FLOWSERVE

# McCANNA CryoSeal®
# Top Entry Cryogenic Ball Valves
## Reduced and Full Port

*Experience In Motion*

**Liquefaction:** Due to liquefaction it has become both technically and economically feasible to transport LNG.

**LNG Carriers:** Highly sophisticated ships with typical capacities of 150,000 cu.m. are used for global transportation

**Regasification Terminals:** Convert liquid natural gas offloaded from LNG carriers back into a gaseous state.

# *McCANNA CryoSeal® Valves*

Natural gas has become one of the most important energy sources in the world, and consumption worldwide is set to grow in the coming decades. It is now an alternative fuel in marine applications, power generation plants and most recently in vehicles. The replacement of fossil fuels such as HFO, MDO and diesel has a significant positive contribution to the environment – almost eliminating emissions of NOX, SOX, CO particulates and reducing CO2 emissions.

The new CryoSeal valve from Flowserve McCANNA represents the optimum design solution for cryogen flow isolation at temperatures as low as -320 °F / -196 °C, offering a number of features which make it ideally suited to applications including LNG liquefaction, transportation and regasification. Its top-entry design enables easy, time-saving in-line maintenance, while its quarter turn operation and special low-torque seat profiles make it simple and cost-effective to automate.

Particularly significant is the fact that the CryoSeal is certified as both fire-safe as well as meeting the ISO15848 standard for fugitive emissions, making it an ideal choice for a number of cryogenic applications.

## *Cryogenic Temperatures to -320 °F (-196 °C)*

- ½" – 6" (15-150mm) Full Port, ½" - 8" (15 -200mm) Reduced Port
- ANSI Class 150, 300, 600
- Buttweld and flanged ends
- 316/316L material
- Cast, full port buttweld body
- Single-piece stem
- ASME B16.34 compliant stem extension wall section
- Extension height to BS 6364, MSS SP-134, MESC SPE 77/200 specifications
- ASME B16.10 – Face to Face (buttweld and reduced port flanged valves)
- ISO 5211 mounting pad
- Designed in accordance with API 6D

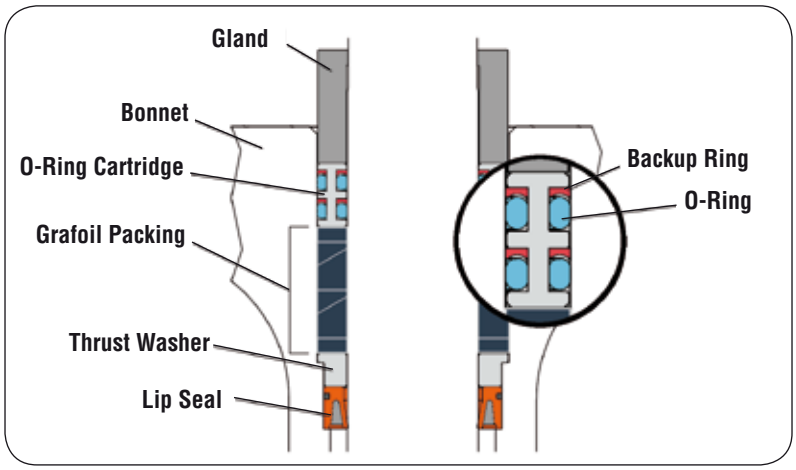
## Features

- Top Entry, Wedge-Seat design
- PCTFE (e.g. Kel-F®) seat material*
- Special low-torque cryogenic seat profile
- All cast non-welded bonnet extension
- Stems are double-sealed
- Live loaded stem seals
- Inline repairable (see IOM FCD MMENIM2007-010AQ for repair instructions/procedures located at flowserve.com)
- Upstream cavity pressure relief
- ISO 15848-1 Fugitive Emission Testing

*Kel-F is a registered trademark of 3M Company

## New Improved Packing Design

Qualified Low-E (ISO 15848-1) and Fire Safe (API 607 Rev6). Packing is live loaded, composed of a PTFE lip seal, cup and cone graphite, and double O-Rings on stem and bonnet




**Stem Seal Assembly**

## Liquefied Natural Gas

LNG, or **L**iquefied **N**atural **G**as, is simply natural gas converted into a liquid by cooling it to -260˚ Fahrenheit. This process reduces its volume by a factor of more than 600 – similar to reducing the volume of a beach ball to the volume of a ping-pong ball. This allows natural gas to be transported efficiently by sea. Once it reaches its destination, LNG is unloaded from ships at import terminals where it is stored as a liquid until it is warmed back to natural gas. The natural gas is then sent through pipelines for distribution to business and homeowners. Additional transportation methods include over-the-road tankers and rail cars.

