Transfer Lines: A Survey, Part II

Spotlight on Sustaining Member

From Jim Weiler, Business Manager, Engineered Systems Group, Distribution & Storage Division, Chart Industries, Inc., jim.weiler@chart-ind.com

Don't Overlook the Ice Balls

Due to their extremely cold temperatures, cryogenic systems offer many opportunities to increase energy efficiency and reduce operating costs.

Considering that most cryogenic systems use temperature differences approaching 400˚F (204˚C), it is very easy for heat to sneak into the system. Any heat that transfers to the cryogenic fluid reduces the system's efficiency and increases the cost of operation for that process. These higher costs can present themselves in higher liquid/gas consumption, slower processing speeds or lower yields. These heat losses affect the gas producer that operates the air separation/liquefaction plant, as well as the firm consuming the liquid/gas as part of their manufacturing or testing process. The entire cryogenic value chain needs to defend itself from heat leak.

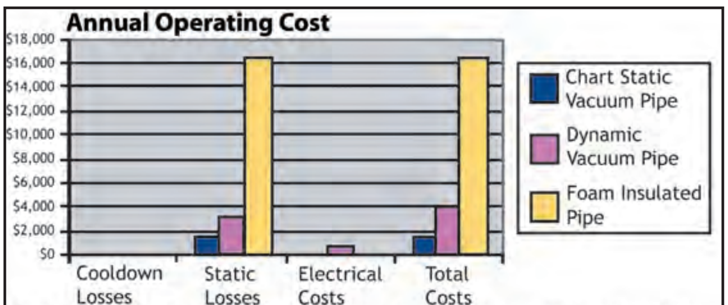
The Big Picture

When evaluating a cryogenic system, companies tend to focus on the large portions of the system such as the piping system that carries the fluid from the storage tank to the point of application. The three main insulation techniques used for cryogenic piping systems are foam insulation, dynamic vacuum and static vacuum. Foam insulated pipe is by far the least efficient of the three and becomes even less efficient over time. Dynamic vacuum insulated pipe uses a vacuum pump installed with the pipe system that continuously pumps on the annular space to maintain a vacuum. Dynamic vacuum systems are significantly more efficient than foam insulated systems; however, they have significant operating cost and reliability issues. Static vacuum insulated systems are the most thermally efficient and have the lowest operating costs.

Among static vacuum insulated pipe systems, there are many different designs to choose from including flexible pipe, rigid pipe, internal bellows, external bellows and Invar. All of these designs have advantages and limitations. For example, flexible pipe offers the ability to be installed in very space constrained locations. However, in trade for its flexibility it yields higher pressure drop, local gas traps and more two-phase liquid gas flow. Rigid pipe does not have the pressure drop, gas trap or two-phase flow issues; however, it requires a little more planning up front. Chart Industries, the world's largest cryogenic equipment manufacturer, manufactures all of these different VIP designs so that we can meet any customer's system requirements.

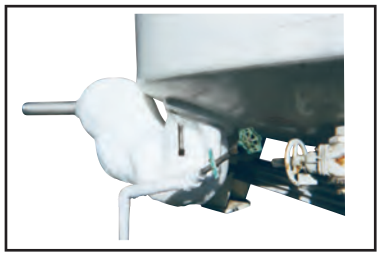
Don't Overlook the Details

Most plants are aware of the fundamental issues in cryogenic systems as they relate to the bulk tank and piping system design and insulation technologies previously noted. It's easy to consider the importance of the insulation system on a 6,000 gal tank, or 150' of pipe. Unfortunately, many facilities tend to ignore details like the connection of the pipe system to the storage tank, or the connection of the pipe system to the end use equipment. Shouldn't the proverbial 80/20 rule apply to cryogenic systems like it does to most other applications? After all, as long as the overall tank and pipe system are well insulated, how much harm can be done in just a couple feet of uninsulated pipe? The answers are simple— the 80/20 rule does not apply, and plenty of harm can be done in just a couple feet of uninsulated pipe.



Based on vendor published studies with LN2. Cooldown is from room temperature and static losses are based on 24/7 operation. Dynamic vacuum system costs include pump electricity but not pump maintenance.

Due to the extreme temperature differences in a cryogenic system (liquid nitrogen is often near -300˚F [-184˚C]), a large amount of heat will transfer very quickly at any location that is not extremely well insulated. These locations are often easy to identify by the presence of ice, frost or condensation ("sweating").



