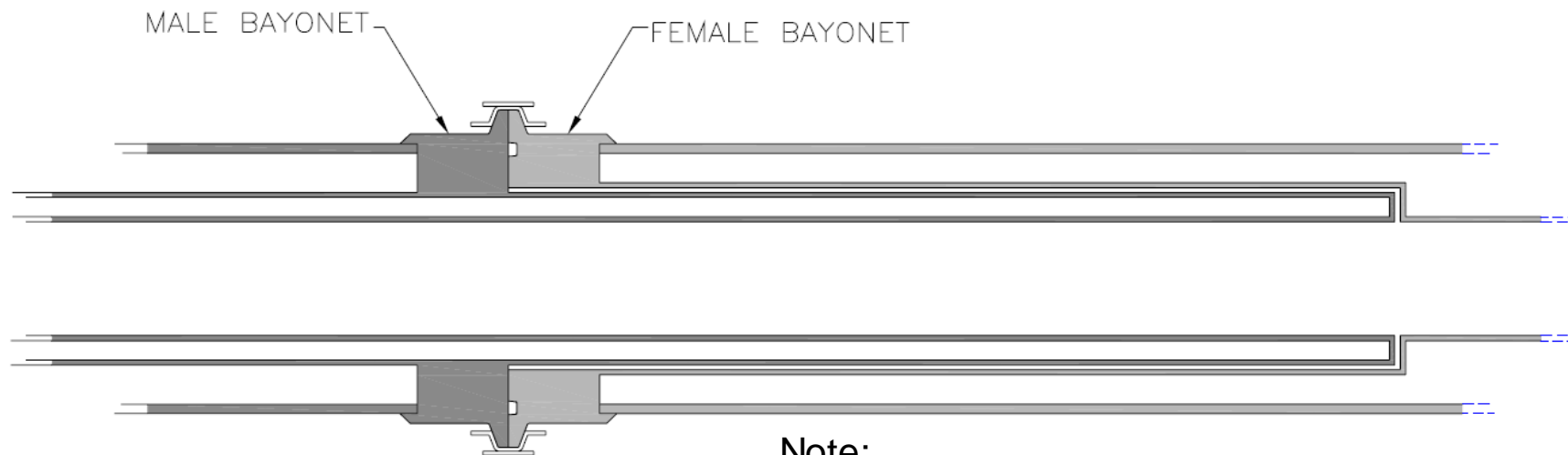


# Cryogenic Equipment

J. G. Weisend II

- Describe the nature, performance and design considerations of various components found in cryogenics
  - Connections
    - Bayonets
    - Flanges
  - Valves

- Demountable piping joints that allow quick connections of cryogenic lines
- Very useful in connecting to replaceable cryogenic liquid supplies. Frequently used in “U-Tubes”
- Reentrant, low heat leak design
- Uses at least one 300 K gas seal and sometimes a cryogenic liquid seal (typically Teflon)
- Must be built to tight mechanical tolerances
- Receiving end must be lower or at least horizontal to delivery end to avoid convection