## LNG Value Chain

| UPSTREAM | MIDSTREAM | | DOWNSTREAM | |
|---|---|---|---|---|
|  |  |  |  |  |
| **Exploration and Production**<br>Natural gas extraction | **Liquefaction**<br>Gas cooled to -260 °F (-162 °C)<br>600 times less volume as a liquid | **Shipping**<br>Easy, safe transportation by LNG carriers | **Storage and Regasification**<br>Vaporization process returns LNG back to gaseous state | **Delivery**<br>Delivered to consumers by pipeline. Burns cleanly and efficiently, minimizing emissions |

**Natural Gas for HHP Engines and LNG Tender Cars**
More than 10,000 gallons LNG capacity – providing a longer range than a diesel locomotive.

**Small-scale liquefaction**
(100-750 tpd) is an increasing part of the overall LNG supply picture as customers seek to take advantage of the economic and environmental benefits associated with using gas in place of diesel and other distillate fuels.

## LNG Production

An LNG train is a liquefied natural gas plant's liquefaction and purification facility. In order to make it practical and commercially viable to transport natural gas from one country to another, its volume has to be greatly reduced. To obtain maximum volume reduction, the gas has to be liquefied (condensed) by refrigeration to less than -162 °C (the boiling point of methane at atmospheric pressure). This process also requires very strict safety measures and precautions during all liquefaction stages, due to the flammable nature of the gas involved. Since the numerous impurities that are naturally found in the raw gas freeze at low temperatures, and would thus block the cryogenic section of the plant, the gas has to be purified before it can be cooled down to cryogenic temperatures. Each LNG plant consists of one or more trains to compress natural gas into liquefied natural gas. A typical train consists of a compression area, propane condenser area, methane, and ethane areas.

## LNG Bunkering

**Bunkering of Liquefied Natural Gas-fueled Marine Vessels**

LNG is an attractive bunker fuel option for many shipping companies through the world. The price of LNG bunker fuel is an economical alternative to other Emission Control Areas (ECA) complaint fuels. The widening gap between natural gas prices and other conventional fuels are major drivers for the development of LNG bunkering investments.
There are multiple options for bunkering LNG on to vessels, depending on how the LNG is sourced and whether or not a bulk storage tank or bunkering vessel is present at the bunkering location.

**Terminal Storage Tank to Vessel:** Vessels arrive at a waterfront facility designed to deliver LNG as a fuel to the vessel. Fixed hoses and cranes or dedicated bunkering arms may be used to handle the fueling hoses and connect them to the vessels. Piping manifolds are in place to coordinate fuel delivery from one or more fuel storage tanks.

**Truck to Vessel:** A tank truck typically consists of a large-frame truck. The mobile facility arrives at a prearranged transfer location and provides hoses that are connected to the truck and to the vessel moored at a dock. Sometimes the hoses are supported on deck and in other arrangements supported from overhead. The transfer usually occurs on a pier or wharf, using a 2-4" (0.05-0.1m) diameter hose.

**Vessel to Vessel:** Some marine terminals allow barges to come alongside cargo ships while at their berths, thus allowing cargo to be loaded and the vessel to be fueled at the same time. Vessel fueling can also occur at anchorages. Vessel-to-vessel transfers are the most common form of bunkering for traditional fuel oil.

CryoSeal 6” Valve with actuator

2” McCANNA CryoSeal test preparation

-320 °F liquid nitrogen testing

## *Cryogenic Testing to BS6364*

Flowserve recognizes that special cryogenic testing requirements are routinely required to support customer needs. A state-of-technology testing facility is located at Flowserve’s Cookeville Valve Operation (USA).

