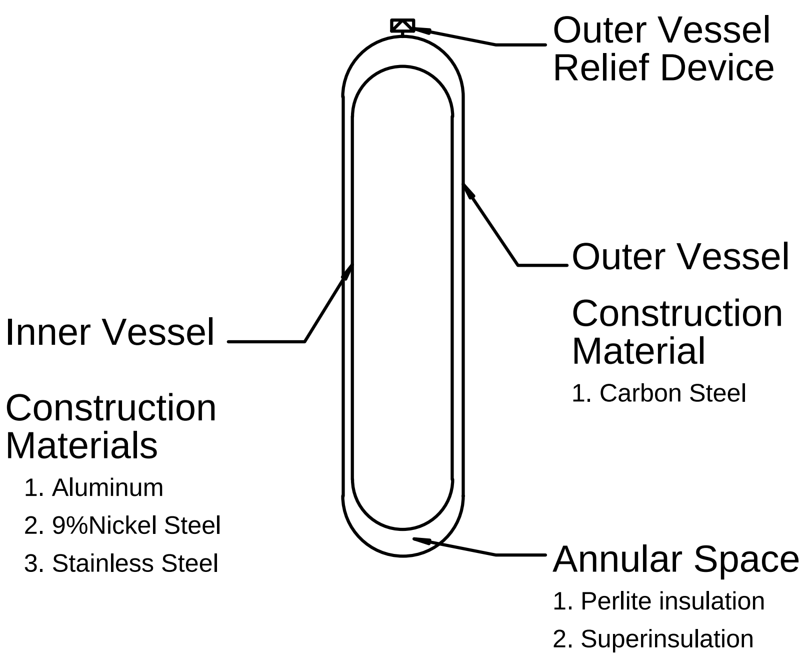
General Information on Cryogenic Liquids, Heat Leak and Tank Dynamics

Liquid oxygen (LOX), liquid argon (LAR), liquid nitrogen (LIN) and liquid hydrogen (LHY) are typically transported and stored as cryogenic fluids mainly due to economic reasons. More gas can be transported with fewer deliveries if the product is in liquid form.

Vacuum insulated containers must be used to store cryogenic liquids because a small amount of heat tends to return the products to their gaseous state. The vacuum insulated containers are analogous to thermos bottles. A tank is comprised of two vessels, an inner tank and outer tank, with insulation in between. The space between the tanks is known as the annular space. Air is removed from the annular space with a vacuum pump. Having a vacuum between tank layers helps to minimize heat transfer to the cryogenic fluid.

The inner tank is an coded vessel (per Section VIII, Div. 1, and Section IX (Welding & Brazing). The outer tank is a *not* an coded vessel, as it is only required to maintain a vacuum. A typical tank design is shown below.

Cryogenic Vessel



The annular space in between the two tanks is insulated to further minimize heat transfer. There are two types of insulation used:

1. **Perlite** – a fine white powder (volcanic ash). This type of insulation fills the annular space completely.
2. **Super insulation** – An aluminum backed plastic (Mylar) wrapped around the inner tank outer wall. Fiberglass paper is placed in between the aluminized Mylar.

Tank Heat Leak

Cryogenic liquid storage vessels are designed to minimize the transfer of heat into the tank. However, some heat transfer, called "heat leak" is inevitable. The heat which is transferred into the tank is absorbed by the cryogenic liquid in the tank. The absorbed heat will cause the temperature of the liquid to rise and cause some of the liquid to be vaporized into gas. Vaporized gas, called "boil off", will be either (1) retained in the tank thus increasing tank pressure, (2) used by the customer through the economizer circuit to the houseline, or (3) vented to the atmosphere. Typical tank boil off rates due to heat leak are presented in the chart below.

Typical Tank Monthly Boil off Rates

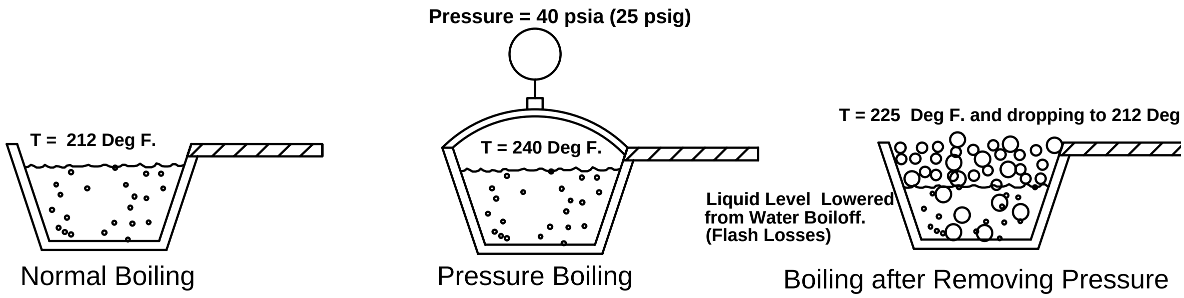
Tank Size (Gallons)	Tank Gaseous Boil off Use or Vent (scf/month)
LOX, LIN, LAR[1]	
500 (super insulated)	25,000
1200-1500 (perlite)	90,000
1500 (super insulated)	60,000
2400 (perlite)	120,000
3000 (perlite)	150,000
4800 (perlite)	180,000
6000 (perlite)	220,000
7500 (perlite)	270,000
9000 (perlite)	300,000
11000 (perlite)	330,000
13000 (perlite)	470,000
LHY[2]	
1500(super/super insulated)	40,000
1500 (super insulated)	110,000
3000 (super insulated)	150,000
4500 (super insulated)	220,000
6000 (super insulated)	250,000
9000 (super insulated)	410,000
9000 (perlite)	600,000
20000 (perlite)	700,000

1. Nitrogen at 100 psig, 60 °F, Perlite – 100 microns, super insulated – 3 micron vacuum
2. Hydrogen at 100 psig, 60 °F, Perlite – 40 microns, super insulated – 1 micron vacuum

Tank Dynamics

Pressure Effects on the Boiling Point of Liquids

Pressure of a liquid directly affects the temperature at which a liquid boils. In the following example, water is used to illustrate this point.



Water Boiling Effects at Different Pressures

Normal Boiling – At normal atmospheric pressure (14.7 psia), water boils at 212 °F. This is analogous to Nitrogen boiling at -321 °F.

Pressure Boiling – If a pressure cooker is used, the water will boil at a higher temperature. In this example, at 40 psia, water boils at 240 °F. This is analogous to Nitrogen boiling at -297 °F at 40 psig.

Boiling after Pressure Removed – If the pan's lid is removed, the liquid will boil furiously, eventually cooling down to 212 °F. The cooling occurs due to evaporating liquid taking energy away. This is referred to as Flash Loss.

Liquid nitrogen, argon, hydrogen, and oxygen all react the same way.

Normal Boiling – The boiling in a cryogenic storage vessel is due to pressure boiling.

Pressure Boiling – Higher pressures elevate the boiling temperature.
For example: at 0 psig, Nitrogen boils at -321 °F. At 40 psig, Nitrogen boils at -297 °F, which is 24 degrees warmer.

Boiling after Pressure Removed – If the tank is vented to atmosphere, the pressure in the tank drops, and depending on the tank conditions, the liquid in the tank may increase boiling.

Still have questions? Visit Air Products' Fast Facts at: www.airproducts.com/fastfacts. You'll find information to help you determine physical properties, along with proper use and storage of cryogenic liquids and compressed gases. Or call our Technical Information Center at 1-800-752-1597.

Learn more about cryogenic liquids

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