td>E</td>
</tr>
<tr>
<td>General Purpose</td>
<td>G</td>
</tr>
<tr>
<td>316 SS</td>
<td>M</td>
</tr>
<tr>
<td>Explosion Proof Watertight</td>
<td>24&quot; 36&quot;</td>
</tr>
<tr>
<td>Open Frame</td>
<td>O</td>
</tr>
<tr>
<td>D.I.N.</td>
<td>P</td>
</tr>
<tr>
<td>Rainproof</td>
<td>R</td>
</tr>
<tr>
<td>Splice Box</td>
<td>S</td>
</tr>
<tr>
<td>Conduit Hub</td>
<td>T</td>
</tr>
<tr>
<td>Submersible</td>
<td>U</td>
</tr>
<tr>
<td>Submersible Splice Box</td>
<td>W</td>
</tr>
<tr>
<td>Explosion Proof Watertight</td>
<td>Y</td>
</tr>
<tr>
<td>With Ground Lead</td>
<td>12 75</td>
</tr>
<tr>
<td>M. With Ground Lead</td>
<td>24 80</td>
</tr>
<tr>
<td>Gold Ring™</td>
<td>4 120 90</td>
</tr>
<tr>
<td>Totally Encapsulated</td>
<td>125 95</td>
</tr>
</tbody>
</table>

**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 $-425\,^\circ F$. 

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 cryogens; 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

Bonnet Extension Meets ISA SP79 Standards

One-Piece Heavy Duty Stem

Quarter-Turn High Flow Capacity Ball Valve

Mounting Pad for Automation

Stainless Steel S-Gasket Body Seals

Orientation Controlled Stem/Ball Connection

Low Torque Polyfill Seats

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 thrust bearing 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.
CRYOGENIC VALVE CONFIGURATIONS

Worcester Controls cryogenic valves are available in four basic body configurations; C4 (1/2"), C4 Diverter (1/2"), C4 Wafer (3/8"), and C51 Flanged (3/8"). 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:
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 $1 \times 10^{-9}$ 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.
C4 and C4 Diverter Valves with Stem Extensions

Valve Sizes: 1/4", 1/2", 3/4", 1" 1/2", 2" (Diverter Not Available in 3/8" and 2")

Styles: Unidirectional Flow, Three-Piece Design

Body: ASTM A473 CF3M, 316L Stainless Steel
ASTM B283 C3700, Brass

Pipe Ends: ASTM A473 CF3M, 316L Stainless Steel
ASTM A473 CF8M, 316L Stainless Steel
ASTM B283 C3700, Brass

Ball: ASTM A276 316 Stainless Steel, Condition A
ASTM A197 H22

Stem: ASTM A473 316L or ASTM A276 316L, Condition A or Condition B

Packaging: Polyfill

Seals: "S" Gaskets (Teflon Coated 316 Stainless Steel)

Stem Packing: Chevron Packing (Teflon Style CV-19 Rings)

General Specifications

Shutoff: The valve exceeds the tightness requirements of ISA SP79 for Level II (10 SCF/ per inch of valve @ 100 psi helium and 320°F maximum leakages).

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 UNI Spec 6308. Body, ball, stem and poppets are degreased.

Lubrication: Molycote 211L

Assembly: Assembled in a Class 100 environment per Federal Standard 209A

Testing: Valves are dry tested, internally pressurized with 80 psi helium, checked with hand-held helium leak detector (Helium Mass Spectrometer) sensitive to 1 x 10^-4 cc/sec.

Wafer Valves and Flanged Valves with and without Extensions

Valve Sizes: 3", 4" and 6"

Style: Unidirectional Flow, Wafer/Flangeless and Ranged Design

Body: ASTM A361 CF8M Stainless Steel

End Plug: ASTM B516 C80000 Brass (Water Only)

Ball: ASTM A240-316 or ASTM A312 GR TP-316 Stainless Steel
ASTM B516 C80000 Brass (Water Only)

Stem: ASTM A276 316 Stainless Steel Condition A

Seals: Polyfill

Body Seat: TFE-4 Virgin

Stem Seats: TFE - 15% Glass Filled

Centering: AISI 316 Stainless Steel

Washers: ASTM B16 C34000 Brass (Water Only)

Thrustbearing: TFE - 15% Glass Filled

Followers: AISI 304 Stainless Steel

Externals: 300 Series Stainless Steel
Body Temperature vs Bonnet Temperature
$rac{1}{4}"-2"$ 3 Piece and Diverter Valves with Extension
Ambient Temperature 75°F

Pressure/Temperature Ratings

Pressure Torque Curves - Polyfill Seats
$rac{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

