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1ST EDITION

STANDARD PROCEDURES FOR HYDROGEN SUPPLY SYSTEMS

PREFACE

As part of a program of harmonization of industry standards, the Compressed Gas Association (CGA) has published CGA H-7, *Standard Procedures for Hydrogen Supply Systems*, jointly produced by members of the International Harmonization Council.

This publication is intended as an international harmonized standard for the worldwide use and application of all members of the Asia Industrial Gases Association (AIGA), Compressed Gas Association (CGA), European Industrial Gases Association (EIGA), and Japan Industrial and Medical Gases Association (JIMGA). Each association's technical content is identical, except for regional regulatory requirements and minor changes in formatting and spelling.

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NOTE—Appendix A (Normative) is a requirement.

NOTE—Appendix B (Normative for U.S. facilities).

NOTE—Appendix C (Informative) is for information only.

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1 Introduction

With the increased emphasis on renewable and clean energy, the hydrogen space is seeing tremendous growth both in activities and in entrants to the space. Much of that growth is taking place in near-consumer locations, such as gas stations and convenience stores, as opposed to the more traditional industrial settings historically associated with the use of hydrogen. Additionally, more personnel are becoming involved with the use of hydrogen.

It is important that these new entrants learn the best practices for working safely with and around hydrogen. The general public has concerns about the safety of hydrogen and must be comfortable with the work of those in the hydrogen space.

2 Scope

This publication provides recommended best practices and standardized procedures for personnel using hydrogen supply systems. The practices and procedures are limited to bulk gaseous and cryogenic liquid hydrogen and do not address nonbulk (cylinders) supply systems. This publication addresses processes for commissioning, filling, decommissioning, maintaining, and operating hydrogen supply systems.

This publication assumes that the hydrogen supply system has been designed and installed in accordance with the appropriate codes, standards, and local permits, as well as having an emergency preparedness plan in place. Users are encouraged to read the applicable codes and standards listed in Section 6 and Section 7 before undertaking any work on a hydrogen supply system. This publication does not replace the content found in those standards but is intended to supply best practices for working around hydrogen and with equipment in hydrogen service.

This publication contains general guidelines for any equipment that is storing, processing, or transporting hydrogen that otherwise has no procedural guidance. It is not intended to replace any system-specific standards or guidelines.

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Authority having jurisdiction (AHJ)

Organization, office, or individual responsible for enforcing the requirements of a code or standard or responsible for approving equipment, materials, installations, or procedures.

NOTE—There may be multiple AHJs with various levels of responsibility and authority.

3.2.2 Asphyxiant

Gas which can cause suffocation when inhaled by man or animals.

NOTE—Although most gases, with the exception of air, oxygen, and a few others, are asphyxiant, the term is mainly used for gases not connected with other hazards, flammability, toxicity, etc.

3.2.3 Bonding

Electrical connection between components to ensure the static electric discharge to earth ground.

3.2.4 Cryogenic

Temperatures less than -130°F (-90°C).

3.2.5 Flammability

Ability of a substance to ignite at some concentration in air.

3.2.6 Fire code

Code enforced by the authority having jurisdiction (AHJ). Typically, the model code is written by the National Fire Protection Association (i.e., NFPA 1, *Fire Code*[®]) or by the International Code Council (i.e., *International Fire Code*) [1, 2].¹

3.2.7 Grounding

Practice of intentionally electrically connecting all exposed metallic items not designed to carry electricity in a room or building as protection from electric shock.

NOTE—Grounding is also known as “earth grounding.”

3.2.8 Inert gas

Nonreactive, nonflammable, noncorrosive gas such as argon, helium, krypton, neon, nitrogen, and xenon.

3.2.9 Process hazards analysis (PHA)

Set of organized and systematic assessments of the potential hazards associated with an industrial process.

NOTE—A PHA provides information intended to assist in making decisions for improving safety and reducing the consequences of unwanted or unplanned releases of hazardous chemicals.

3.2.10 Purge

Elimination of an undesirable contaminant by displacement with another fluid.

4 General safety principles

The unique properties of hydrogen provide the reasoning for the safety practices described in this section. Section 5 provides specific examples of how these elements are put into practice.

4.1 Hydrogen properties

Globally Harmonized System of Classification and Labeling of Chemicals (GHS) list hydrogen as “an extremely flammable gas.” It is the lightest of all elements. It is naturally buoyant and lighter than air in gaseous form. However, hydrogen can migrate along the ground when in liquid or cryogenic gaseous form and is less buoyant than air. When warmed up, hydrogen can rise and become trapped under obstructions such as roofs or enclosures.