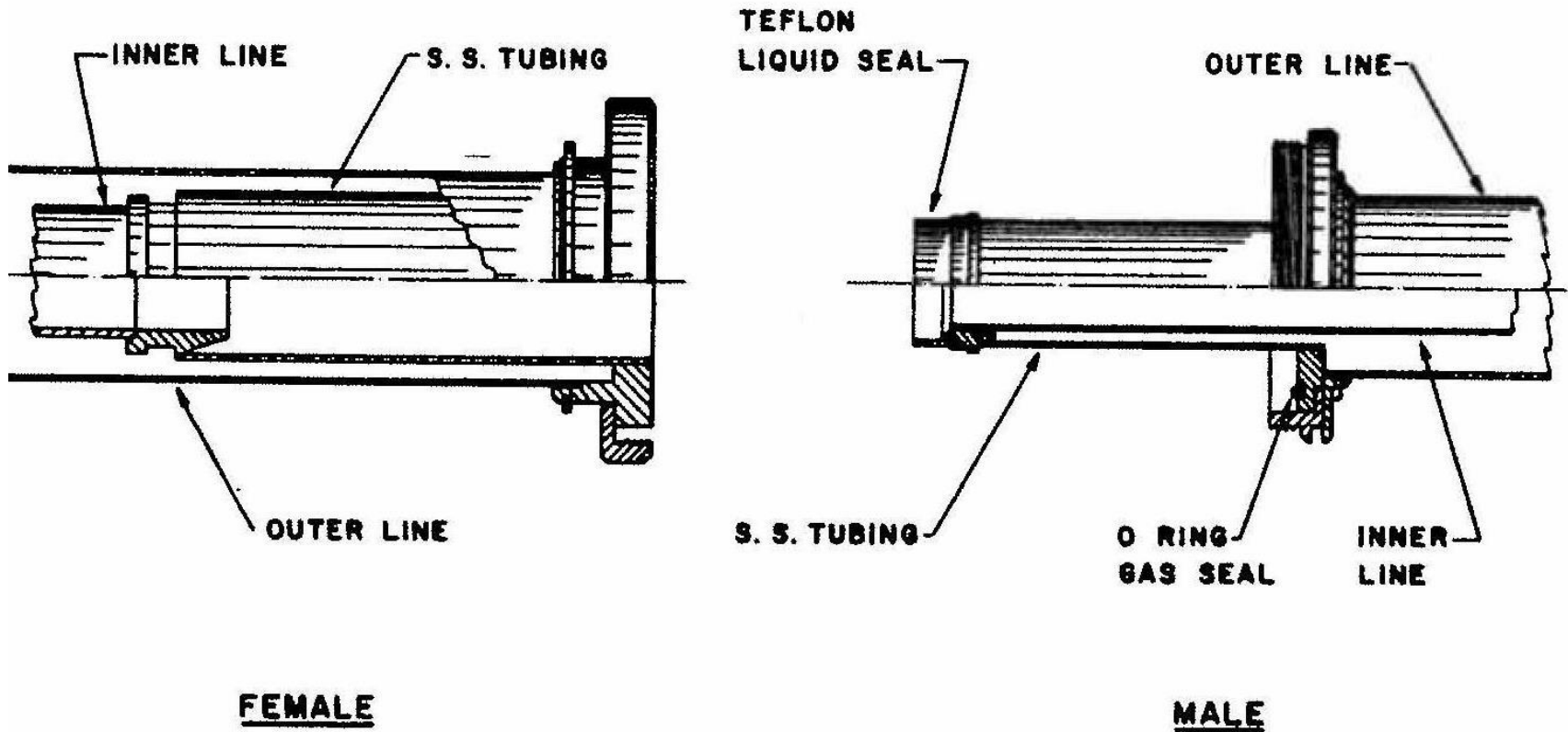


Note:  
No liquid seal  
Very tight tolerances between  
male & female sides to minimize convection  
Long, thin walls connect 300 K and 4.2 K



# Air Force Style Hydrogen Bayonet

from "Cryogenic Equipment" – D. Daney [Handbook of Cryogenic Engineering](#)





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# FNAL/SMTF Bayonet Can



EUROPEAN  
SPALLATION  
SOURCE





LUND  
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# SNS Refrigeration Plant showing U-tubes