**Cryogenic Test Capabilities include:**

High Pressure Test Bunker
Liquid Nitrogen (LN2) Storage and Delivery System
Cryogenic Dunk Tank
Automated Control and Data Collection System
BS6364 Test Report

6” McCANNA cryogenic valve removed from -320 °F LN2 tank

**LN2 Storage and Delivery System**

3000 gallon vacuum insulated storage tank
Vacuum Jacketed Pipeline

**Cryogenic Dunk Tank**

180 gallon vacuum insulated test tank includes integrated valve support system
Accommodates valves up to 8”
Equipped with automated level control
Includes forced nitrogen gas exhaust system
Automated Control and Data Collection System

## Certifications

- BS 6364 and API 608 (buttweld and reduced port flanged valves) - design and testing requirements
- API 607 and ISO 10497 - fire test
- ISO 15848-1 fugitive emission testing. Tightness Class BH, Endurance Class C01
- API 598 testing
- AAR (American Association of Railroads)

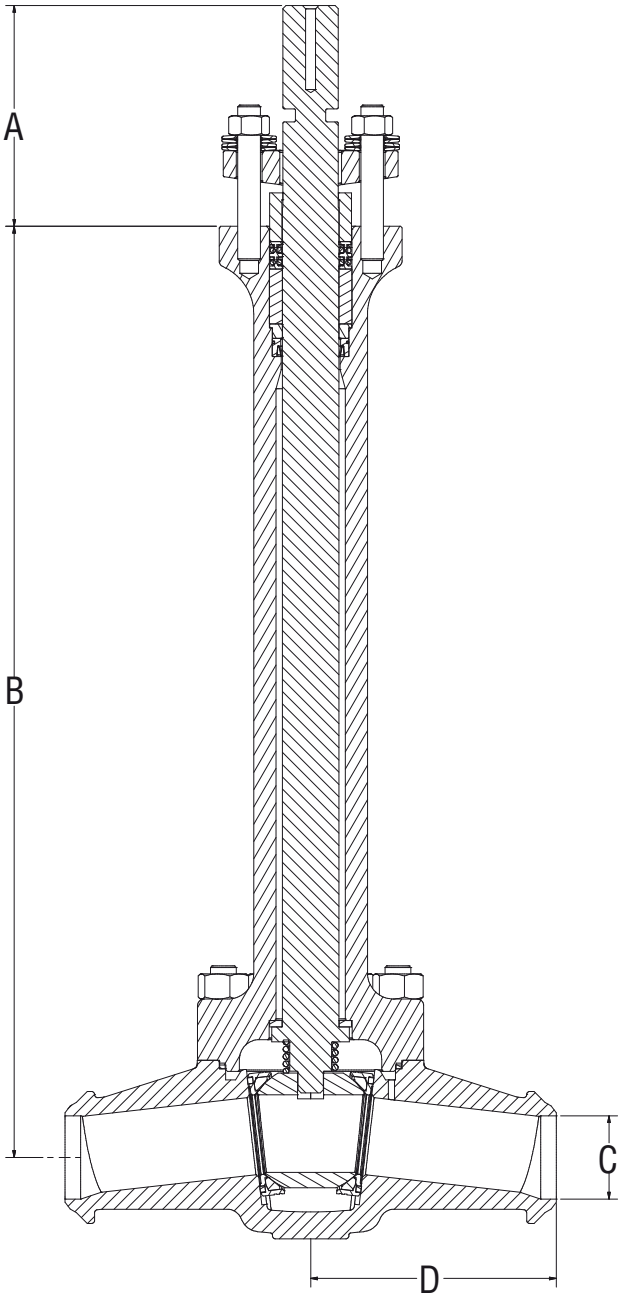
## Applications

- Over-the-road LNG-LPG trailers (fail safe – fire safe)
- LNG (Liquid Natural Gas) terminal storage, unloading and transportation facilities
- Air separation plants (mainly under 2”), BOF, baseloading, pipeline
- Liquid and gaseous oxygen for steel production - BOF process, inerting and heat treatment
- Liquid and gaseous Hydrogen, Nitrogen and Helium
- CO2 and Nitrogen injection for oil recovery
- Gas liquefaction
- High purity cryogenic / gas systems for electronics, medical and hospital oxygen systems
- LNG PEAK shaving terminals
- Over-the-road CO2, LN2 food carriers
