



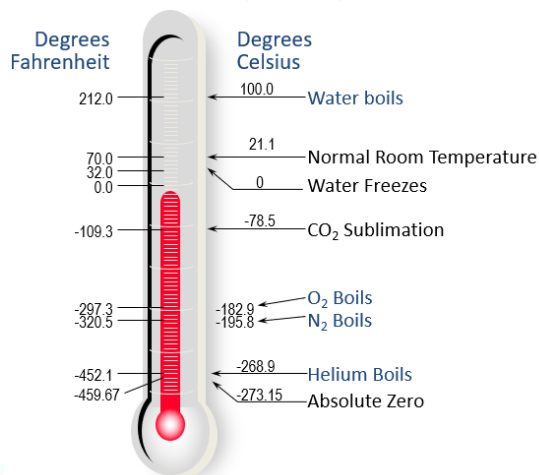
## Cryogenic Liquids Notes

Sept 2022

Under DOT, CGA and IFC the current definition is a compressed gas with a boiling point below -130°F (-90°C)

The following gases are handled like cryogenic liquids but by definition are refrigerated liquids because their boiling points are above -130°F (90°C)

- Liquid Carbon Dioxide            -109.3°F (-78.5°C)
- Liquid Nitrous Oxide            -127.4°F (-88.5°C)



Name	BP Temp @ 1 atm		Liquid Density @ BP		Latent Heat of Vaporization		Gas Density @ 70F (21C)		Gas from Liquid
	°F	°C	lb/ft3	kg/m3	btu/lb	J/kg	lb/ft3	kg/m3	vol/vol
Air	-318	-194	54.6	875	88.2	205.0	0.075	1.20	728
Argon	-303	-186	87.0	1393	70.2	163.2	0.103	1.65	842
Carbon Monoxide	-313	-192	51.1	819	92.8	215.7	0.073	1.17	706
Fluorine	-307	-188	94.1	1507	74.1	172.2	0.098	1.57	961
Helium	-452	-269	7.8	125	10.3	23.9	0.010	0.16	754
Hydrogen	-423	-253	4.4	71	192.7	447.9	0.005	0.08	850
Methane	-259	-162	26.5	424	219.2	509.5	0.042	0.67	636
Nitrogen	-320	-196	50.5	808	85.7	199.2	0.072	1.15	696
Oxygen	-297	-183	71.3	1142	91.7	213.1	0.083	1.33	861



## Key Cryogenic Codes/Standards

IFC Chapter 55, "Cryogenic Fluids" Chapter 58 and Chapter 63 all refer to NFPA 55 for flammable and ANSI/CGA P-18 for inert

NFPA® 55, "Compressed Gases and Cryogenic Fluids Code"

ANSI/CGA P-18, "Standard For Bulk Inert Gas Systems"

CGA M-1, "Medical Gas Supply Systems"

NFPA 99, Standard for Health Care Facilities

To maintain cold temperature, liquid must be vaporized constantly.

## Liquid can be

Asphyxiant ( $N_2$ , He)

Flammable ( $H_2$ )

Oxidizer ( $F_2$ ,  $O_2$ )

Toxic ( $F_2$ , CO)

## Cryogenic burns

can come from liquid or vapors from the liquid

eyes

skin

can come from un-insulated lines or equipment

hands and feet

## Embrittlement of materials

carbon steel

plastics and rubber

## Freeze out contaminants

moisture plugged lines

## Provide adequate ventilation

## Use proper personal protective equipment

## Proper system design

system compatible with product, temperature and pressure

protect areas of system where liquid can accumulate with pressure relief devices

Cold embrittlement of carbon steel. Copper, aluminum, pyrex glass and stainless steel are compatible

Large expansion volumes

Cooling a gas increases the vapor specific gravity

## Liquid Nitrogen

The most common cryogen, many uses

Cryotherapy, Ice Cream

## Liquid Oxygen

Liquid oxygen dewars on fresh fish trucks to keep them alive during transport

Liquid oxygen spills onto asphalt can be reactive.