<table>
<thead>
<tr>
<th>Size (in.)</th>
<th>Cv Value</th>
<th>Equivalent Length (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$rac{1}{4}$&quot;</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>$rac{1}{2}$&quot;</td>
<td>720</td>
<td>720</td>
</tr>
<tr>
<td>1&quot;</td>
<td>1020</td>
<td>1020</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Size</th>
<th>1/8&quot;</th>
<th>1/4&quot;</th>
<th>1/2&quot;</th>
<th>3/4&quot;</th>
<th>1&quot;</th>
<th>1 1/4&quot;</th>
<th>2&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.57</td>
<td>2.50</td>
<td>7.86</td>
<td>5.53</td>
<td>3.97</td>
<td>8.02</td>
<td>1.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(55.28)</td>
<td>(63.50)</td>
<td>(199.6)</td>
<td>(140)</td>
<td>(101)</td>
<td>(204)</td>
<td>(43.9)</td>
</tr>
<tr>
<td></td>
<td>2.79</td>
<td>2.73</td>
<td>7.96</td>
<td>5.53</td>
<td>3.97</td>
<td>8.12</td>
<td>1.80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(70.87)</td>
<td>(69.34)</td>
<td>(202.2)</td>
<td>(140)</td>
<td>(101)</td>
<td>(206)</td>
<td>(45.7)</td>
</tr>
<tr>
<td></td>
<td>3.69</td>
<td>3.62</td>
<td>8.91</td>
<td>5.53</td>
<td>5.56</td>
<td>9.09</td>
<td>2.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(93.73)</td>
<td>(91.95)</td>
<td>(226.3)</td>
<td>(140)</td>
<td>(141)</td>
<td>(231)</td>
<td>(59.7)</td>
</tr>
<tr>
<td></td>
<td>4.53</td>
<td>4.47</td>
<td>10.23</td>
<td>6.72</td>
<td>6.75</td>
<td>10.27</td>
<td>3.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(115.1)</td>
<td>(113.5)</td>
<td>(259.8)</td>
<td>(171)</td>
<td>(172)</td>
<td>(261)</td>
<td>(78.2)</td>
</tr>
<tr>
<td></td>
<td>4.98</td>
<td>4.90</td>
<td>10.41</td>
<td>6.72</td>
<td>6.75</td>
<td>10.46</td>
<td>3.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(126.5)</td>
<td>(124.5)</td>
<td>(264.4)</td>
<td>(171)</td>
<td>(172)</td>
<td>(261)</td>
<td>(83.0)</td>
</tr>
</tbody>
</table>

### 1/2" - 2" Cryogenic C4 Diverter Ball Valves

Extended and non-extended bonnets

<table>
<thead>
<tr>
<th>Size</th>
<th>1/8&quot;</th>
<th>1/4&quot;</th>
<th>1/2&quot;</th>
<th>3/4&quot;</th>
<th>1&quot;</th>
<th>1 1/4&quot;</th>
<th>2&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.57</td>
<td>2.50</td>
<td>7.86</td>
<td>5.53</td>
<td>3.97</td>
<td>8.02</td>
<td>1.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(55.28)</td>
<td>(63.50)</td>
<td>(199.6)</td>
<td>(140)</td>
<td>(101)</td>
<td>(204)</td>
<td>(43.9)</td>
</tr>
<tr>
<td></td>
<td>2.79</td>
<td>2.73</td>
<td>7.96</td>
<td>5.53</td>
<td>3.97</td>
<td>8.12</td>
<td>1.80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(70.87)</td>
<td>(69.34)</td>
<td>(202.2)</td>
<td>(140)</td>
<td>(101)</td>
<td>(206)</td>
<td>(45.7)</td>
</tr>
<tr>
<td></td>
<td>3.69</td>
<td>3.62</td>
<td>8.91</td>
<td>5.53</td>
<td>5.56</td>
<td>9.09</td>
<td>2.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(93.73)</td>
<td>(91.95)</td>
<td>(226.3)</td>
<td>(140)</td>
<td>(141)</td>
<td>(231)</td>
<td>(59.7)</td>
</tr>
<tr>
<td></td>
<td>4.53</td>
<td>4.47</td>
<td>10.23</td>
<td>6.72</td>
<td>6.75</td>
<td>10.27</td>
<td>3.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(115.1)</td>
<td>(113.5)</td>
<td>(259.8)</td>
<td>(171)</td>
<td>(172)</td>
<td>(261)</td>
<td>(78.2)</td>
</tr>
<tr>
<td></td>
<td>4.98</td>
<td>4.90</td>
<td>10.41</td>
<td>6.72</td>
<td>6.75</td>
<td>10.46</td>
<td>3.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(126.5)</td>
<td>(124.5)</td>
<td>(264.4)</td>
<td>(171)</td>
<td>(172)</td>
<td>(261)</td>
<td>(83.0)</td>
</tr>
</tbody>
</table>
### 3" - 6" Cryogenic C4 Wafer Ball Valves
Extended and non-extended bonnets

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3&quot;</td>
<td>4.50 (114.3)</td>
<td>5.31 (135)</td>
<td>15.38 (391)</td>
<td>3.88 (98.5)</td>
<td>18.72 (475)</td>
<td>7.22 (193.4)</td>
<td>17.68 (449)</td>
<td>6.18 (157)</td>
<td>22.0 (559)</td>
<td>5.88 (149)</td>
</tr>
<tr>
<td>4&quot;</td>
<td>5.81 (147.6)</td>
<td>6.81 (173)</td>
<td>15.98 (406)</td>
<td>4.48 (114)</td>
<td>19.34 (491)</td>
<td>7.84 (199.1)</td>
<td>18.30 (464.8)</td>
<td>6.80 (172.7)</td>
<td>22.0 (559)</td>
<td>7.50 (190)</td>
</tr>
<tr>
<td>6&quot;</td>
<td>7.38 (187.5)</td>
<td>8.69 (221)</td>
<td>18.0 (457)</td>
<td>6.19 (157)</td>
<td>22.02 (565)</td>
<td>11.21 (284.7)</td>
<td>21.63 (549.4)</td>
<td>9.82 (249.4)</td>
<td>26.0 (660)</td>
<td>9.88 (251)</td>
</tr>
</tbody>
</table>