- Pharmaceutical – temperature control, lyophylization, blood storage, cryosurgery
- Food processing – frozen food, heat transfer
- Sewage plants – LOX, LO2, for treatment
- Industrial air conditioning – ammonia, Freon
- Petroleum refining unleaded gasoline – gas treatment from skids, fractionation oil wells
- Schools, hospitals, laboratories, weld supply houses, oxygen system, low temperature storage and distribution
- Aerospace – LOX fuelling, rocket testing, LN2 , LHe systems


Please contact your Flowserve McCANNA representative for assistance in specifying materials and cleaning procedures for valves in O2 or H2 service


Please contact your Flowserve McCANNA representative for assistance in specifying materials for LOX, GOX, LH and LHe

## Butt Weld Valves




## CryoSeal Materials of Construction

| Parts Description | Material |
|---|---|
| Body - Buttweld or flanged ends | ASTM A351/A744, Grade CF3M, UNS J92800 (316L SS) CF8M for flanged bodies |
| Cast Bonnet Extension | ASTM A351/A744; Grade CF8M, 316 SS |
| Stem | N50 ASTM A479; UNS S20910 |
| Ball | ASTM A276, UNS S31600, Type 316 or ASTM A351, Grade CF8M |
| Spring | Inconel® X750 |
| Seat Ring | ASTM A276 UNS S31600 Type 316 |
| Seats | PCTFE (e.g. Kel-F®)* |
| Bonnet Stud | ASTM A320 - Grade B8 Class 2 (AISI Type 304) |
| Adjuster Stud | ASTM A193 - Grade B8M2 Class 2B or Grade B8M3 Class 2C (AISI Type 316) |
| Adjuster nuts | ASTM A194 GRADE 8M (AISI 316 SS) |
| Bonnet nuts | ASTM A194 Grade 8 (AISI Type 304) |

*Kel-F is a registered trademark of 3M Company

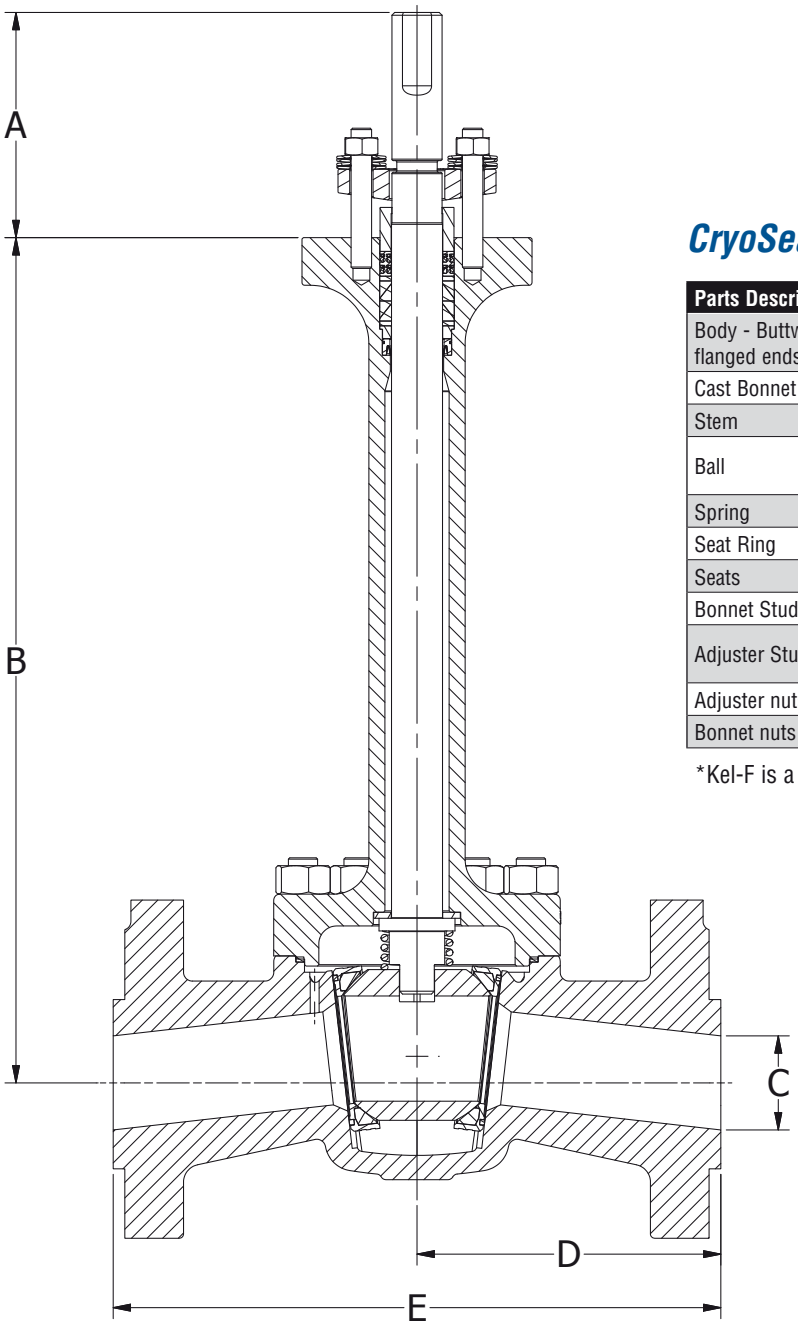
## Dimensions for Butt Weld Valves (inch)

