LETTER BALLOT NB11-1901

Subj: Installation of High Pressure Composite Pressure Vessels

Explanation: The FRP Subgroup initiated this proposal to provide guidance for a safe installation of high pressure vessels operating in close proximity to the public.

PM: Dale Keeler

Background: Most jurisdictions and Inspectors have little knowledge of the materials (fiber reinforced plastic) used in the construction of high pressure hydrogen storage vessels. In addition, these are high pressure (MAWP 15,000 psi) vessels operating very close to the public. The FRP Subgroup initiated this supplement to ensure that vessel installation would receive extra attention.

Existing Text: None

Proposed Revision: Initial Release

Rationale: The high pressure vessels are intended for use in vehicle fueling stations. The public will be very close to these high pressure (MAWP 15,000 psi) vessels, and extra care should be observed when installing the vessels.

Notes during discussion:

S3.0 H2 Pressure Vessel Installation

At the time of vessel installation, the latest revisions of all documents referenced in this supplement shall be utilized.

S3.1 Scope

This supplement provides requirements for the installation of high pressure composite vessels (tanks) intended for storage of gaseous hydrogen. This supplement is applicable to pressure vessels with the MAWP not exceeding 15,000 psi, and is applicable to the following classes of vessels:

a) Metallic vessel with a Fiber Reinforced Plastic (FRP) hoop wrap over the shell part of the vessel (both load sharing).
b) Metallic vessel with a full FRP wrap (both load sharing
c) FRP vessel with a non load sharing metallic liner
d) FRP vessel with a non load sharing non metallic liner

S3.2 Supports

Design of supports, foundations, and settings shall consider the dead loads, live loads, wind, and seismic loads. Vibration, and thermal expansion shall also be considered. The design of supports, foundations, and settings shall be in accordance with ASCE/SEI 7, *Minimum Design Loads for Buildings and Other Structures*. The importance factors used in calculating the seismic and wind loads shall be the highest value specified for any category in ASCE/SEI 7.

S3.3 Clearances

The pressure vessel installation shall allow sufficient clearance for normal operation, maintenance, and inspection. Stacking of pressure vessels is permitted. The minimum spacing between pressure vessels (shell OD to shell OD) shall be 1 ft

vertical and 2 ft horizontal. Vessel nameplates shall be visible after installation for inspection.

The location of the vessels shall comply with NFPA [2, Table 7.3.2.3.1.2(a)] *Minimum Distance From Outdoor (GH_2) Systems to Exposures (U.S.Units).*

S3.4 Piping Loads

piping loads on vessel nozzles shall be determined by a formal flexibility analysis per B31.3 paragraph 319.4.2(c). The piping loads shall not exceed the maximum nozzle loads defined by the vessel manufacturer.

S3.5 Mechanical Connections

Mechanical connections shall comply with pressure vessel manufacturer's instructions. Cast iron pipe, valves, and fittings are prohibited. Connections to threaded nozzles shall have primary and secondary seals. The seal design shall include a method of detecting a leak in the primary seal. Seal functionality shall be demonstrated at the initial pressurization of the vessel.

S3.6 Pressure Indicating Devices

Each pressure vessel shall be equipped with a local pressure gage. The dial range shall be from 0 psi to not less than 1.25 times the vessel MAWP. The pressure gage shall have an opening not to exceed 0.055in (1.4mm) (No. 54 drill size) at the inlet connection. In addition, vessel pressure shall be monitored by a suitable remote pressure indicating device with alarm having an indicating range of 0 psi to not less than 1.25 times the vessel MAWP.

S3.7 Pressure Relief Devices

Each pressure vessel shall be protected by pressure relief devices per the following requirements.

a) Pressure relief devices shall be suitable for gaseous hydrogen service.

b) Pressure relief devices are to be manufactured in accordance with a national or international standard and certified for capacity (or resistance to flow for rupture disk devices) by the National Board.
c) Dead weight or weighted lever pressure relief valves are prohibited.
d) Pressure relief valves shall not be fitted with lifting devices.
e) The pressure relief device shall be installed directly on the pressure vessel with no isolation valves between the vessel and the pressure relief device except:
    1) when these isolation valves are so constructed or positively controlled that closing the maximum number of valves ate one time will not reduce the pressure relieving capacity, or
    2) upon specific acceptance od the Jurisdiction. An isolation valve between vessel and its pressure relief device should b provided for inspection and repair only. The isolation valve shall be arranged so it can be locked or sealed open.
f) The discharge from pressure relief device(s) shall be directed upward so as to prevent any impingement of escaping gas upon the vessel, adjacent vessels, adjacent structures, or personnel. The pressure relief device(s) discharge piping shall be designed so that it cannot become plugged by animals, rain water, or other materials.
g) The pressure relief device(s) shall be set at a pressure not exceeding the MAWP of the vessel.
h) The pressure relief device(s) shall have sufficient capacity to ensure the pressure vessel is not exposed to a pressure greater than that specified in the original code of construction
i) The owner shall document the basis for selection of the pressure relief device(s) used, including capacity, and
j) have such analysis available for review by the jurisdiction.
k) Pressure relief devices and discharge piping shall be supported so that reaction forces are not transmitted to the vessel.
l) Heat detection system - a heat activated system shall be provided so that the vessel contents will be vented per f)

(above) if any part of the vessel is exposed to a temperature higher than 185 °F.

m) Positive methods shall be incorporated to prevent overfilling of the vessel.