### 3" - 6" Cryogenic C51 Flanged Ball Valves
Extended and non-extended bonnets

<table>
<thead>
<tr>
<th>Valve Size</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Unit</th>
<th>Without</th>
<th>With</th>
<th>Without</th>
<th>With</th>
<th>Without</th>
<th>With</th>
<th>Without</th>
<th>With</th>
<th>Without</th>
<th>With</th>
<th>Without</th>
<th>With</th>
</tr>
</thead>
<tbody>
<tr>
<td>3&quot;</td>
<td>8.00 (203.2)</td>
<td>3.62</td>
<td>3.06</td>
<td>15.38 (391)</td>
<td>3.88 (98.6)</td>
<td>18.72 (475)</td>
<td>7.22 (193.4)</td>
<td>17.68 (449)</td>
<td>6.18 (157)</td>
<td>22.0 (559)</td>
<td>2.50 (63.5)</td>
<td>46 (20.9)</td>
<td>39.5 (11.7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4&quot;</td>
<td>9.00 (228.6)</td>
<td>4.00</td>
<td>4.03</td>
<td>15.98 (406)</td>
<td>4.48 (114)</td>
<td>19.34 (491)</td>
<td>7.84 (199.9)</td>
<td>18.30 (464.8)</td>
<td>6.80 (172.7)</td>
<td>22.0 (559)</td>
<td>3.25 (82.5)</td>
<td>69 (31.3)</td>
<td>67 (24.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6&quot;</td>
<td>10.50 (266.7)</td>
<td>4.25</td>
<td>4.06</td>
<td>18.0 (457)</td>
<td>6.19 (157)</td>
<td>23.02 (585)</td>
<td>11.2 (285)</td>
<td>21.63 (549.4)</td>
<td>9.82 (249.4)</td>
<td>26.0 (660)</td>
<td>4.38 (111.2)</td>
<td>139 (63.1)</td>
<td>125 (49.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**HOW TO ORDER**

<table>
<thead>
<tr>
<th>Size</th>
<th>3/4&quot;</th>
<th>C4</th>
<th>6</th>
<th>6</th>
<th>P</th>
<th>M</th>
<th>SE</th>
<th>N</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Size</th>
<th>C4</th>
<th>1-Brass</th>
<th>1-Brass</th>
<th>P-Polyfill</th>
<th>MTFE Coated S.S.</th>
<th>SE</th>
<th>SW</th>
<th>SWW</th>
<th>BWI</th>
<th>TE</th>
<th>N'without Stem Extension</th>
<th>Blank-with Stem Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot;</td>
<td>C4</td>
<td>6-316 Stainless Steel</td>
<td>6-316 Stainless Steel</td>
<td>P-Polyfill</td>
<td>MTFE Coated S.S.</td>
<td>SE</td>
<td>SW</td>
<td>SWW</td>
<td>BWI</td>
<td>TE</td>
<td>N'without Stem Extension</td>
<td>Blank-with Stem Extension</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>C4</td>
<td>6-316 Stainless Steel</td>
<td>6-316 Stainless Steel</td>
<td>P-Polyfill</td>
<td>MTFE Coated S.S.</td>
<td>SE</td>
<td>SW</td>
<td>SWW</td>
<td>BWI</td>
<td>TE</td>
<td>N'without Stem Extension</td>
<td>Blank-with Stem Extension</td>
</tr>
<tr>
<td>1/4&quot;</td>
<td>C4</td>
<td>6-316 Stainless Steel</td>
<td>6-316 Stainless Steel</td>
<td>P-Polyfill</td>
<td>MTFE Coated S.S.</td>
<td>SE</td>
<td>SW</td>
<td>SWW</td>
<td>BWI</td>
<td>TE</td>
<td>N'without Stem Extension</td>
<td>Blank-with Stem Extension</td>
</tr>
<tr>
<td>1&quot;</td>
<td>C4</td>
<td>6-316 Stainless Steel</td>
<td>6-316 Stainless Steel</td>
<td>P-Polyfill</td>
<td>MTFE Coated S.S.</td>
<td>SE</td>
<td>SW</td>
<td>SWW</td>
<td>BWI</td>
<td>TE</td>
<td>N'without Stem Extension</td>
<td>Blank-with Stem Extension</td>
</tr>
<tr>
<td>1 1/8&quot;</td>
<td>C4</td>
<td>6-316 Stainless Steel</td>
<td>6-316 Stainless Steel</td>
<td>P-Polyfill</td>
<td>MTFE Coated S.S.</td>
<td>SE</td>
<td>SW</td>
<td>SWW</td>
<td>BWI</td>
<td>TE</td>
<td>N'without Stem Extension</td>
<td>Blank-with Stem Extension</td>
</tr>
<tr>
<td>2&quot;</td>
<td>C4</td>
<td>6-316 Stainless Steel</td>
<td>6-316 Stainless Steel</td>
<td>P-Polyfill</td>
<td>MTFE Coated S.S.</td>
<td>SE</td>
<td>SW</td>
<td>SWW</td>
<td>BWI</td>
<td>TE</td>
<td>N'without Stem Extension</td>
<td>Blank-with Stem Extension</td>
</tr>
</tbody>
</table>

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

**SWW - not available in 3/4", 1/4".**

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

Ordering Example above is a 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: CRYOGENS CAN CAUSE SEVERE BURNS, SUFFOCATION OR OTHER SERIOUS INJURIES. ENVIRONMENTS CONTAINING CRYOGENIC VALVES NEED PROPER VENTILATION AND LOW OXYGEN WARNING DEVICES.**

---

**Worcester Controls**
A BTR Company

P.O. BOX 538, 33 LOCKE DRIVE
MARLBOROUGH, MA 01752
(508) 481-4600 TELEX 6617563
FAX (508) 481-4454

20 MID DOMINION ACRES
SCARBOROUGH, ONTARIO, CANADA
M1S 4A5
(416) 298-1671 TELEX 065-25135
TELEFAX (416) 298-8330

Distributed by:

**MIDLAND PIPE & SUPPLY CO.**
2829 South 61st Court
Cicero, IL 60650
Phone 312-656-4200

PRINTED IN U.S.A. 6901W
The Overfill Problem

Experiments that receive large, and especially frequent, LN$_2$ 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 LN$_2$ 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, LN$_2$ 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 installed\(^1\) and operating on the D0, 65 psig, 20,000 gls. LN$_2$ dewar.