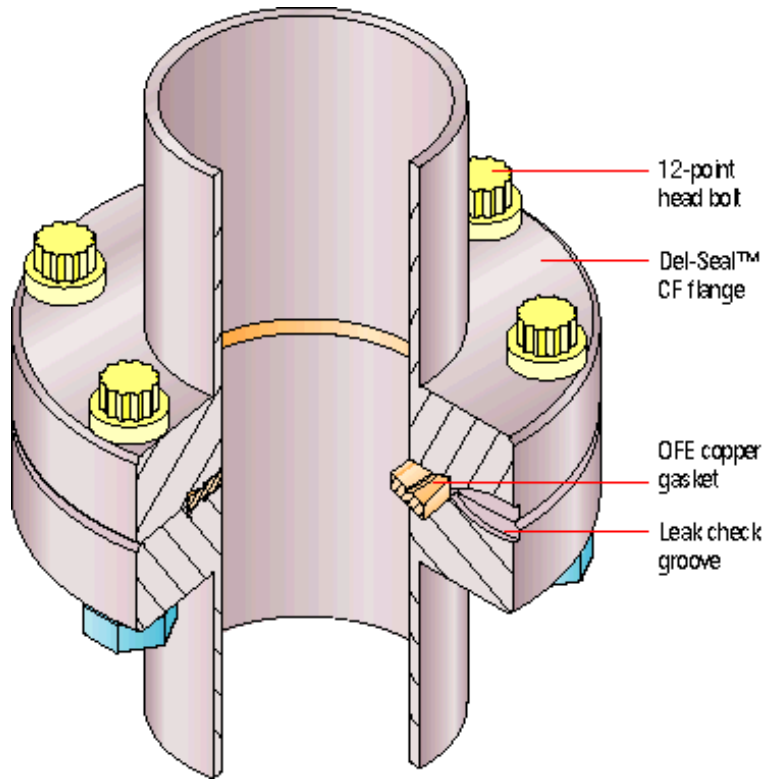


- How else do we connect pipes at cryogenic temperatures?
  - Welding is almost always the most reliable approach but sometimes a demountable joint is required.
- There are a number of demountable flange options
  - Anything involving a polymer or rubber O-ring will clearly not work at cryogenic temperatures
  - Sealing options include
    - Flanges using a soft metal gasket ( typically copper) such as Conflat flanges
    - Flanges using a metal “c” ring
    - Flanges using an indium o-ring – best used in test scenarios and typically home-made
  - With proper design and installation all of these approaches can provide leak tight joints down even at superfluid helium temperatures ( $< 2.2$  K)
- Note that vacuum and liquid leaks are a major source of problems in cryogenics. Carefully thought out and reliable connections are a key to success

