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Bulk Gaseous Hydrogen Systems

By
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The use of bulk gaseous hydrogen for the production of scientific glassware requires specialized equipment for safe handling. The system outlined in this article was installed in 1988 for use by the Glassblowing Facility in the Department of Chemistry and Biochemistry at Arizona State University. The National Fire Protection Association (NFPA) publishes *Standards for Gaseous Hydrogen Systems at Consumer Sites, NFPA-50A.* Additionally, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting and Allied Processes, NFPA 51*, includes information relative to hydrogen-oxygen installations. State and local fire code restrictions may require additional equipment in your area. Check with local authorities to make certain your system design meets fire codes.

Due to the location of the hydrogen supply system in a high traffic pedestrian area, the Department of Chemistry and University officials required the system be of a "fail-safe" design. The system incorporates several levels of protection from flashback into the piping, regulator failure causing system overpressure, and workspace ventilation.

The hydrogen supply building (Figure 1) is a specially designed brick and steel structure adjacent to the glassblowing facility. The roof of the structure is designed to "hinge" and blow back against the adjacent brick wall in the event of an explosion. In a catastrophic system failure and explosion, the blast would be directed upward rather than outward to reduce the chance of personal injury. The manifold (Figure 2) is a dual bank switching manifold with capability of delivering 2640 cubic feet of hydrogen gas at pressures up to 40 pounds per square inch. Welded 3/4" stainless steel tubing was used for the underground connections to the glassblowing facility. Once inside the facility, copper tubing was used for connections to the workstations.

Figure 1

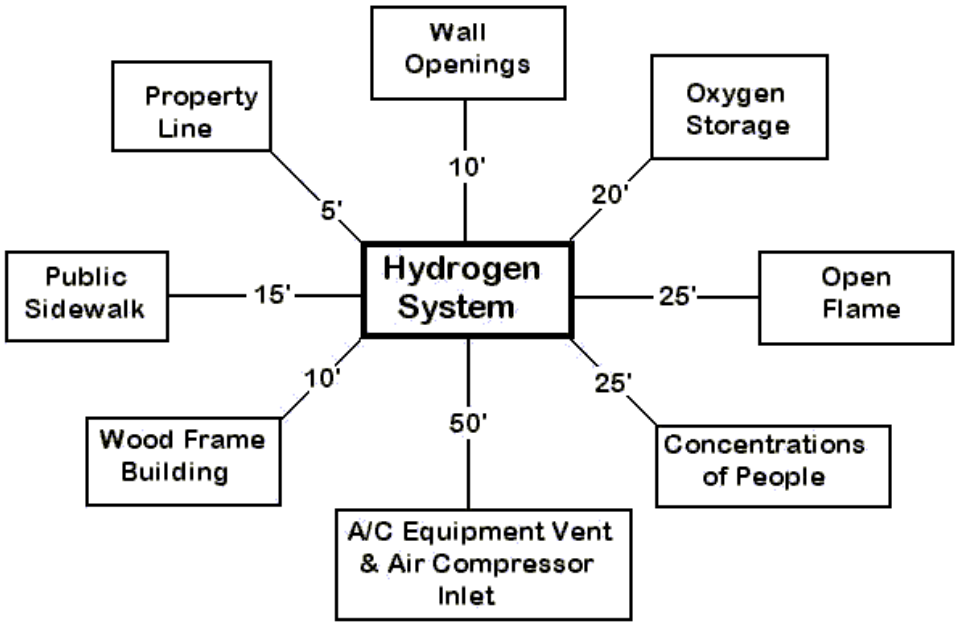
Figure 2

Selection of a suitable site for a hydrogen supply building is discussed in NFPA-50A. Additionally, standards for minimum distances from combustible materials, oxygen sources, and pedestrian traffic are outlined. The following table displays the NFPA recommendation for location of a hydrogen supply system of varying volume. (See Table I & II)

	Size of Hydrogen System		
Nature of Location	**<3,000CF**	**3,000CF-15,000CF**	**>15,000CF**
Outdoors	**I**	**I**	**I**
In a separate building	**II**	**II**	**II**
In a special room	**III**	**III**	**Not Permitted**
Inside buildings not in a special room and exposed to other occupancies	**IV**	**Not Permitted**	**Not Permitted**

***Specific details about each location can be found in Table 3-2.2 of NFPA 50 A*

Table I



Information compiled from NFPA-50A - Standard for Gaseous Hydrogen Systems

Table II

The main hydrogen manifold (Figure 3) shows the location of regulators, valves, and gas cylinders.