S3.8 Installation

a) Isolation valve(s) shall be installed directly on each vessel, but not between the vessel and the pressure relief device except as noted in e) above.

b) Vessels shall **not** be buried.

c) Vessels may be installed in a vault subject to a hazard analysis to include as a minimum the following:

1) ventilation
2) inlet and outlet openings
3) access to vessels
4) clearances
5) intrusion of ground water
6) designed for cover loads
7) explosion control
8) ignition sources
9) noncombustible construction
10) remote monitoring for leaks, smoke, and fire
11) remote controlled isolation valves
12) other safety requirements

d) Fire and heat detection / suppression provisions shall comply with local jurisdictional requirements and as a minimum include relief scenarios in the event of a fire or impending overpressure from heat sources

e) Installation locations shall provide the following:

1) Guard posts shall be provided to protect the vessels from vehicular damage per NFPA [2:4.14.1. Protection from wind, seismic events, and other miscellaneous impacts shall be provided.

2)Supports and barriers shall be constructed of non-combustible materials.

3)Vessels shall be protected from degradation due to direct sunlight.

4)Access to vessels shall be limited to authorized personnel.

5)Any fence surrounding the vessels shall be provided with a minimum of two gates. The gates shall open outward, and shall be opened from the inside without a key.

6) Access for initial and periodic visual inspection and NDE of vessels, supports, piping, pressure gages or devices, relief devices and related piping, and other associated equipment.

7) Completed installations shall be certified by the local jurisdiction or an authorized inspection agency as meeting all the above and jurisdictional requirements prior to first use. This certification shall include an itemized check list identifying all applicable areas with initial and date of the authorized inspection personnel. This certification shall be posted in a conspicuous location and on file with the local jurisdiction. Certificates shall be updated as required by mandated subsequent inspections.

8)Piping installation shall comply with ASME B31.12 *Hydrogen Piping and Pipelines* or NFPA [2:7.1.15]

8. The installation area shall be placarded per NFPA [2:7.3.1.2.5].

The vessels shall be electrically bonded and grounded per NFPA [55:10.2.6].

S3.9 Ladders and runways

A minimum of two exits shall be provided for each walkway or enclosed space. The distance from any point on the walkway to the nearest exit shall not exceed 75 ft.

S3.10 Checklist

The following checklist lists most, but not necessarily all, items that should be reviewed at the time of high pressure hydrogen vessel installation.

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Installation of Hydrogen Tanks Checklist

1. Construction Code Compliance
    a. Manufacturers data plate (record all information)
    b. ASME Code with appropriate designator for the type of Construction
    c. Capacity (when indicated on nameplate in water volume)
    d. Manufactured date, expiration date, or/service life
2. Condition of tank – paint, signs
    a. Condition of all painted surfaces
    b. Visible damage per inspection guidelines ~ (scratches, gouges, impact, etc.)
    c. Flammable warning signs
    d. No smoking, welding, or open flame signs
    e. Exterior protective barrier condition
3. Foundations / Supports per the jurisdiction building code
    a. fire protection
    b. painted metallic parts
    c. anchoring / securing of supports
    d. is support frame condition acceptable
    e. are tanks installed on a firm foundation
4. Tank Connections / Fittings
    a. Connections equipped with required correctly rated valves, (shut off valves, relief device, excess flow valve)
    b. Remote operated emergency shut off or isolation valves
    c. protected from damage
    d. leak free
5. Gauges
    a. Dedicated pressure gauge for each tank.
    b. Gauges in good condition, display ~ 1.25 x operating pressure
    c. remote and local indicating gauges function

6. Pressure Relief Device(s)
    a. information legible
    b. isolation valve between PRD and tank
    c. pressure relief device is properly certified (ASME/NB)
    d. discharge unobstructed
    e. properly capped/protected to prevent entry of foreign material or objects
    f. weep holes to drain moisture
    g. free of corrosion
    h. routine inspection and test documents (date and results)
7. Fence / Security
    a. Area properly secured
    b. Limited / restricted access provided
    c. Camouflaged
    d. Properly protected from errant vehicle damage
    e. Protection from vandalism (rifle shot, etc)
8. location and spacing of tanks
    a. proper tank spacing to allow inspection
    b. proper tank spacing to allow for maintenance or replacement
    c. stacking does not exceed allowable limits
9. presence of combustible materials
    a. area is free from combustible materials
10. vault installed tanks
    a. non combustible construction
    b. at least two points of_access (entrance and egress)
    c. secured against unauthorized entry
    d. adequate ventilation
    e. fire suppression
    f. adequate access for inspection, maintenance, and replacement
    g. Confined space signs (vault installation)
11. Shading
    a. shade to prevent solar heating