Pump Capacities

The trailer mounted pump capacities of the current LN$_2$ 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 LN$_2$ are listed in Table 1.

Table 1. Transfer Pump Limiting values.

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Where used</th>
<th>Max. Press.</th>
<th>Max. Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Union Carbide</td>
<td>only CHL</td>
<td>460 psig</td>
<td>240 gpm @ 275 psig</td>
</tr>
<tr>
<td>Liquid Carbonic</td>
<td>bal. Fermilab(^2)</td>
<td>220 psig</td>
<td>180 gpm @ 150 psig</td>
</tr>
</tbody>
</table>

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 LN$_2$ 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 valve\(^3\) 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 Relay\(^4\), 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 expensive\(^5\) and given the 6,000 gals. size of the trailers the large gas space solution is only possible in the case of the largest installed dewars. DO 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 gals. 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 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 cost\(^6\). Any installation for which the reliability of the LN\(_2\) source is crucial, and DO 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
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

Total Pressure (psig)

Flow (gpm)

100% RATED SPEED (7100 RPM)
90% (6390 RPM)
80% (5580 RPM)
70% (4970 RPM)
60% (4760 RPM)
50% (3550 RPM)

CAUTION: DO NOT EXCEED 40 AMPS
Figure 3 - Liquid Carbonic Trailer
Piping Schematic

Note: See reverse side for Piping Legend.
Piping Legend

V-1 Bottom fill and drain valve - 3"
V-2 Vapor return - 1 1/2"
V-3 Liquid to PB coil - 1"
V-4 Pump inlet - 2 1/2"
V-5 Top fill valve - 2"
V-6 Pump recycle - 1 1/2"
V-7 Meter discharge - 1 1/2"
V-8 Meter discharge line drain - 3/8"
V-9 Main fill line drain - 3/8"
V-10 Liquid level gauge equalizer - 1/4"
V-11 Liquid level gauge gas phase isolation - 1/4"
V-12 Liquid level gauge liquid phase isolation - 1/4"
V-13 Empty trycock - 3/8"
V-14 Full trycock - 3/8"
V-15 Manual vent - 2 1/2"
V-16 Pump discharge pressure gauge isolation - 1/4"
V-17 In-transit relief valve isolation - 1/2"
V-18 Rupture disc selector valve - 2"
V-19 Main vacuum valve - 2"
V-20 Vacuum probe isolation - 1/8"
V-21 Vacuum probe - 1/8"
SV-1 Inner vessel safety set 33 psig
SV-2 Pump inlet safety relief set 50 psig
SV-3 Pump discharge safety relief set 350 psig
SV-4 Fill line safety relief set 350 psig
CV-1 Swing check valve - 1 1/2"
S-1 Pump inlet strainer
PI-1 Inner vessel pressure gauge (0-100 psig)
PI-3 Pump discharge pressure gauge (0-400 psig)
SD-1 Inner vessel rupture disc (2-2") (50-58 psi)
SD-2 Outer (jacket) vessel relief device (6")
PCV-1 In-transit road relief pressure regulator set 15 psig
LI-1 Liquid level indicator Barton 227 (0-100"")
P-1 Pump belt driven (90-120 gpm)
PB-1 Pressure build 140 gpm loxfin
M-1 Flow meter (40-120 gpm)
DC-1 Discharge flex hose with 1-1/2" union connector
DC-2 Fill and drain connection with 3" union hose connector
DC-3 Vapor recovery connection with 1-1/2" union hose connector
DC-4 Gas sample - quick disconnect
DC-5 Liquid sample - quick disconnect
Figure 4 - Dewar "Delivery Overfill" Inlet Solution

* Set DP = 75% "full" level
i.e. \((P_b - P_t) = 0.75 \Delta P_{\text{max}}\)
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 \(-425^\circ F\).
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 cryogens; 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 Polynfill 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, Polynfill 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.
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 thrust bearing 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.
Worcester Controls cryogenic valves are available in four basic body configurations: C4 (¾"2"), C4 Diverter (½"2"), C4 Wafer (3½"6), and C51 Flanged (3½"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 $1 \times 10^{-4}$ 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.
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

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.
C4 and C4 Diverter Valves with Stem Extensions

Valve Sizes: \( \frac{1}{2}, \frac{3}{4}, 1, 1\frac{1}{4}, 1\frac{1}{2}, 2 \) (Diverter Not Available in \( \frac{1}{4}, \frac{3}{8}, \frac{5}{16} \))

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 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 A747 316L or ASTM A278, 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 Seals: Centering A1S1 316 Stainless

Stem Seal: TFE - 151 M! Glass Filled

Thrustbearing: Polyfill

External: 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 A209 (Stainless Steel Only)
- BW1 - Butt Weld Ends for Schedule 10 Pipe (Dimensions to ANSI B16.25) (Stainless Steel Only)
- TE - Tube Ends (Swet Ends for Type K, L, and M Copper Tubing to ASTM B860 (Brass Only)