Concrete pad at tanker offloading

Liquid oxygen portable breathers

A personal breather is filled from a larger mother tank by the user

Medical gas supply companies use pickup trucks with a dewar to fill the mother tanks at the residence

### Liquid Helium

Coldest known material

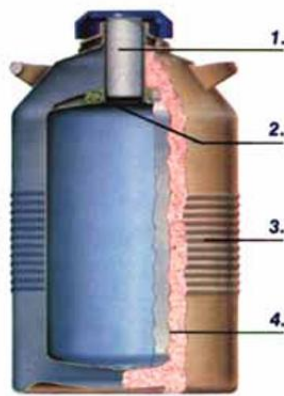
Superconductivity

### Dewars

Sir James Dewar, a Scottish chemist and physicist. He is best known for his invention of the vacuum flask, which he used in conjunction with research into the liquefaction of gases

#### Open Dewar

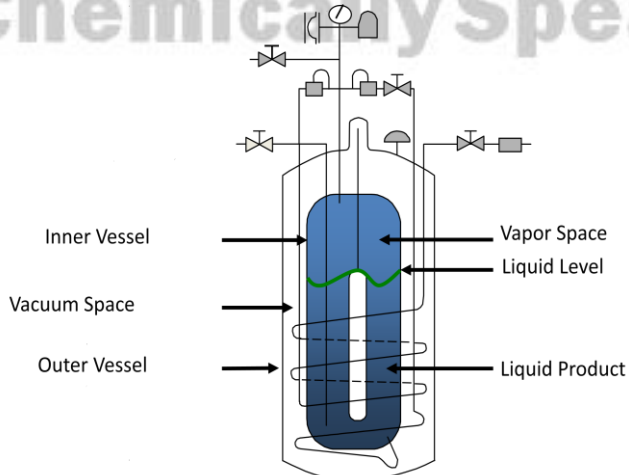
1. Plug opening
2. Inner insulation
3. Outer Shell
4. Dewar or Inner Tank

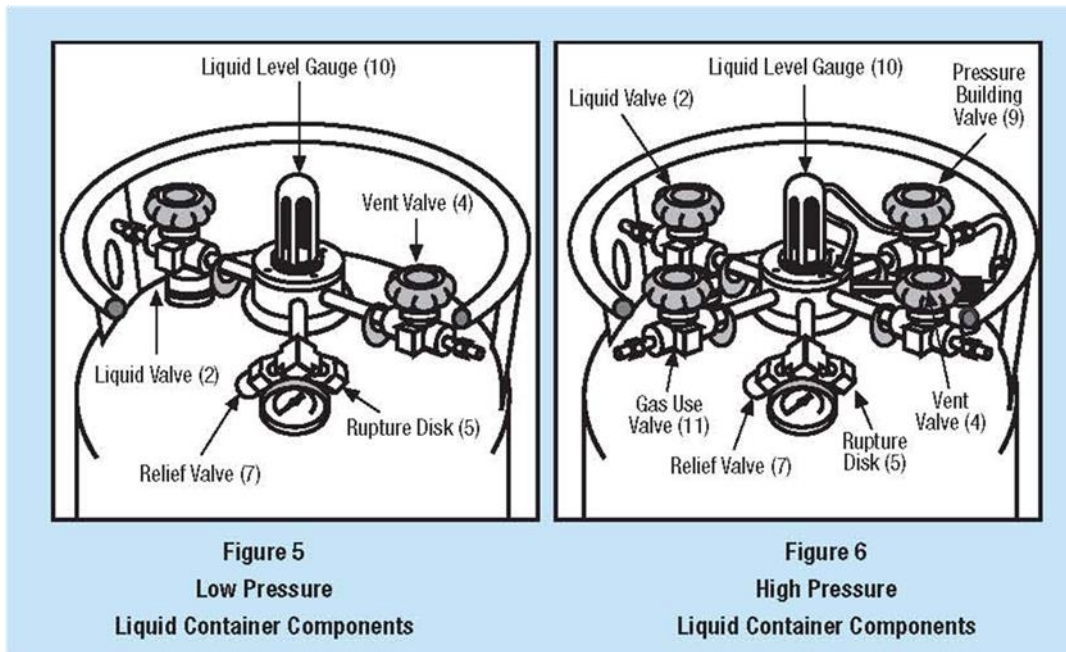


#### Closed type

A pressurized, double-walled, insulated portable container used to hold either a cryogenic liquefied gas or refrigerated liquefied gas. (large thermos bottle)

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Vent valve to allow air to vent while filling  
Liquid valve to draw off liquid from the bottom  
Gas (use) valve to draw off gas from vapor space  
Pressure Building Valve