| Valve Size | A | B | C | D | Weight (lbs) |
|---|---|---|---|---|---|
| ½" 300# | 3.99 | 15 | 0.62 | 2.75 | 17.1 |
| ½" 600# | 3.99 | 15 | 0.62 | 3.25 | 20.1 |
| ¾" 300# | 3.99 | 15 | 0.82 | 3.00 | 17.2 |
| ¾" 600# | 3.99 | 15 | 0.82 | 3.75 | 20.3 |
| 1" 300# | 3.99 | 15 | 1.05 | 3.25 | 17.2 |
| 1" 600# | 3.99 | 15 | 1.05 | 4.25 | 20.2 |
| 1½" 300# | 3.94 | 18 | 1.61 | 3.75 | 28 |
| 1½" 600# | 4.26 | 18 | 1.61 | 4.75 | 36.7 |
| 2" 300# | 4.47 | 18 | 2.07 | 4.25 | 48.2 |
| 2" 600# | 4.85 | 18 | 2.07 | 5.75 | 59.8 |
| 3" 300# | 7.35 | 24 | 3.07 | 5.56 | 147 |
| 3" 600# | 8.00 | 24 | 3.07 | 7.00 | 170 |
| 4" 300# | 7.75 | 24 | 4.03 | 6.00 | 217 |
| 4" 600# | 7.50 | 24 | 4.03 | 8.50 | 293 |
| 6" 300# | 9.18 | 24 | 6.07 | 9.00 | 465 |
| 6" 600# | 9.38 | 24 | 6.07 | 11.00 | 588 |