Temperature Range: -425°F to +500°F

Maximum Pressure: 1500 psi

Wafer Valves and Flanged Valves with and without Extensions

Valve Sizes: \( 3", 4", 6" \)

Style: Unidirectional Flow, Water/Flangeless and flanged Design

Body: ASTM A351 CF8M Stainless Steel

End Plug: ASTM B564 C31600 Brass (Water Only)

Ball: ASTM A240-316 or ASTM A312 GR TP-316 Stainless Steel
- ASTM B564 C31600 Brass (Water Only)

Stem: ASTM A276 316 Stainless Steel Condition A

Seats: Polyfill

Body Seal: TFE-Virgin

Seals: TFE - 15% Glass Filled

Centering: A1S1 316 Stainless Steel

Washers: ASTM B121 C34000 Brass (Water Only)

Thrustbearing: TFE - 15% Glass Filled

General Specifications

Shutoff: The valve exceeds the tightness requirements of ISA 579 for Level II (10 SCFH per inch of valve at 100 psi helium and 300°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, 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 60 psi helium, checked with hand-held helium leak detector (Holium Mass Spectrometer) sensitive to 1 x 10^6 e-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
PARTS IDENTIFICATION

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

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

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

<table>
<thead>
<tr>
<th>Size</th>
<th>1/4&quot;</th>
<th>3/8&quot;</th>
<th>1/2&quot;</th>
<th>3/4&quot;</th>
<th>1&quot;</th>
<th>1-1/4&quot;</th>
<th>1-1/2&quot;</th>
<th>2&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4&quot;</td>
<td>2.50 (63.50)</td>
<td>2.50 (63.50)</td>
<td>2.73 (69.34)</td>
<td>5.37 (140)</td>
<td>3.97 (101)</td>
<td>8.02 (203)</td>
<td>1.73 (43.9)</td>
<td>1.75 (44.4)</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>2.79 (72.1)</td>
<td>2.79 (72.1)</td>
<td>2.96 (75.2)</td>
<td>5.37 (140)</td>
<td>3.97 (101)</td>
<td>8.12 (206)</td>
<td>1.80 (45.7)</td>
<td>2.00 (50.8)</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>3.69 (93.73)</td>
<td>3.62 (91.95)</td>
<td>5.53 (140)</td>
<td>5.56 (141)</td>
<td>9.09 (231)</td>
<td>2.35 (59.7)</td>
<td>2.38 (60.4)</td>
<td>2.38 (60.4)</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>4.53 (115.1)</td>
<td>4.47 (113.5)</td>
<td>10.23 (259.8)</td>
<td>6.75 (172)</td>
<td>10.27 (261)</td>
<td>3.08 (78.2)</td>
<td>3.20 (81.3)</td>
<td>3.20 (81.3)</td>
</tr>
<tr>
<td>1&quot;</td>
<td>4.98 (126.5)</td>
<td>4.90 (124.5)</td>
<td>10.41 (264.4)</td>
<td>6.75 (172)</td>
<td>10.46 (261)</td>
<td>3.27 (83.0)</td>
<td>3.57 (90.7)</td>
<td>3.57 (90.7)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Size</th>
<th>1/2&quot;</th>
<th>3/4&quot;</th>
<th>1&quot;</th>
<th>1-1/4&quot;</th>
<th>1-1/2&quot;</th>
<th>2&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;</td>
<td>2.57 (65.82)</td>
<td>2.50 (63.50)</td>
<td>2.96 (75.2)</td>
<td>5.37 (140)</td>
<td>3.97 (101)</td>
<td>8.02 (203)</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>3.69 (93.73)</td>
<td>3.62 (91.95)</td>
<td>5.53 (140)</td>
<td>5.56 (141)</td>
<td>9.09 (231)</td>
<td>2.35 (59.7)</td>
</tr>
<tr>
<td>1&quot;</td>
<td>4.53 (115.1)</td>
<td>4.47 (113.5)</td>
<td>10.23 (259.8)</td>
<td>6.75 (172)</td>
<td>10.27 (261)</td>
<td>3.08 (78.2)</td>
</tr>
<tr>
<td>1-1/4&quot;</td>
<td>4.98 (126.5)</td>
<td>4.90 (124.5)</td>
<td>10.41 (264.4)</td>
<td>6.75 (172)</td>
<td>10.46 (261)</td>
<td>3.27 (83.0)</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>6.00 (152.4)</td>
<td>6.00 (152.4)</td>
<td>10.90 (277.1)</td>
<td>8.91 (226.1)</td>
<td>10.90 (277.1)</td>
<td>3.95 (100.3)</td>
</tr>
</tbody>
</table>
### 3" - 6" Cryogenic C4 Wafer Ball Valves

**Extended and non-extended bonnets**

| Valve Sizes | E | D | W | Wt. w/o Bonnet | Wt. w/o Body | Wt. w/o Seat | Wt. w/o Disc | Wt. w/o Bushing | Wt. w/o Valve | Wt. w/o Wafer | Wt. w/o Body & | Wt. w/o Body & | Wt. w/o Body & | Wt. w/o Body & | Wt. w/o Body & | Wt. w/o Body & | Wt. w/o Body & | Wt. w/o Body & | Wt. w/o Body & | Wt. w/o Body & | Wt. w/o Body & | Wt. w/o Body & |
|-------------|---|---|---|----------------|--------------|-------------|-------------|----------------|--------------|-------------|----------------|--------------|-------------|----------------|--------------|-------------|--------------|--------------|-------------|--------------|--------------|--------------|--------------|
| 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 (12.1) | 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 (12.1) |
| 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 (15.2) | 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 (15.2) |
| 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 (25.5) | 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 (25.5) |