Allows liquid to exit bottom of cylinder, through a tube that is in insulation space  
As it does this, it heats up due to heat from the outside of the cylinder and converts back into a gas  
This expansion to vapor increases the pressure  
The gas is piped back into vapor space at the top, which provides pressure to force out gas or liquid

Pressure building coil might develop a frost line on the exterior of the dewar wall  
To maintain cold temperatures a cryogenic cylinder will vaporize some liquid. This will vent periodically from the cylinder through a spring loaded pressure relief device

Tank pressure relief rupture disk in case the spring loaded reliefs fail



Tank high pressure relief, spring loaded

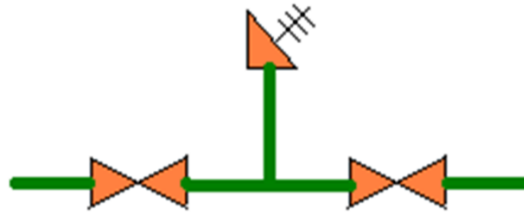
Normal pressure relief, spring loaded low pressure, for high pressure the seal is removed and valve closed

Dewar outlet connections must be tamper proof

When dispensing liquid through a piping system, pressure relief valves must be installed where ever liquid can be trapped

### Pressure Relief Valve

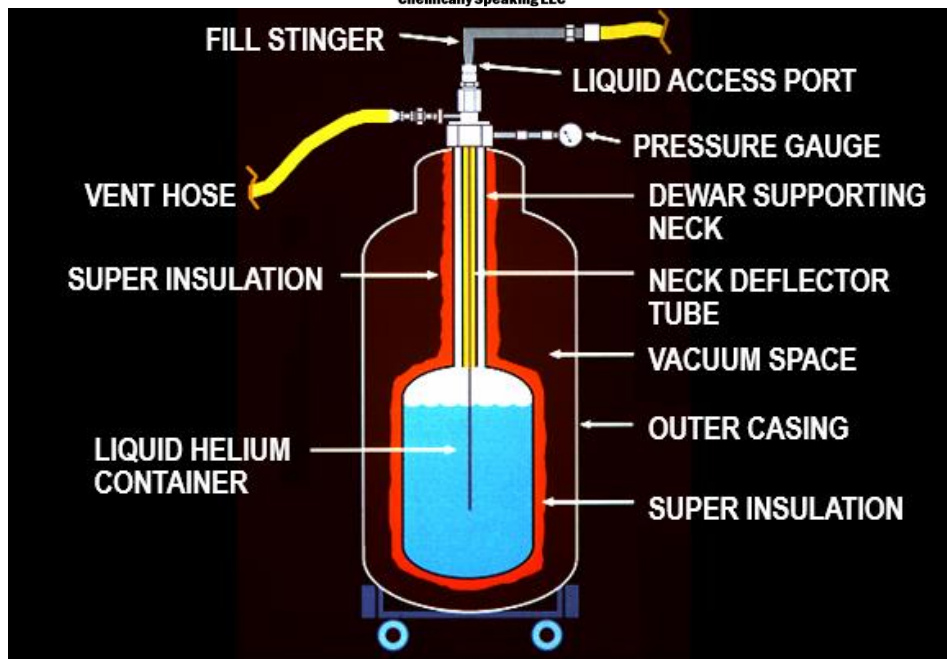
Feel t



### Valves

Helium dewars are designed differently because air can solidify and plug the opening

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Some Carbon dioxide dewars are refilled in place