## Dimensions for Butt Weld Valves (mm)

| Valve Size | A | B | C | D | Weight (kg) |
|---|---|---|---|---|---|
| 0.5" 300# | 101.3 | 381.0 | 15.8 | 69.9 | 7.8 |
| 0.5" 600# | 101.3 | 381.0 | 15.8 | 82.6 | 9.1 |
| 0.75" 300# | 101.3 | 381.0 | 20.9 | 76.2 | 7.8 |
| 0.75" 600# | 101.3 | 381.0 | 20.9 | 95.3 | 9.2 |
| 1" 300# | 101.3 | 381.0 | 26.7 | 82.6 | 7.8 |
| 1" 600# | 101.3 | 381.0 | 26.7 | 108.0 | 9.2 |
| 1.5" 300# | 100.1 | 457.2 | 40.9 | 95.3 | 12.7 |
| 1.5" 600# | 108.2 | 457.2 | 40.9 | 120.7 | 16.6 |
| 2" 300# | 113.5 | 457.2 | 52.6 | 108.0 | 21.9 |
| 2" 600# | 123.2 | 457.2 | 52.6 | 146.1 | 27.1 |
| 3" 300# | 186.7 | 609.6 | 78.0 | 141.2 | 66.7 |
| 3" 600# | 203.2 | 609.6 | 78.0 | 177.8 | 77.1 |
| 4" 300# | 196.9 | 609.6 | 102.4 | 152.4 | 98.4 |
| 4" 600# | 190.5 | 609.6 | 102.4 | 215.9 | 132.9 |
| 6" 300# | 233.2 | 609.6 | 154.2 | 228.6 | 210.9 |
| 6" 600# | 238.3 | 609.6 | 154.2 | 279.4 | 266.7 |

## Flanged Valves

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| Cast Bonnet Extension | ASTM A351/A744; Grade CF8M, 316 SS |
| Stem | N50 ASTM A479; UNS S20910 |
| Ball | ASTM A276, UNS S31600, Type 316 or ASTM A351, Grade CF8M |
| Spring | Inconel® X750 |
| Seat Ring | ASTM A276 UNS S31600 Type 316 |
| Seats | PCTFE (e.g. Kel-F®)* |
| Bonnet Stud | ASTM A320 - Grade B8 Class 2 (AISI Type 304) |
| Adjuster Stud | ASTM A193 - Grade B8M2 Class 2B or Grade B8M3 Class 2C (AISI Type 316) |
| Adjuster nuts | ASTM A194 GRADE 8M (AISI 316 SS) |
| Bonnet nuts | ASTM A194 Grade 8 (AISI Type 304) |

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0.50
- 0.75
- 1.00
- 1.50
- 2.00
- 3.00
- 4.00
- 6.00

Please contact your Flowserve McCANNA representative for assistance in specifying materials and cleaning procedures for valves in $O^2$ or $H^2$ service

## Dimensions for Flange Valves (inch)

**Reduced Port**

| Valve Size | A | B | C | D | E (F-to-F) | Weight (lbs) |
|---|---|---|---|---|---|---|
| 1½" 150# | 3.99 | 15.00 | 1.60 | 3.25 | 6.50 | 24.5 |
| 1½" 300# | 3.99 | 15.00 | 1.69 | 3.75 | 7.50 | 31.5 |
| 1½" 600# | 3.99 | 15.00 | 1.56 | 4.75 | 9.50 | 38.5 |
| 2" 150# | 3.94 | 18.00 | 2.01 | 3.50 | 7.00 | 37.5 |
| 2" 300# | 3.94 | 18.00 | 2.12 | 4.25 | 8.50 | 43.5 |
| 2" 600# | 4.26 | 18.00 | 2.14 | 5.75 | 11.50 | 53.5 |
| 3" 150# | 4.47 | 18.00 | 3.12 | 4.00 | 8.00 | 63 |
| 3" 300# | 4.47 | 18.00 | 3.14 | 5.57 | 11.13 | 81 |
| 3" 600# | 4.85 | 18.00 | 3.19 | 7.00 | 14.00 | 101 |
| 4" 150# | 7.16 | 24.00 | 4.01 | 4.50 | 9.00 | 170 |
| 4" 300# | 7.16 | 24.00 | 3.99 | 6.00 | 12.00 | 195 |
| 4" 600# | 8.00 | 24.00 | 3.98 | 8.50 | 17.00 | 225 |
| 6" 150# | 7.75 | 24.00 | 5.92 | 7.75 | 15.50 | 264 |
| 6" 300# | 7.75 | 24.00 | 5.97 | 7.94 | 15.88 | 306 |
| 6" 600# | 7.50 | 24.00 | 6.00 | 11.00 | 22.00 | 366 |
| 8" 150# | 9.18 | 24.00 | 8.00 | 9.00 | 18.00 | 510 |
| 8" 300# | 9.18 | 24.00 | 8.26 | 9.88 | 19.75 | 578 |
| 8" 600# | 9.38 | 24.00 | 8.12 | 13.00 | 26.00 | 698 |