### 3" - 6" Cryogenic C51 Flanged Ball Valves

**Extended and non-extended bonnets**

<table>
<thead>
<tr>
<th>Valve Sizes</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Weight w/ Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
<th>Weight w/o Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>3&quot;</td>
<td>8.00 (203.2)</td>
<td>3.62 (91.9)</td>
<td>3.06 (77.7)</td>
<td>15.38 (391)</td>
<td>3.68 (98.6)</td>
<td>18.72 (475)</td>
<td>7.22 (183.4)</td>
<td>17.68 (449)</td>
<td>6.18 (157)</td>
<td>22.0 (559)</td>
<td>5.88 (149)</td>
<td>2.50 (63.5)</td>
<td>27 (12.2)</td>
<td>21 (12.1)</td>
<td>3.88 (98.5)</td>
<td>18.72 (475)</td>
<td>7.22 (183.4)</td>
<td>17.68 (449)</td>
<td>6.18 (157)</td>
<td>22.0 (559)</td>
<td>5.88 (149)</td>
<td>2.50 (63.5)</td>
</tr>
<tr>
<td>4&quot;</td>
<td>9.00 (226.6)</td>
<td>4.00 (101)</td>
<td>4.03 (102)</td>
<td>15.98 (406)</td>
<td>4.48 (114)</td>
<td>19.34 (491)</td>
<td>7.84 (199.1)</td>
<td>18.30 (464.8)</td>
<td>6.80 (172.7)</td>
<td>22.0 (559)</td>
<td>7.50 (190)</td>
<td>3.25 (82.5)</td>
<td>41 (18.6)</td>
<td>34 (15.2)</td>
<td>4.48 (114)</td>
<td>19.34 (491)</td>
<td>7.84 (199.1)</td>
<td>18.30 (464.8)</td>
<td>6.80 (172.7)</td>
<td>22.0 (559)</td>
<td>7.50 (190)</td>
<td>3.25 (82.5)</td>
</tr>
<tr>
<td>6&quot;</td>
<td>10.50 (266.7)</td>
<td>4.25 (108)</td>
<td>6.06 (154)</td>
<td>18.0 (457)</td>
<td>6.19 (157)</td>
<td>23.02 (585)</td>
<td>11.2 (285)</td>
<td>21.63 (549.4)</td>
<td>9.82 (249.4)</td>
<td>26.0 (660)</td>
<td>9.88 (251)</td>
<td>4.38 (111.2)</td>
<td>94 (42.6)</td>
<td>64 (25.5)</td>
<td>6.19 (157)</td>
<td>23.02 (585)</td>
<td>11.2 (285)</td>
<td>21.63 (549.4)</td>
<td>9.82 (249.4)</td>
<td>26.0 (660)</td>
<td>9.88 (251)</td>
<td>4.38 (111.2)</td>
</tr>
</tbody>
</table>
## HOW TO ORDER

<table>
<thead>
<tr>
<th>Size</th>
<th>Type</th>
<th>Material</th>
<th>Material</th>
<th>Sealing Material</th>
<th>End Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot;</td>
<td>C4</td>
<td>1-Brass</td>
<td>6-316 Stainless Steel</td>
<td>P-Polyfill</td>
<td>M-TFE</td>
<td>Screw End any Sch. pipe, Brass + 316 S.S.</td>
</tr>
<tr>
<td>1&quot;</td>
<td>C4</td>
<td>1-Brass</td>
<td>6-316 Stainless Steel</td>
<td>P-Polyfill</td>
<td>M-TFE</td>
<td>Screw End any Sch. pipe, Brass + 316 S.S.</td>
</tr>
<tr>
<td>1 1/2&quot;</td>
<td>C4</td>
<td>1-Brass</td>
<td>6-316 Stainless Steel</td>
<td>P-Polyfill</td>
<td>M-TFE</td>
<td>Screw End any Sch. pipe, Brass + 316 S.S.</td>
</tr>
<tr>
<td>2&quot;</td>
<td>C4</td>
<td>1-Brass</td>
<td>6-316 Stainless Steel</td>
<td>P-Polyfill</td>
<td>M-TFE</td>
<td>Screw End any Sch. pipe, Brass + 316 S.S.</td>
</tr>
<tr>
<td>3&quot;</td>
<td>C4-(W)</td>
<td>1-Brass</td>
<td>6-316 Stainless Steel</td>
<td>P-Polyfill</td>
<td>TFE</td>
<td>Screw End any Sch. pipe, Brass + 316 S.S.</td>
</tr>
<tr>
<td>4&quot;</td>
<td>C4-(W)</td>
<td>1-Brass</td>
<td>6-316 Stainless Steel</td>
<td>P-Polyfill</td>
<td>TFE</td>
<td>Screw End any Sch. pipe, Brass + 316 S.S.</td>
</tr>
<tr>
<td>6&quot;</td>
<td>C4-(W)</td>
<td>1-Brass</td>
<td>6-316 Stainless Steel</td>
<td>P-Polyfill</td>
<td>TFE</td>
<td>Screw End any Sch. pipe, Brass + 316 S.S.</td>
</tr>
</tbody>
</table>

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

**SWO - not available in 3/4", 1".**

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

Ordering Example above is a 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.