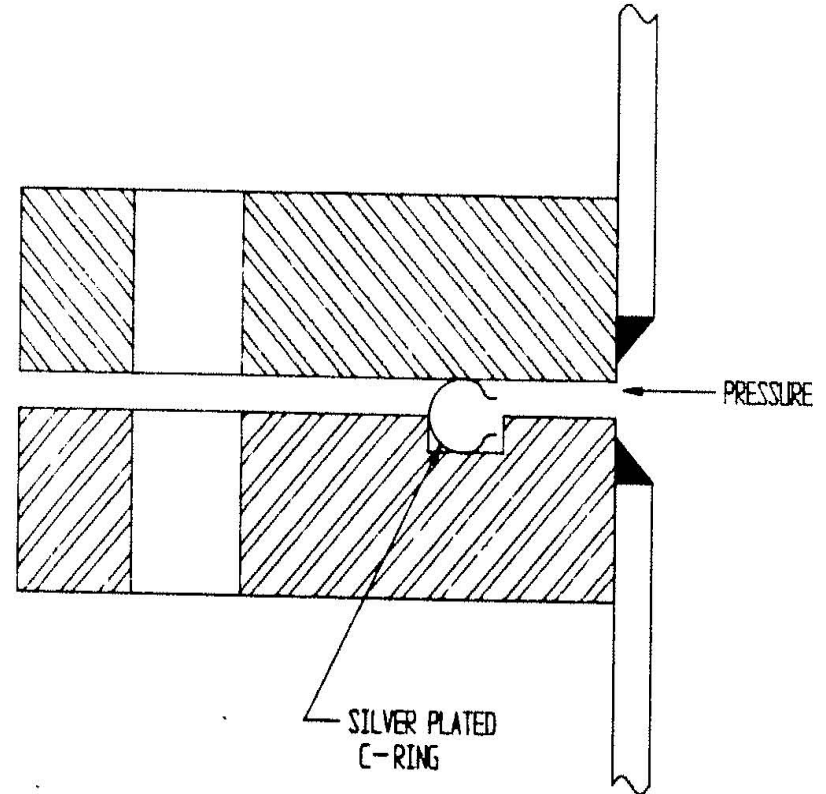




# Examples of Flanged Connections for Cryogenic Use (both are commercially available)



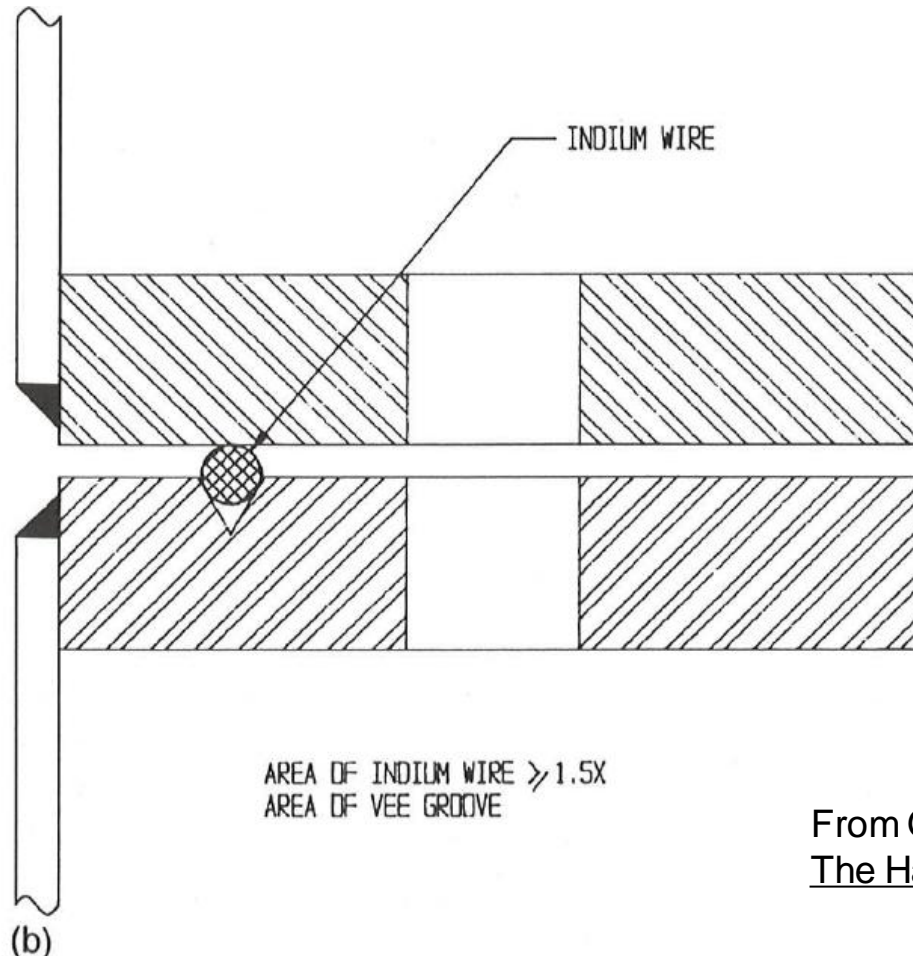
ConFlat Style  
Soft Metal Gasket



C Ring Style



# Example of Indium O-Ring Seal



From G. McIntosh in  
The Handbook of Cryogenic Engineering



- If upon cool down the flange material shrinks more than the bolt material then the seal may open up and leak
- One way to prevent this is to use invar washers so that the seal actually tightens during cool down
- The goal here is to size the components such that the bolt shrinks more than the combination of the 2 flanges and the invar washer

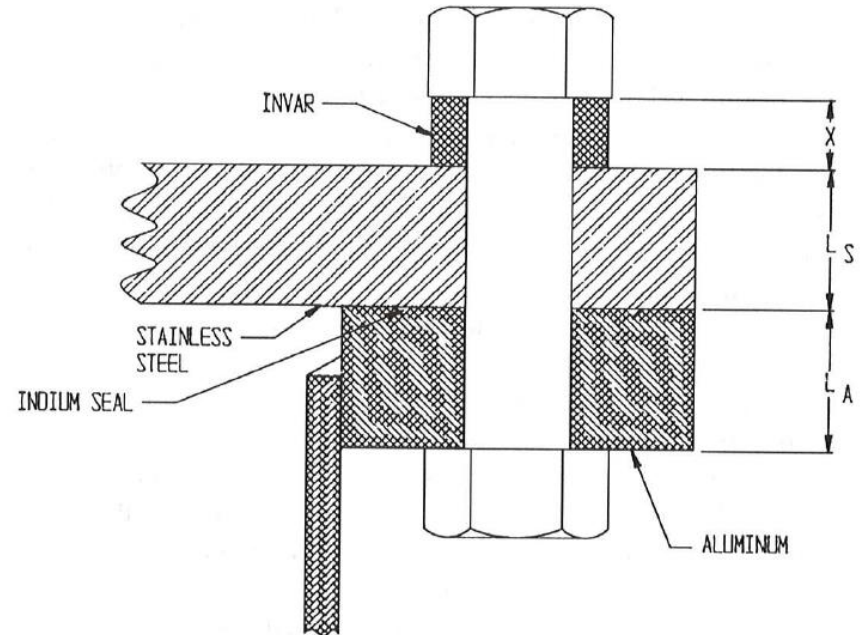


Figure 5-1 Flange joint with Invar washer.

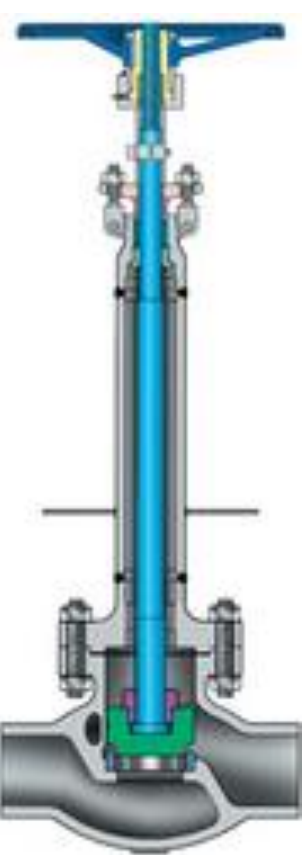
- Valves are an important part of cryogenic systems
- Valves direct flows and control both flow rates and pressure drops
- Cryogenic valves have to operate at cryogenic temperatures and minimize the heat leak from room temperature
- Except in very specialized cases, cryogenic valves have room temperature actuators
- Valves can be manually operated or more commonly operated via a control system. The actuators for remote operation are typically electro pneumatic – a current or voltage signal from the control system regulates the pressure on the pneumatic drive that controls the valve position.
- A wide range of cryogenic valves is available in industry