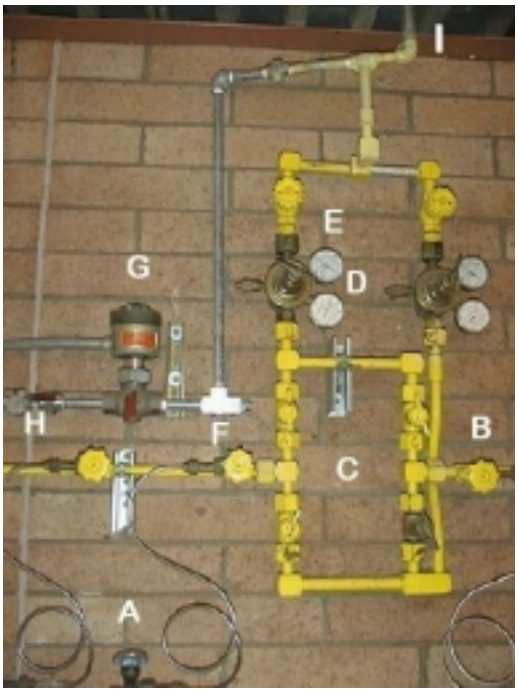


Figure 3

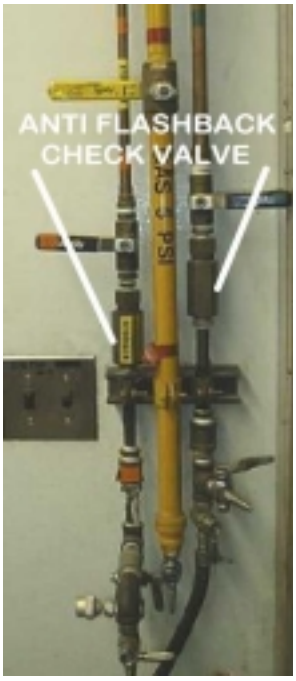


Figure 4

(A) 220 cu.ft. hydrogen cylinder. Size 44 cylinder with a filled pressure of 2000 PSI. Industrial grade hydrogen (99.9% purity)
(B) Individual main manifold valves with in-line back flow check valve. These valves allow connection of new cylinders to the system while in operation.
(C) Proper adjustment of the four main control valves allows automatic switching between cylinder banks.
(D) The two stage regulators reduce the gas delivery pressure from 2000 PSI to 0-40 PSI.
(E) Main shut off valves.
(F) To protect the system from high flow failures (i.e., broken hose or fitting failure) an adjustable safety excess flow valve should be installed in the gas delivery side of the hydrogen manifold. The valve will instantly detect and stop surges in the hydrogen flow caused by a malfunction in the system. Once the flow is back to the normal operating level, the excess flow valve will automatically open and the operation of the system will resume.
(G) The electric solenoid valve in this system controls two 200-CFM exhaust fans in the Glassblowing Facility. These exhaust fans must be turned on to allow hydrogen gas to be delivered into the system.
(H) The quick close ball valve isolates manifold from the delivery piping.
(I) In the event of regulator diaphragm rupture, the safety relief valve vents excessive gas pressure to the atmosphere.

Workstation connections (Figure 4) are fitted with anti flashback check valves for additional protection. As required by NFPA 50A and 51, in-line reverse gas flow check valves must be installed when hydrogen is used in conjunction with oxygen or compressed air. These check valves are designed to protect the operator from the dangers of reverse flow and flashback into the gas delivery system. These valves keep the gas flowing freely under normal operating pressure, but automatically close when a flashback occurs.

Figure 5

Liquid flashback arrestors are recommended when hydrogen is used with oxygen or compressed air. The liquid flashback arrestor is designed to protect the main gas supply from the dangers of reverse flow and flashbacks. Flashbacks occur when rapid flame propagation causes flames to pass back through the torch and progress into the upstream equipment. The liquid flashback arrestor is essentially a gas bubbler filled with a non-volatile liquid. In normal operation, the fuel gas flows through the liquid reservoir and is delivered to the torches. If a flashback and reverse flow occurs, the reverse flow check valve stops the gas flow and the liquid will extinguish the flashback flame. To maintain this protection and to ensure that the arrestor has not become damaged or inoperative during use, a routine inspection program should be followed as specified by the manufacturer.

To prevent flashback, hand torches are equipped with anti flashback check valves on the hydrogen and oxygen lines. (See Figure 6) For flexible hose protection, the check valves should be mounted directly to the torch. The alternate mounting can be at the work station connections, as shown in Figure 4.

Figure 6

NFPA regulations require that hydrogen delivery, storage, and manifold system be clearly labeled. The permanent placard should read: "HYDROGEN -- FLAMMABLE GAS -- NO SMOKING -- NO OPEN FLAMES", or equivalent. (See Figure 7) The underground hydrogen pipeline should be clearly marked as well (Figure 8).

Figure 7

Figure 8

For further information regarding design and installation of gaseous hydrogen systems, visit the Compressed Gas Association website at http://www.cganet.com/Pubs/Free/tb-3.htm . Additional information is also available on the Arizona State University, Department of Chemistry and Biochemistry Glassblowing Facility website at http://www.public.asu.edu/~aomdw/GLASS.