Cautions: 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**

A BTR Company

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

20 MID-DOMINION ACRES
SCARBOROUGH, ONTARIO CANADA
M1S 4A5
(416) 296-1671 TELEX 065 25135
TELEFAX (416) 296-8330

**Distributed by:**

MIDLAND PIPE & SUPPLY CO.
2829 South 61st Court
Cicero, IL 60650
Phone 312-656-4200

PRINTED IN U.S.A 6/90 SWP
Series 37 Pneumatic Actuator

Aluminum rack and pinion actuator for dependable ON/OFF operation in general service applications.
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 1/4”-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 breakaway 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 breakaway requirements of the valve.

Operating Sequence
Inches (mm)

<table>
<thead>
<tr>
<th>Size</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>C₂</th>
<th>D</th>
<th>E</th>
<th>E₁</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>H₁</th>
<th>J</th>
<th>J₁</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>0537</td>
<td>1.57</td>
<td>.47</td>
<td>.47</td>
<td>.47</td>
<td>.47</td>
<td>2.17</td>
<td>2.29</td>
<td>2.44</td>
<td>3.17</td>
<td>5.75</td>
<td>4.34</td>
<td>.57</td>
<td>.22</td>
<td>.30</td>
<td>.83</td>
<td>.42</td>
<td>10.02X</td>
<td>3.00</td>
</tr>
<tr>
<td>0537S</td>
<td></td>
<td>.50</td>
<td>.47</td>
<td>.50</td>
<td>.50</td>
<td>3.57</td>
<td>3.65</td>
<td>3.85</td>
<td>4.34</td>
<td>7.00</td>
<td>5.70</td>
<td>6.70</td>
<td>.35</td>
<td>.30</td>
<td>1.25</td>
<td>.63</td>
<td>14.00X</td>
<td>3.00</td>
</tr>
<tr>
<td>1537</td>
<td>2.36</td>
<td>.59</td>
<td>.47</td>
<td>.59</td>
<td>.47</td>
<td>2.22</td>
<td>4.66</td>
<td>3.66</td>
<td>3.35</td>
<td>5.30</td>
<td>4.70</td>
<td>170.10</td>
<td>5.20</td>
<td>.35</td>
<td>.30</td>
<td>1.25</td>
<td>.63</td>
<td>14.00X</td>
</tr>
<tr>
<td>1537S</td>
<td></td>
<td>.67</td>
<td>.59</td>
<td>.67</td>
<td>.59</td>
<td>5.20</td>
<td>5.70</td>
<td>6.70</td>
<td>5.30</td>
<td>7.40</td>
<td>6.70</td>
<td>170.10</td>
<td>5.20</td>
<td>.35</td>
<td>.30</td>
<td>1.25</td>
<td>.63</td>
<td>14.00X</td>
</tr>
</tbody>
</table>

Dimensions are for layout purposes only. For tolerances contact Worcester Controls. Metric equivalents are converted from standard English.

### Torque Output - Double Acting Actuator:

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Operating Pressure Bar</th>
<th>PSI</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
<th>120</th>
</tr>
</thead>
<tbody>
<tr>
<td>0537</td>
<td>2.7</td>
<td>2.7</td>
<td>3.4</td>
<td>4.1</td>
<td>4.8</td>
<td>5.4</td>
<td>6.0</td>
<td>6.8</td>
<td>8.2</td>
<td></td>
</tr>
<tr>
<td>1537</td>
<td>2.22</td>
<td>2.25</td>
<td>2.9</td>
<td>3.3</td>
<td>3.9</td>
<td>4.5</td>
<td>5.1</td>
<td>5.6</td>
<td>6.7</td>
<td></td>
</tr>
</tbody>
</table>

Note: All figures are rounded.

### Air Consumption per Stroke:

<table>
<thead>
<tr>
<th>Size</th>
<th>Free Air</th>
<th>0537</th>
<th>1537</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO OPEN</td>
<td>FL³</td>
<td>.011</td>
<td>.04</td>
</tr>
<tr>
<td>TO CLOSE</td>
<td>FL³</td>
<td>.111</td>
<td>.04</td>
</tr>
</tbody>
</table>

### Weight:

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Double Acting</th>
<th>Spring Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>0537</td>
<td>1.75</td>
<td>2.25</td>
</tr>
<tr>
<td>1537</td>
<td>6.6</td>
<td>9.7</td>
</tr>
</tbody>
</table>

### Opening/Closing Times:

<table>
<thead>
<tr>
<th>Model No.</th>
<th>0537</th>
<th>1537</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average times under 50% load conditions (80 PSI)</td>
<td>less than one second</td>
<td>less than one second</td>
</tr>
</tbody>
</table>

### Operating Conditions:

- **Temperature Range**: 0°F to +175°F
- **Degree of Rotation**: 0° to 90° with max/min on over travel at 175°F. Motor may fail at other end of stroke, i.e. -7°F to 90° or 0° to 175°F
- **Operating Medium**: Air or non-corrosive gas
### How To Order

<table>
<thead>
<tr>
<th>Size</th>
<th>Body Material</th>
<th>Special Services</th>
<th>Series</th>
<th>Modifications/ Solenoid</th>
<th>Solenoid Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>05</td>
<td>Aluminum Body</td>
<td>Blank—In Line Mount</td>
<td>37</td>
<td>Blank—General Purpose Solenoid (NEMA I)</td>
<td>6, 12, 24 DC; 24, 115, 230 AC (60 cycle)</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>9—Cross-Line Mount</td>
<td></td>
<td>S—Spring Return</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>W—Splashproof Solenoid (NEMA III)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X—Hazardous Locations Solenoid (NEMA VII &amp; IX)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N—No Solenoid (No Block)</td>
<td></td>
</tr>
</tbody>
</table>

**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.
Appendix, A2

Specifications for
Fairchild Model 24
Snap Acting Relay
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.

