HYDROGEN Safety Panel

WHITE PAPER

Qualified Individual for Liquefied Hydrogen

Foreward

This document was developed by the Hydrogen Safety Panel (HSP) and its members (https://www.h2tools.org/hsp/members). The HSP was formed in 2003 by the Fuel Cell Technologies Office from the Office of Energy Efficiency & Renewable Energy of the U.S. Department of Energy to help develop and implement practices and procedures that would ensure safety in the operation, handling and use of hydrogen and hydrogen systems. The primary objective is to enable the safe and timely transition to hydrogen and fuel cell technologies. This is accomplished by:

- Providing expertise and recommendations and assist with identifying safety-related technical data gaps, best practices, and lessons learned, and
- Ensuring that safety planning and safety practices are incorporated into hydrogen projects.

The HSP's members collectively have over 400 years of experience and represent a cross-section of expertise from the commercial, industrial, government, and academic sectors. HSP members participate in a variety of standards development organizations including the American Society of Mechanical Engineers (ASME), CSA Group (CSA), International Organization for Standardization (ISO), National Fire Protection Association (NFPA), Society of Automotive Engineers (SAE), and Underwriters Laboratories (UL). HSP members also contribute to peer-reviewed literature and trade magazines on hydrogen safety and present at national and international forums. The HSP has reviewed over 325 projects covering vehicle fueling stations, auxiliary power, backup power, combined heat and power, industrial truck fueling, portable power, mobile applications, and research & development activities. For more information on the HSP and additional hydrogen safety resources, please visit http://h2tools.org.

Background

The HSP has reviewed many safety plans for gaseous hydrogen. An emerging trend is the use of liquid (cryogenic) hydrogen in the commercial market, potentially near residential areas, for fueling hydrogen fuel cell vehicles. Finding a "qualified" person to determine liquid hydrogen code compliance is difficult, and the skills necessary of such an individual are not well defined in the codes and standards. The HSP has developed this white paper as a tool for permitting agencies (e.g., authorities having jurisdiction, certifiers, and installers) to ensure qualified personnel have the necessary credentials.

The change in hydrogen fuel stations from gaseous to liquid hydrogen represents more than just a change of the physical state of the molecules. The safety requirements are different for hydrogen at cryogenic temperatures (<-423°F) for the following primary reasons:

1. Components used for gaseous hydrogen are usually not suitable for low temperatures.
2. Liquid hydrogen can travel farther in a release before dissipating, causing additional siting issues.
3. There are large changes in pressure as the hydrogen expands from liquid to gas.
4. Most other molecules solidify at liquid hydrogen/cold hydrogen vapor temperatures (i.e., air and moisture, and other factors).

In addition, until recently, gaseous hydrogen has been primarily used in retail fueling stations, and liquid hydrogen has been used mostly in industrial environments. Today, liquid hydrogen is starting to enter commercial areas as a supply for hydrogen fuel cell vehicles, making this a critical time to address the need for specifying what is meant by "qualified" individual.

Discussion

A "qualified" individual for liquid hydrogen should be qualified in all aspects of liquid hydrogen systems, as discussed in the seven categories listed below. Questions are included for each category to help ascertain if the liquid hydrogen expert is qualified.

1. Liquid Hydrogen Properties
    a. Is the individual aware of the pressure and temperature design requirements of liquid hydrogen (e.g., worst case temperature of -423°F and pressure of 150 to170 psig) in the storage tank?
    b. Is the individual aware of the flow rates from a vent stack and the potential hazards to the surroundings with a liquid/gaseous hydrogen release?
2. Design
    a. Has the individual previously designed and managed the installation of liquid hydrogen systems?
    b. Is the individual familiar with the liquid hydrogen codes (examples may include NFPA 2/55 and CGA G-5.5/H-3/H-5/P-12/P-28/S-1.3)?
    c. Has the individual been involved with siting a liquid hydrogen system?
    d. Does the individual understand how relief device set points and flow rates are determined (examples may include understanding that the relief devices must be designed for overfill from a transport pump, heat leak, fire, loss of vacuum, and runaway tank pressure control)?
    e. Does the individual understand how the level and pressure on a liquid hydrogen tank can be safely controlled (examples may include a full trycock system with relief devices/back pressure regulators)?
    f. Does the individual understand the mechanical design needs for the liquid hydrogen system (e.g., thermal expansion and ice)?
    g. Does the individual know when fireproofing is required on liquid hydrogen tank leg supports (examples may include when the bottom of the tank is greater than 18 inches from grade)?
3. Process Equipment and Properties of Materials
    a. Is the individual aware of how a liquid hydrogen tank is typically piped (examples may include vacuum jackets on fill lines, relief valves piped to a vent stack, and safe control of the tank pressure and level)?

   b. Does the individual know what materials of construction are typically used with liquid hydrogen (examples may include 304/316 stainless steel, aluminum, and brass/copper with silver solder; tin lead is NOT acceptable)?
   c. Has the individual calculated expansion contraction rates of metals involved in liquid hydrogen storage or movement?
4. Safety Systems and Reviews
   a. Has the individual led or facilitated a hazard review for liquid hydrogen systems?
   b. Is the individual aware of the safety systems used with a typical liquid hydrogen system (examples may include-low temperature shutdown, emergency shutdown device, and all relief valves being piped to a vent stack designed for liquid hydrogen)?
5. Emergency Procedures
   a. Does the individual have knowledge of emergency procedures for a liquid hydrogen system? What is the basis of this knowledge?
   b. Has the individual trained any fire departments on the system design, the hazards of liquid hydrogen, and the safety systems associated with liquid hydrogen use?
6. Operations (current and historical)
   a. How many operating liquid hydrogen systems has the individual visited and studied?
   b. What historical problems has the individual observed with a liquid hydrogen system (example may include incorrect expansion contraction calculations, icing of lines, icing of vaporizers, fog issues, and incorrect piping of emergency shutdown devices)?
   c. Does the individual understand how to review the system for correct components, pressure rating, pressure testing, purging and filling, and suitability to fill and operate (examples may include an operational readiness inspection)?
   d. Does the individual understand how changes are made and documented from design through installation/startup, and during operations (for example, a management of change process)?
   e. Does the individual understand how the training of onsite personnel for the liquid hydrogen system will be accomplished, and what to include in the scope of the training?
7. Maintenance
   a. Has the individual worked on a liquid hydrogen system on site during initial construction and after the liquid hydrogen system is active?
   b. Does the individual understand how a liquid hydrogen system is purged (examples may include purging with nitrogen, if warmed to ambient conditions, or purging with helium, if at liquid hydrogen temperatures) prior to opening for repair?

As an example, a qualified individual for liquid hydrogen would most likely (but not always) have an engineering degree, with skills developed through hands-on design, installation/commissioning, operations, and maintenance under a mentor (for at least three systems). The authority having jurisdiction should have the final say on whether a company or individual involved is acceptable as a “qualified” individual.