Cryogenic Experiences Applied To LNG Sampling Research

Kevin Warner

The study of cryogenics has been a fascinating branch of physics for over two centuries, and just mentioning the word conjures up images of everything from cold, boiling nitrogen vapor to the preserved body of Walt Disney. Cryogenic research was initiated when Scottish physicist William Thomson, known as Lord Kelvin, realized the relationship between gas volume and temperature could be extrapolated to zero volume at a very low temperature. That temperature is "absolute zero," the temperature at which molecular motion stops: about -459 degrees Fahrenheit, or simply zero Kelvin (0 K). Cryogenic research occurs at temperatures very near absolute zero, within milli-Kelvin or micro-Kelvin of zero, but all cryogenic research passes through the warmer regions of low temperature and yields valuable lessons that can be applied to LNG at about 113 K (-256 degrees Fahrenheit).

Gases exist as molecules moving at high speeds, occasionally colliding with one another but having little or no interaction otherwise. The molecular speed is proportional to temperature on an absolute scale (the Kelvin scale), and lighter molecules move faster than heavier ones. As the temperature of a gas is decreased, the molecules slow down and weak attractions between molecules become more significant until a liquid state is eventually formed. The attractive van der Waals force, named for Dutch physicist Johannes Diderik van der Waals, varies by molecule, depending on the molecule's structure. Heavier molecules with polar structures liquefy at relatively high temperatures (for example, water liquefies at 373 K), whereas light molecules liquefy at lower temperatures (for example, helium liquefies at about 4 K). LNG is a mixture of methane, ethane, nitrogen and a few other molecules and is considered a cryogenic fluid within the energy industry.

LNG is created to facilitate easier transportation and storage of natural gas when pipelines are not available. Countries without energy resources depend on shipments of LNG to charge their natural gas grid, from which residential, commercial, industrial and electric power producers derive energy. LNG sampling is the process of extracting LNG in a liquid state, vaporizing the liquid, and then measuring the composition using a gas chromatograph analyzer to determine the gas' suitability for use and its monetary value. Since the vaporizer itself touches the LNG handles, the design of the probe, tubing and vaporizer inlet must conform to cryogenic standards.

LNG sampling R&D depends heavily on a core knowledge of cryogenic design principles. These can be broken into broad categories, including materials, vacuum technology, heat flow and electronics. Embrittlement is a primary concern, along with material selection. Thermal stress can be significant at all junctions, and ordinary joining techniques and materials may not be suitable. The most common connectors are not rated for low temperatures, so custom solutions are common. Sealants are problematic, since many solidify at lower temperatures and do not perform their intended functions. Vacuum systems are critical in cryogenics to provide thermal isolation between components at different temperatures. It is not uncommon for components separated by fractions of an inch to vary in temperature by 300 K.

Vacuum technology enables superior insulating capabilities for LNG sampling systems. Vacuumjacketed tubing is far superior to conventional insulation. The control of heat flow is critical to maintaining any cryogenic system. The largest challenge in LNG sampling is the constant introduction of flowing LNG into a much hotter system. Its sole purpose is to vaporize LNG by adding heat, while maintaining the liquid state of LNG itself as required by ISO 8943, the standard governing LNG sampling. Additionally, the source of the flowing LNG is a pipeline, which regularly

experiences flow rate, temperature and pressure fluctuations of its own. Since temperature changes as small as 0.1 K can create pre-vaporization within the system, controlling heat flow throughout the system is particularly tricky and requires years of testing to achieve a suitable design.

For more information, visit www.mustangsampling.com, call (713)482-6930 or email Kevin.Warner@MustangSampling.com.