Typically, the connections (tank-to-pipe system, old pipe system to new pipe system, pipe system to end use equipment, etc.) are the most common locations neglected. This oversight often occurs because one firm might have ownership of the bulk tank while another firm has ownership of the pipe system, and neither firm wants to take ownership of the interface or connection. As a result, the connection is made in a short period of time with readily available materials that are considered "good enough," rather than being carefully selected and integrally designed for optimal efficiency.

The most frequent offense of this lack of ownership is the connection of the pipe system to the bulk tank. Approximately 90% of cryogenic bulk storage tanks are manufactured to store the gas in liquid form to achieve volume efficiencies. When gas is required from the system, liquid is withdrawn from the tank and vaporized. Since the liquid needs to be vaporized for the gas application, insulation is not needed on the withdrawal line as high heat transfer rates are desired. Unfortunately, many of these standard design bulk tanks with uninsulated withdrawal lines are placed into liquid-use applications, where they can cause significant problems and inefficiencies in the system.

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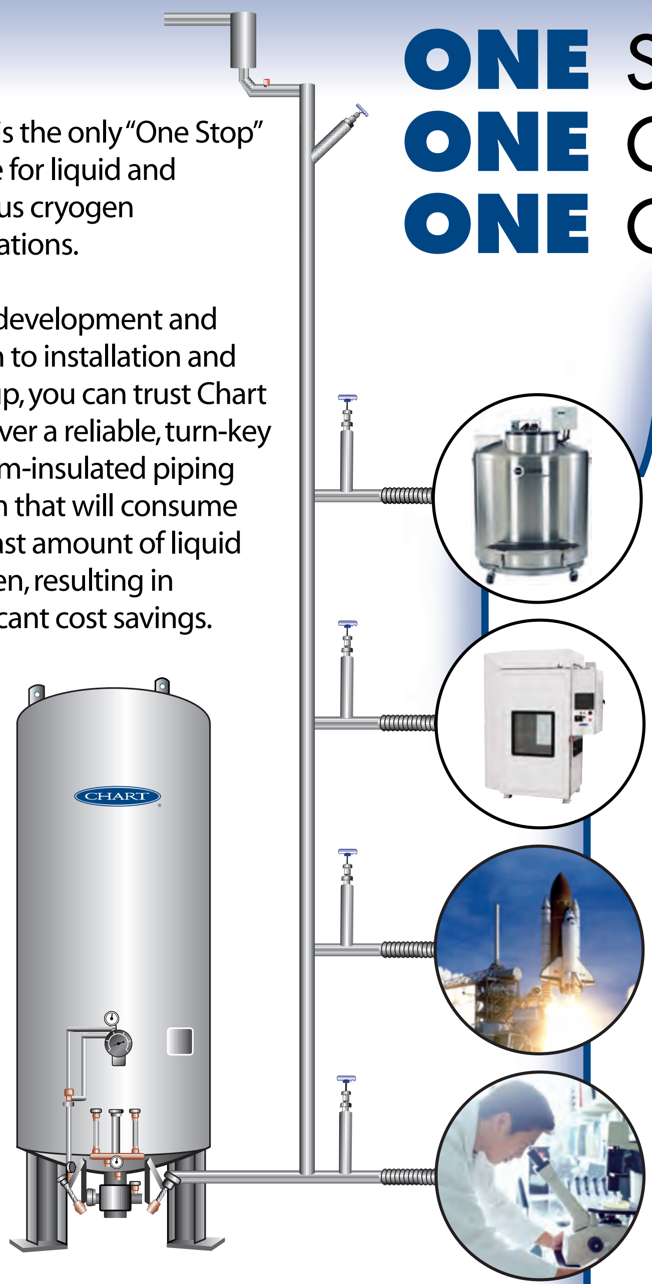

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Transfer Lines: A Survey

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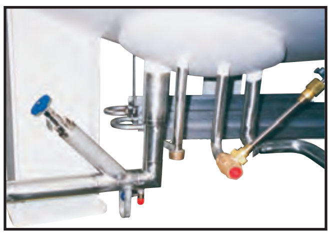
Any heat that enters the system at the tank-to-pipe system connection is carried through to the application at the end of the pipe system. The heat influx at the beginning of the system can cause local boiling and two-phase liquid/gas flow. Two-phase flow will create significantly higher pressure drops through the pipe system, irregular liquid delivery, warmer liquid, increased wear on soft goods such as valve seats, and other system complications.