### Microbulk

Dewars that are fixed and can be refilled by tanker

Made to DOT Specification

Flat base that does not require special foundation

Deliver liquid or gas



230-1500 liters  
Nitrogen or Argon



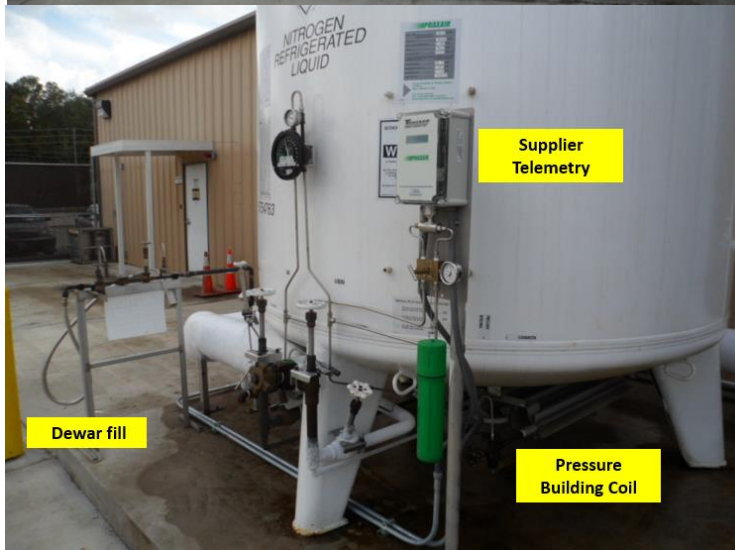
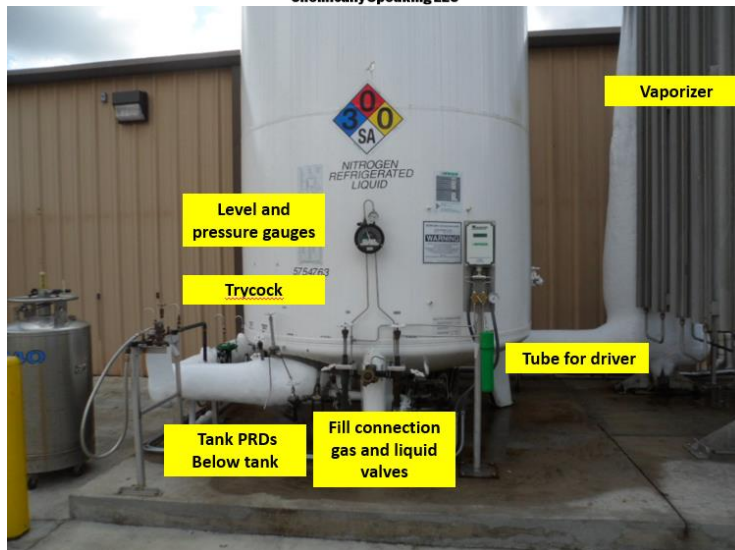
### Fixed Tank

Fixed Tanks are made to ASME specifications  
Horizontal or vertical

- Pressure relief
- Vacuum Gauge
- Trycock
- Vaporizer
- Pressure Building Coil
- Fill connection



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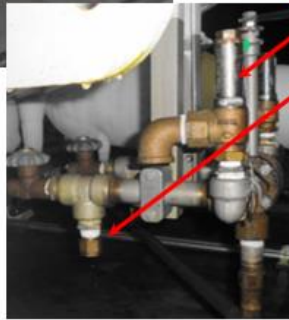


PRV's are tested and adjusted at the manufacturer to relieve at a specified pressure, These are then wired and sealed  
 To change this setting requires the wire seal to be broken





Level expressed as inches water column. Actual level is dependent on cryogenic liquid and temperature of the liquid



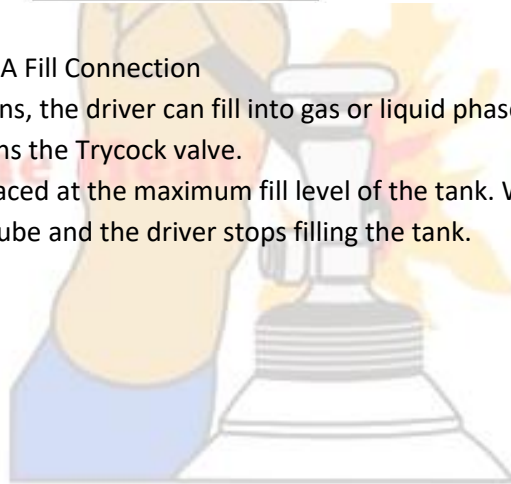
- Tank PRV system, Piping goes to the top of tank (vapor) to vent vapor
- Switch over valve
- PRV set at MAWP
- PRD burst disk is 1.5 MAWP

Gas and liquid fill valves, CGA Fill Connection

Depending on tank conditions, the driver can fill into gas or liquid phase or both

During filling the driver opens the Trycock valve.

The piping to the valve is placed at the maximum fill level of the tank. When the liquid reaches this level, liquid will come out of the tube and the driver stops filling the tank.



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