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# Basic Valve Types

(All can be implemented in cryogenic systems with proper design and materials)

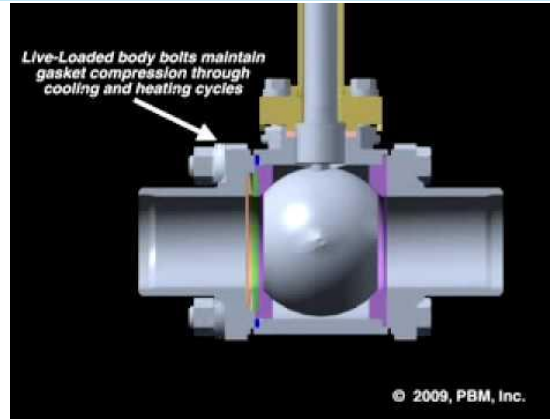


Globe



Gate

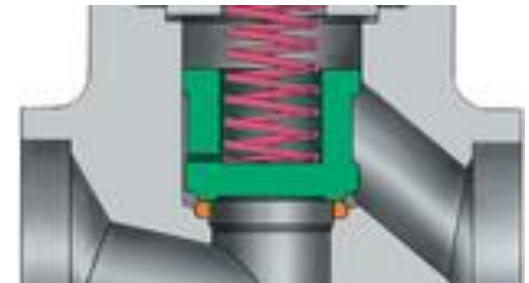
Ball



Butterfly



Relief



Check



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# Examples of Cryogenic Valves



CVI  
Model 2060

Contains  
vacuum jacket  
Heat Leak reduced  
via thin walled tubes

1 inch valve has a  
measured heat leak of  
1.3 W to 4.2 K



JT Valve  
Cryocomp  
½ inch IPS  
Designed to be  
installed inside  
cryostats  
Heat Leak to 4.2 K is ~  
1 W

# Sizing of Valves

- Valves are typically sized using the parameter  $C_v$ 
  - This parameter is defined as the number of Gal/min of water that passes through the valve with a pressure drop of 1 psi
  - This can be related to properties we care about in cryogenics by



- Be sure to use appropriate properties
- Note  $^{\circ}\text{R} = (9/5)\text{K}$

## Liquid Flow

$$C_v = \frac{Q_l \sqrt{G}}{\sqrt{\Delta P}} = \frac{7.2W_l}{\sqrt{G\Delta P}}$$

where:

$C_v$  = Valve Flow Coefficient

$\Delta P$  = Pressure Drop (psi)

$Q_l$  = Liquid Flow Rate (gpm)

$G$  = Specific Gravity =  $\frac{\text{density of subject fluid}}{\text{density of water}}$

$W_l$  = Liquid Flow Rate ( lbs/sec)

## Gaseous Flow

$$C_v = \frac{\sqrt{T}}{22.8} \left| \frac{Q_g \sqrt{G}}{61 \sqrt{P_1 \Delta P}} = \frac{730W_g}{\sqrt{GP_2 \Delta P}} \right| \frac{\sqrt{T}}{22.8}$$

where:

$C_v$  = Valve Flow Coefficient

$\Delta P$  = Pressure Drop (psi)

$Q_g$  = Gaseous Flow Rate (scfh)

$G$  = Specific Gravity =  $\frac{\text{density of subject gas at stp}}{\text{density of air}}$

$W_g$  = Gaseous Flow Rate (lbs/sec)

$P_1$  = Absolute Upstream Pressure (psia)

$P_2$  = Downstream Absolute Pressure (psia)

$T$  = Absolute Temperature ( $^{\circ}\text{R}$ )

Note: When the pressure drop ( $\Delta P$ ) is equal to or greater than  $1/2$  the absolute upstream pressure ( $P_1$ ), substitute

$$\left| \frac{P_1}{2} \right| \text{ for } \sqrt{P_1 \Delta P}$$

From Acme  
Cryogenics  
Catalog