F172–06/07
3003.7.11 through 3003.7.11.2 (New), 3504.2.2 (New), Chapter 45

Proponent: Paul J. Buehler, Jr., Plug Power, Inc.

1. Add new text as follows:

3003.7.11 Outdoor hydrogen storage cabinets. Bottled hydrogen gas may be stored in quantities of up to 4,225 scf in specially designed hydrogen storage cabinets meeting Telcordia GR-487-CORE. Cabinets used for this purpose must be also be listed by a nationally recognized testing laboratory. Such cabinets shall be deemed to meet the requirements of Sections 3003.7.2, 3003.7.4, 3003.7.5, and 3003.13.

3003.7.11.1 Combustible waste, vegetation and similar materials. Combustible waste, vegetation and similar materials shall be kept a minimum of 3 feet (914 mm) from outdoor hydrogen storage cabinets.

3003.7.11.2 Electrical equipment. Unclassified electrical equipment shall be located no closer than 5 feet (1520 mm) from the Outdoor Hydrogen Storage Cabinet.

Exceptions:

1. Unfused transfer switches mounted in outdoor rated NEMA enclosures may be located within 5 feet (1520 m) provided that the device is no taller than 4 feet (1220 mm) above finished grade.
2. Landline and wireless telephone equipment may be located within 5 feet (1520 mm) of outdoor hydrogen storage cabinets provided that the telephone equipment is housed in Network Equipment Building Systems (NEBS) rated enclosures meeting Telcordia GR-487-CORE.

2. Add new text as follows:

3504.2.2 Outdoor hydrogen storage cabinets. Storage of up to 4,225 standard cubic feet of bottled hydrogen gas in an outdoor hydrogen storage cabinet shall be in accordance with Section 3003.7.11.

3. Add referenced standard to Chapter 45 as follows:

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Telecordia GR-487-CORE -00 General Requirements for Electronic Equipment Cabinets

Reason: Revise outdated material because current *International Fire Code* and NFPA 55 sections do not deal with the storage of bottled hydrogen out of doors inside cabinets, but rather only consider "naked" cylinders or indoor gas cabinets per Sections 2703.8.6 and 3006.2.3.

This amendment is to facilitate the placement of bottled hydrogen in proximity to low powered electrical equipment meeting only the highest standards of the telecommunications industry. This is superior to current code language because it deals with increasingly common use of a flammable gas in frequently encountered situations. Current work in the fuel cell industry has indicated that hydrogen fuel must fit into locations not anticipated in prior revisions to the codes. Therefore, the fuel cell industry is performing basic research and testing on fuel cells and the associated hydrogen storage. This testing has led to several conclusions: that hydrogen gas is not as persistent as once thought; and that methods of enclosure for hydrogen cylinders and telecommunications equipment have not been duly noted by existing codes. Therefore, this amendment attempts to include both of these facets into the upcoming code.

Substantiation: Cabinets meeting Telcordia NEBS criteria are certified for use in locations likely to encounter gun shot, brush fire, and/or earthquake hazards. Telecommunications equipment is also effectively sealed inside weather-proof and EMI rated cabinets. The enclosed telecommunications equipment is low power and is not an ordinary arc/spark hazard, although it is not usually considered to be intrinsically safe. Likewise, stored hydrogen cylinders located inside a cabinet meeting the same standards are protected from the same brush fire, gun shot and earthquake hazards as the telecommunications equipment.

Current hydrogen research by Swain and Tchouvelev has yielded data suggesting that hydrogen gas does not sink and pool, but rather dissipates upward quickly in open air in a predictable manner. Furthermore, fully charged standard gas cylinders evacuate (blow down) in between 100 and 120 seconds. Thus, the exposure time is limited to this blow down period.

Current design Outdoor Hydrogen Storage Cabinets thus protect stored hydrogen in a manner which was not anticipated previously. Furthermore, there are other safeguards built into such cabinets. The stored hydrogen is connected to some device which consumes the hydrogen through the use of valves, regulators and piping.

A small or large leak internal to the Outdoor Hydrogen Storage Cabinet will result in a buoyant release of hydrogen gas through the ridge vent. Such a leak could be the result of a Pressure Relief Device (PRD) activation, or as the result of a plumbing failure at a weld or threaded connection, etc. The leaked hydrogen gas will then buoyantly exit at the elevation of the ridge vent, nominally 70+ inches above finished grade and dissipate into the atmosphere quickly. This is in stark contrast to a PRD release on a bottle not inside a container, which would result in hydrogen gas being expelled in a plane parallel to the long side of the bottle as jets in four directions.

Likewise, there are safeguards against leaks between the Outdoor Hydrogen Storage Cabinet and the hydrogen consuming device. In the event that there is a plumbing rupture, an excess flow valve operates which then sends the hydrogen up the vent stack for a sonic release. The vent stack is designed and oriented following CGA 5.5 guidelines. The amount of hydrogen expelled through the leaking hose will be just the amount in the plumbing in between the excess flow valve and the consuming device. One such Outdoor Hydrogen Storage Cabinet utilizes ¼" diameter tubing (6.35 mm) with a length of approximately 124 inches (3149.6 mm), rendering a volume of 6.1 cubic inches (99.75 cm^3).

Assume that the majority of the plumbing is internal to the Outdoor Hydrogen Storage Cabinet except for the last 6 inches (152.4 mm) and that in the worst case the connection hose is essentially on the ground or very close to the ground. Thus, if a 5 foot (1524 mm) radius were to be drawn around such a hose, it would depict a hemisphere (as the hose is near to the ground). The volume of such a hemisphere is 452,389 cubic inches (7,414,655 cm^3). Therefore, the volume of expelled hydrogen is $1.34x10^{-7}$ % of the hemisphere's volume; this is clearly less than 4% LFL in free air.

Bibliography:

International Journal of Hydrogen Energy 30 (2005) 1447 – 1455, M.R. Swain, et.al, *Ignition of lean hydrogen – air mixtures*
"An Experimental Investigation into the Ignition of Leaking Hydrogen", M.R. Swain, Unpublished
Telcordia GR-487-CORE, *Generic Requirements for Electronic Equipment Cabinets*
"Hydrogen Clearance Distances", Stuart Energy Systems Corporation, 12 Sep 2004

Cost Impact: The code change proposal will not increase the cost of construction.

Analysis: Results of review of the proposed standard(s) will be posted on the ICC Website by August 20, 2006.

Public Hearing: Committee: AS AM D
Assembly: ASF AMF DF