**Full Port**

| Valve Size | A | B | C | D | E (F-to-F) | Weight (lbs) |
|---|---|---|---|---|---|---|
| 1" 150# | 3.99 | 15.00 | 1.00 | 3.50 | 7.00 | 17.5 |
| 1" 300# | 3.99 | 15.00 | 1.00 | 3.75 | 7.50 | 23.5 |
| 1" 600# | 3.99 | 15.00 | 1.00 | 5.00 | 10.00 | 29.5 |
| 1½" 150# | 3.94 | 18.00 | 1.50 | 4.38 | 8.75 | 31 |
| 1½" 300# | 3.94 | 18.00 | 1.50 | 4.75 | 9.50 | 37 |
| 1½" 600# | 4.26 | 18.00 | 1.50 | 6.25 | 12.50 | 47 |
| 2" 150# | 4.47 | 18.00 | 2.00 | 5.25 | 10.50 | 44 |
| 2" 300# | 4.47 | 18.00 | 2.00 | 5.56 | 11.12 | 62 |
| 2" 600# | 4.85 | 18.00 | 2.00 | 6.50 | 13.00 | 81 |
| 3" 150# | 7.16 | 24.00 | 3.00 | 6.75 | 13.50 | 159 |
| 3" 300# | 7.16 | 24.00 | 3.00 | 7.63 | 15.25 | 184 |
| 3" 600# | 8.00 | 24.00 | 3.00 | 8.75 | 17.50 | 198 |
| 4" 150# | 7.75 | 24.00 | 4.00 | 8.50 | 17.00 | 266 |
| 4" 300# | 7.75 | 24.00 | 4.00 | 9.00 | 18.00 | 271 |
| 4" 600# | 7.50 | 24.00 | 4.00 | 10.00 | 20.00 | 367 |
| 6" 150# | 9.18 | 24.00 | 6.00 | 10.75 | 21.50 | 494 |
| 6" 300# | 9.18 | 24.00 | 6.00 | 11.00 | 22.00 | 547 |
| 6" 600# | 9.38 | 24.00 | 6.00 | 13.00 | 26.00 | 735 |

## Dimensions for Flange Valves (mm)

**Reduced Port**

| Valve Size | A | B | C | D | E (F-to-F) | Weight (kg) |
|---|---|---|---|---|---|---|
| 1.5" 150# | 101.3 | 381.0 | 40.6 | 82.6 | 165.1 | 11.1 |
| 1.5" 300# | 101.3 | 381.0 | 42.9 | 95.3 | 190.5 | 14.3 |
| 1.5" 600# | 101.3 | 381.0 | 39.6 | 120.7 | 241.3 | 17.5 |
| 2" 150# | 100.1 | 457.2 | 51.1 | 88.9 | 177.8 | 17.0 |
| 2" 300# | 100.1 | 457.2 | 53.8 | 108.0 | 215.9 | 19.7 |
| 2" 600# | 108.2 | 457.2 | 54.4 | 146.1 | 292.1 | 24.3 |
| 3" 150# | 113.5 | 457.2 | 79.2 | 101.6 | 203.2 | 28.6 |
| 3" 300# | 113.5 | 457.2 | 79.8 | 141.4 | 282.7 | 36.7 |
| 3" 600# | 123.2 | 457.2 | 81.0 | 177.8 | 355.6 | 45.8 |
| 4" 150# | 181.9 | 609.6 | 101.9 | 114.3 | 228.6 | 77.1 |
| 4" 300# | 181.9 | 609.6 | 101.3 | 152.4 | 304.8 | 88.5 |
| 4" 600# | 203.2 | 609.6 | 101.1 | 215.9 | 431.8 | 102.1 |
| 6" 150# | 196.9 | 609.6 | 150.4 | 196.9 | 393.7 | 119.7 |
| 6" 300# | 196.9 | 609.6 | 151.6 | 201.7 | 403.4 | 138.8 |
| 6" 600# | 190.5 | 609.6 | 152.4 | 279.4 | 558.8 | 166.0 |
| 8" 150# | 233.2 | 609.6 | 203.2 | 228.6 | 457.2 | 231.3 |
| 8" 300# | 233.2 | 609.6 | 209.8 | 250.8 | 501.7 | 262.2 |
| 8" 600# | 238.3 | 609.6 | 206.2 | 330.2 | 660.4 | 316.6 |

