



COMPRESSED GAS ASSOCIATION, INC.

POSITION STATEMENT

PS-8—2004

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PROTECTION OF CRYOGENIC STORAGE TANKS FROM OVERPRESSURE DURING OPERATOR-ATTENDED REFILL

Background

Cryogenic vessels designed for the storage of liquid nitrogen, oxygen, argon, natural gas, helium, hydrogen, or ethylene are routinely filled from a pressure source. Some pressurized loading systems may be capable of dead-end pressures greater than the maximum allowable working pressure (MAWP) of the vessels they are filling. Many pressurized loading systems include manual pressure control of the cryogenic vessel by an operator who manipulates the liquid and gas phase valves, ending the process when liquid product is indicated from the try-cock valve or when the desired level is indicated on a liquid level instrument gauge.

Question

How should cryogenic storage tanks designed, built, and stamped in accordance with the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1 (ASME Code) be protected from overpressure that might occur during refill [1]?

Answer

Operators of manual pressure-controlled loading systems shall receive proper and ongoing training. Furthermore, their skills to operate the system and to control the tank pressure within the proper operating range as well as within the MAWP shall be recertified periodically. Where these provisions are in place, the manual loading operation is not considered as a component of "the maximum quantity that can be supplied to the attached equipment" as described in the ASME Code, paragraph UG-133 [1].

In addition to the requirements of CGA S-1.3, *Pressure Relief Device Standards—Part 3—Stationary Storage Containers for Compressed Gases*, the owner shall provide sufficient pressure relief capacity to ensure that the off-loading system cannot pressurize the storage tank above the lesser of its test pressure or $1.5 \times \text{MAWP}$ [2]. The test pressure is recorded on the U1, U1-A, or R-2 form.

Frequently a cryogenic storage tank is filled by a gas supplier or a gas supplier's agent that is not the owner of the tank. However, it is the tank owner's responsibility to ensure the cryogenic storage tank is adequately protected against overpressure and the gas supplier can safely make deliveries. The storage tank owner should confirm that the tank pressure cannot exceed the lesser of the tank's test pressure or $1.5 \times \text{MAWP}$. Upon request from the tank owner, the gas supplier shall provide the delivery vehicle flow and pressure characteristics to the tank owner. These are typically provided as a curve describing the pressure rise across the pump as a function of flow for the pump operating at maximum speed. For pressure transfer systems this is typically provided as the maximum flow rate and pressure of the delivery system. It is the storage tank owner's responsibility to provide a system for identifying changes that affect tank relief device sizing, available tank relief device capacity, and maximum delivery pressure and flow rate for its supplier. Changes that impact the protection of the cryogenic storage tank during operator-attended fill should be identified and, if necessary, communicated to the supplier.

This answer is applicable only to cryogenic storage tanks constructed as follows:

- Designed for the following cryogenic liquids: nitrogen, oxygen, argon, natural gas, helium, hydrogen, or ethylene;

- Constructed from 304, 304L, 304N, 304LN, 316, 316L, 316N, 316LN, 201L or 201LN stainless steels, from 9nickel steel, or from 5083 or 5086 aluminum. For 201L and 201LN stainless steel, the heads shall be used in the annealed condition after forming; and
- Not subject to cyclic service as defined in the ASME Code [1].

Reasons for cryogenic storage tank requirements

The materials of construction of cryogenic storage vessels have excellent fracture toughness at cryogenic temperatures. This material property provides the vessel a large flaw tolerance capability.

The stored cryogenic liquids are noncorrosive.

Thermal and pressure cycling are minimal; any undetected flaw will not grow to a critical size by stress-corrosion-cracking or fatigue crack growth mechanisms.

The materials of construction of these cryogenic storage vessels are stronger at operating temperature than at the temperature at pressure test. Since the vessel is proven safe at its pressure test, it will remain so throughout its normal service life.

Recommended method for analysis of relief capacity

Cryogenic storage tanks are provided with a relief valve system in accordance with CGA S-1.3 [2]. The owner should conduct the following analysis to ensure that the relief capacity of this system is sufficient so the off-loading system cannot pressurize the vessel above the lesser of the test pressure or $1.5 \times \text{MAWP}$. Where the relief system includes a rupture disk, the capacity of any relief valve shall be ignored. Where the relief system includes only relief valves, the effect of chatter induced by the relief line components shall be considered.

All off-loading systems that can be expected to fill the subject tank shall be considered for this analysis. This selection should consider contract carriers and other alternative suppliers that may be used. The analysis should be repeated any time the tanker off-loading system or the tank relief system is changed.

Calculate the internal pressure at the top of the tank using the following assumptions:

- the off-loading system is operated at the maximum output curve the operator can select, whether or not this selection is appropriate for the tank under analysis;
- all valves in the path between the off-loading system and the tank relief devices are in the full open position;
- the tank is liquid full; and
- liquid phase product is discharging through the relief system.

The pressure developed at the top of the tank under the previous assumptions shall not exceed the lesser of the test pressure or $1.5 \times \text{MAWP}$. Corrective measures may include the following:

- Increase the size and capacity of the relief system;
- Reduce the resistance of the relief system. For example, the capacity of the diverter valve (if any) may be increased;
- Install a permanent resistance in the fill piping. Such a resistance may be an orifice, venturi, or similar device; and
- Install a mechanical pressure-sensing device in the fill piping that isolates the delivery vehicle from the cryogenic liquid storage vessel.

The maximum pressure to which the fill piping and components are subjected shall not exceed their allowable pressure.