As people become better educated about these systems, they are learning to ask for a vacuum insulated withdrawal line on their bulk storage tank. A vacuum insulated withdrawal provides a liquid line with the same efficient insulation system as that used to insulate the entire bulk storage tank. The vacuum insulated withdrawal will end in a vacuum insulated bayonet fitting, which connects directly to a mating bayonet on the vacuum insulated pipe system. The combination of the vacuum insulated withdrawal and the bayoneted vacuum insulated pipe system provides an efficient, frost-free liquid delivery into the facility to the point of use.



Vacuum insulated withdrawal lines have been available on bulk storage tanks for many years, but end users are not likely to have the feature on their tanks unless they make a specific request to their gas supplier. As the concept of MicroBulk systems (1,000 to 3,000 liter capacity) becomes increasingly popular with smaller companies these tanks are now also available with vacuum insulated withdrawals.

A Complete System Perspective

Unless someone takes accountability for the complete cryogenic system design and performance, multiple items can easily be overlooked or neglected. Due to the extreme temperatures in cryogenics, a slight oversight in the design or installation can create a major inefficiency in the system operation. One of the worst places, and unfortunately the most common to have such an oversight, is the connection of the vacuum insulated pipe system to the liquid supply tank. If this connection is not all vacuum insulated, the heat transferred into the system at this location can be greater than the heat leak from the rest of the pipe system!

With today's high energy costs, any new cryogenic system should be evaluated and designed from a complete system perspective to obtain the most efficient system for the long-term lowest cost of operation. Any existing cryogenic systems should be reviewed for opportunities to improve system efficiency and lower operating costs. Taking a little time today to understand the economics will easily justify the investment for better efficiency tomorrow. Particular attention should be given to the interfaces of various portions of the system. In the course of reviewing the system, leave no ice ball unturned.

From John Bonn, President, VJ Systems LLC, johnbonn@vjsystems-llc.com.

Versatility of Vacuum Jacketed Pipe

Vacuum jacketed pipe is now being used to transfer Liquefied Natural Gas (LNG) for new LNG terminals being built throughout the world. It is difficult to keep up with the amount of these new terminals being proposed, however there as many as 60 new receiving terminals being evaluated for North America alone. At present there are only five LNG terminals operating in North America.

The first application for use in LNG terminals was in 1996 at Atlantic LNG (ALNG) sending terminal. 3,000 feet of 4" NPS recirculation line were installed and evaluated on its overall performance, reliability and safety of this method of insulation. This insulation system proved to be very successful and the performance of this line has been witnessed by most all LNG terminal owners and there has been no maintenance or service required on this vacuum insulated piping. However there has been considerable maintenance required on the larger 30" NPS line with standard mechanically insulation that runs parallel to this vacuum insulated pipe. Once these lines are cooled down they will stay cold for their entire operational life of about 20 to 25 years.

The robustness of a vacuum jacketed pipe system has allowed owner/operators of LNG terminals to look at more cost saving and safer methods of transferring LNG to and from ships. VJ Systems has developed LNG transfer pipe that will allow the LNG piping to be installed aboveground, underground and underwater. This is an advantage that is not available with mechanically insulated pipe or cost effective if a method is established.

The factory fabricated static vacuum jacketed pipe is designed in long spool sections with a pipe within a pipe and sealed at the ends. These sections are between 24 to 30 meters long and each section is evacuated and sealed with a permanent high vacuum in the annular space prior to shipping. The sizes of these lines vary from 4" NPS to 42" NPS. The contractor's pipe installation time is reduced based on a reduction in weld time to less than half required for all other pipe and insulation systems. All LNG lines have welded end connection to conform to the NFPA 59A requirements.

This pipe can be shop fabricated in parallel with work being done at the site and shipped to the site when all field support activity is completed. This parallel operation allows the LNG terminal to get on line sooner to start the revenue stream from the terminal.

Vacuum jacketed pipe has a static vacuum insulation system that surpasses all other insulation systems available today. This insulation system and technology has been used since the early 1950s with reliable performance results. The unique feature of a static vacuum system is that the performance over time does not change as with all other cryo-

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