**Full Port**

| Valve Size | A | B | C | D | E (F-to-F) | Weight (kg) |
|---|---|---|---|---|---|---|
| 1" 150# | 101.3 | 381.0 | 25.4 | 88.9 | 177.8 | 7.9 |
| 1" 300# | 101.3 | 381.0 | 25.4 | 95.3 | 190.5 | 10.7 |
| 1" 600# | 101.3 | 381.0 | 25.4 | 127.0 | 254.0 | 13.4 |
| 1.5" 150# | 100.1 | 457.2 | 38.1 | 111.1 | 222.3 | 14.1 |
| 1.5" 300# | 100.1 | 457.2 | 38.1 | 120.7 | 241.3 | 16.8 |
| 1.5" 600# | 108.2 | 457.2 | 38.1 | 158.8 | 317.5 | 21.3 |
| 2" 150# | 113.5 | 457.2 | 50.8 | 133.4 | 266.7 | 20.0 |
| 2" 300# | 113.5 | 457.2 | 50.8 | 141.2 | 282.4 | 28.1 |
| 2" 600# | 123.2 | 457.2 | 50.8 | 165.1 | 330.2 | 36.7 |
| 3" 150# | 181.9 | 609.6 | 76.2 | 171.5 | 342.9 | 72.1 |
| 3" 300# | 181.9 | 609.6 | 76.2 | 193.7 | 387.4 | 83.5 |
| 3" 600# | 203.2 | 609.6 | 76.2 | 222.3 | 444.5 | 89.8 |
| 4" 150# | 196.9 | 609.6 | 101.6 | 215.9 | 431.8 | 120.7 |
| 4" 300# | 196.9 | 609.6 | 101.6 | 228.6 | 457.2 | 122.9 |
| 4" 600# | 190.5 | 609.6 | 101.6 | 254.0 | 508.0 | 166.5 |
| 6" 150# | 233.2 | 609.6 | 152.4 | 273.1 | 546.1 | 224.1 |
| 6" 300# | 233.2 | 609.6 | 152.4 | 279.4 | 558.8 | 248.1 |
| 6" 600# | 238.3 | 609.6 | 152.4 | 330.2 | 660.4 | 333.4 |

## CryoSeal - How to Order

| 4.0 | CX | 60 | P | S6 | K | 6N | |
|---|---|---|---|---|---|---|---|
| **Valve Size** | **Type** | **Pressure** | **End Connection** | **Body Material** | **Standard Seats** | **Trim** | **Special Preparation** |
| 0.50 | CX - Cryogenic | 15 - ANSI Cl 150 | 1 - Flanged | S6 - CF8M | K-PCTFE (e.g. Kel-F®)* | 6N | |
| 0.75 | | 30 - ANSI Cl 300 | P - Sch 40 Buttweld | 6L - CF3M | | | |
| 1.00 | | 60 - ANSI Cl 600 | S - Sch 80 Buttweld | | | | |
| 1.50 | | 1F - Full Port, ANSI Cl 150 | | | | | |
| 2.00 | | 3F - Full Port, ANSI Cl 300 | | | | | |
| 3.00 | | 6F - Full Port, ANSI Cl 600 | | | | | |
| 4.00 | | | | | | | |
| 6.00 | | | | | | | |
| 8.00 | | | | | | | |

**Notes:**

1. Full Port sizes 1.0" to 6.0"  2. Std port sizes 0.50" (½") to 8.0"

⚠ Please contact your Flowserve McCANNA representative for assistance in specifying materials and cleaning procedures for valves in $O^2$ or $H^2$ service

⚠ Please contact your Flowserve McCANNA representative for assistance in specifying materials for LOX, GOX, LH and LHe

*Kel-F is a registered trademark of 3M Company


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