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.

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.
- **Change in signal to operate** ........ see chart
- **Repeatability** ......................... ±2" (5 cm) W.C.
- **CV Rating** ............................. 0.23
- **Mounting** .............................. any position — pipe or bracket
- **Temperature limits** .................. (-40°F to +200°F)
- **Air consumption** ..................... less than .015 SCFM (.03 m³/HR)

**Materials of Construction**

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

<table>
<thead>
<tr>
<th>Range</th>
<th>Inlet and Outlet</th>
<th>Change in Signal to Operate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot;W.C.-10 psig</td>
<td>¼”</td>
<td>0.2” W.C.</td>
</tr>
<tr>
<td>2&quot;W.C.-10 psig</td>
<td>¾”</td>
<td>0.2” W.C.</td>
</tr>
<tr>
<td>.5–30 psig</td>
<td>¼”</td>
<td>0.1 psig</td>
</tr>
<tr>
<td>.5–30 psig</td>
<td>¾”</td>
<td>0.1 psig</td>
</tr>
<tr>
<td>1.0–60 psig</td>
<td>¼”</td>
<td>0.2 psig</td>
</tr>
<tr>
<td>1.0–60 psig</td>
<td>¾”</td>
<td>0.2 psig</td>
</tr>
<tr>
<td>2.0–120 psig</td>
<td>¼”</td>
<td>0.5 psig</td>
</tr>
<tr>
<td>2.0–120 psig</td>
<td>¾”</td>
<td>0.5 psig</td>
</tr>
</tbody>
</table>

**OUTLINE DIMENSIONS**

MODEL 24
SNAP ACTING RELAY

![Diagram of model 24 snap acting relay](image)
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.
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.

<table>
<thead>
<tr>
<th>Catalog Number</th>
<th>Range</th>
<th>Change in Signal to Operate</th>
</tr>
</thead>
<tbody>
<tr>
<td>243122 243222</td>
<td>2&quot; W.C.–10 psig (5cm–70 kPa)</td>
<td>$\frac{1}{4}&quot;$ 0.2&quot; W.C. .5 cm</td>
</tr>
<tr>
<td>243123 243223</td>
<td>2&quot; W.C.–10 psig (5cm–70 kPa)</td>
<td>$\frac{3}{8}&quot;$ 0.2&quot; W.C. .5 cm</td>
</tr>
<tr>
<td>243132 243232</td>
<td>.5–30 psig (3.5–200 kPa)</td>
<td>$\frac{1}{4}&quot;$ 0.1 psig .7 kPa</td>
</tr>
<tr>
<td>243133 243233</td>
<td>.5–30 psig (3.5–200 kPa)</td>
<td>$\frac{3}{8}&quot;$ 0.1 psig .7 kPa</td>
</tr>
<tr>
<td>243142 243242</td>
<td>1.0–60 psig (7–420 kPa)</td>
<td>$\frac{1}{4}&quot;$ 0.2 psig 1.4 kPa</td>
</tr>
<tr>
<td>243143 243243</td>
<td>1.0–60 psig (7–420 kPa)</td>
<td>$\frac{3}{8}&quot;$ 0.2 psig 1.4 kPa</td>
</tr>
<tr>
<td>243162 243262</td>
<td>2.0–120 psig (14–840 kPa)</td>
<td>$\frac{1}{4}&quot;$ 0.5 psig 3.5 kPa</td>
</tr>
<tr>
<td>243163 243263</td>
<td>2.0–120 psig (14–840 kPa)</td>
<td>$\frac{3}{8}&quot;$ 0.5 psig 3.5 kPa</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Option</th>
<th>Suffix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separate supply to pilot</td>
<td>SS</td>
</tr>
<tr>
<td>Knob adjustment</td>
<td>K</td>
</tr>
<tr>
<td>Tamper proof cap</td>
<td>T</td>
</tr>
</tbody>
</table>

Optional Mounting Bracket: EB-09921

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

<table>
<thead>
<tr>
<th>Dewar Pressure</th>
<th>Material Wt. Heads &amp; Shells</th>
<th>Shell Thickness</th>
<th>Mat'l Cost Increment</th>
</tr>
</thead>
<tbody>
<tr>
<td>65 psig + Vacuum</td>
<td>12,660#</td>
<td>0.228&quot;</td>
<td>2</td>
</tr>
<tr>
<td>150 psig + Vacuum</td>
<td>28,000#</td>
<td>-----</td>
<td>3</td>
</tr>
<tr>
<td>250 psig + Vacuum</td>
<td>43,200#</td>
<td>0.778&quot;</td>
<td>$61,080</td>
</tr>
</tbody>
</table>

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

page 4 of 5
The Costs of the D0 Overfill Solution

<table>
<thead>
<tr>
<th>Parts</th>
<th>'89 Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Worcester C4, 1&quot;, Cryogenic ball valve</td>
<td>$850</td>
</tr>
<tr>
<td>2. Worcester series 37 valve actuator</td>
<td>$350</td>
</tr>
<tr>
<td>3. Fairchild Model 24 Snap Action Relay</td>
<td>$187</td>
</tr>
<tr>
<td>4. Miscellany</td>
<td>$100</td>
</tr>
</tbody>
</table>

**SUB-TOTAL** $1487

**Installation**

| P/O normal install | $000 |

**TOTAL** $1487