Hydrogen has a low ignition energy, high burning velocity, and a wide flammability range. Releases of hydrogen will create a flammable cloud that will ignite in the presence of an ignition source. Personnel who are involved with any activity within the hydrogen site shall be aware of the dangers caused by ordinary everyday items like cell phones, lighters, cigarettes, watches, or standard flashlights. Energy from these items can cause an explosion in hydrogen-enriched atmospheres. Additionally, static electricity can be an ignition source. All sources of ignition should be eliminated. Burning hydrogen can result in a flash fire and subsequent jet fire. A confined cloud can result in an explosion. Hydrogen burns with an almost invisible bluish flame. The flame is so pale in

¹ References are shown by bracketed numbers and are listed in order of appearance in the reference section.

daylight that a person can feel heat or be burned by hydrogen that was accidentally ignited without having seen a flame.

Large volumes of hydrogen can displace air and serve as an asphyxiant. Since hydrogen is flammable at 4% in air, it is a flammability hazard well before it can act as an asphyxiant.

Liquid hydrogen has a temperature that can liquify air. Exposed bare piping will generate air condensation that can create both a cryogenic burn hazard and fire hazards from oxygen-enriched environments (i.e., a concentration greater than 23.5% by volume).

More detailed information can be found in CGA G-5, *Hydrogen* [3].

4.2 Safe venting of hydrogen

Intentional hydrogen releases shall be directed to a vent stack that is designed to have sufficient height and separation from equipment, structures, and exposures to prevent expanding gas restrictions (confinement) and to ensure potential heat from hydrogen flames are not in the proximity of people and structures.

Venting cryogenic gaseous hydrogen, which is not as buoyant as warm gaseous hydrogen, can create a flammable hydrogen cloud that will drift downwind. Cryogenic releases create visible water vapor clouds. These clouds should be observed to avoid flammable mixtures at or near grade by adjusting the vent rate.

Vented hydrogen is subject to ignition from static electricity and lightning. Some recommended practices for venting hydrogen in the presence of lightning are as follows:

- Avoid venting for 30 minutes after lightning has been seen. Reset the 30-minute no-vent time when new lightning has been seen; and
- During that 30-minute period, cease outdoor work.

The ignition of vented hydrogen at the stack exit is not uncommon. Properly engineered vent stacks take such fires into consideration. It is important to isolate the vented hydrogen, when possible, to minimize the stack fires duration.

Water shall not be sprayed onto a vent stack.

See CGA G-5.5, *Standard for Hydrogen Vent Systems*, for more details about venting and how to size a stack that releases hydrogen at a safe elevation [4].

4.3 Grounding of hydrogen supply systems

To reduce the chances of hydrogen ignition, ground all equipment in hydrogen service and all associated equipment for the hydrogen supply system. The ignition of hydrogen clouds can come from a wide range of sources, common to other flammable gases, but also includes static electric discharge from friction caused in transfers and venting. Electrical zone classifications outlined in NFPA 70, *National Electric Code*® and NFPA 2, *Hydrogen Technologies Code*, shall be followed [5, 6]. Some typical causes of ignition are arcs from electrical equipment and open flames. Other sources are sparks from working with tools or electrical devices. Careful attention to grounding of hydrogen equipment is critical.

Grounding electrodes shall have clean metal surfaces and be free of paint or other nonconductive materials. The grounding system shall have a resistance to ground of 25 ohms or less. See NFPA 70 [5]. Provisions in laws and regulations may vary by country. In this case, the jurisdictional laws and regulations shall take precedence.

CGA H-5, *Standard for Bulk Hydrogen Supply Systems*, provides details about grounding [7].

4.4 Personal protective equipment

Appropriate personal protective equipment (PPE) shall be worn when working on a bulk hydrogen supply system or within the separation distances outlined in NFPA 2 [6]. The appropriate PPE includes the following:

- eye protection (glasses or shields);

- gloves (leather or cryogenic);
- hard hats;
- safety shoes;
- hearing protection (for noise from venting and equipment operation);
- flame retardant (FR) clothing; and
- on-person gas monitoring to test area continually for a flammable atmosphere.

CGA P-44, *Selection of Personal Protective Equipment*, provides further information about PPE [8].

NOTE—These PPE requirements do not apply to individuals who are dispensing hydrogen to a vehicle.

4.5 Purging equipment and piping

A key step in working on hydrogen supply systems is to purge the system with an inert gas, usually nitrogen, to remove air before hydrogen is added to the system, or to remove hydrogen before opening the system to the atmosphere. See Figure 1 and Figure 2 for purging systems into and out of service.

Hydrogen supply systems shall be purged into service for operation. Hydrogen supply systems shall be purged out of service for maintenance and repair and other procedures, which are considered to be out of normal operation. This section provides the overall considerations for purging.

Liquid hydrogen supply systems shall be free of gases other than hydrogen or helium prior to introduction of liquid hydrogen. Liquid hydrogen will freeze solid any gas except for hydrogen and helium.

Hydrogen shall be purged from the system with nitrogen before moving equipment from the supply system site.

Systems should be purged with inert gas before introducing gaseous hydrogen. The level of oxygen shall be less than 1.0% concentration as measured with a handheld or personal gas monitor.

When removing a liquid hydrogen supply system from service, liquid hydrogen shall be removed and the system allowed to warm up before purging with nitrogen.

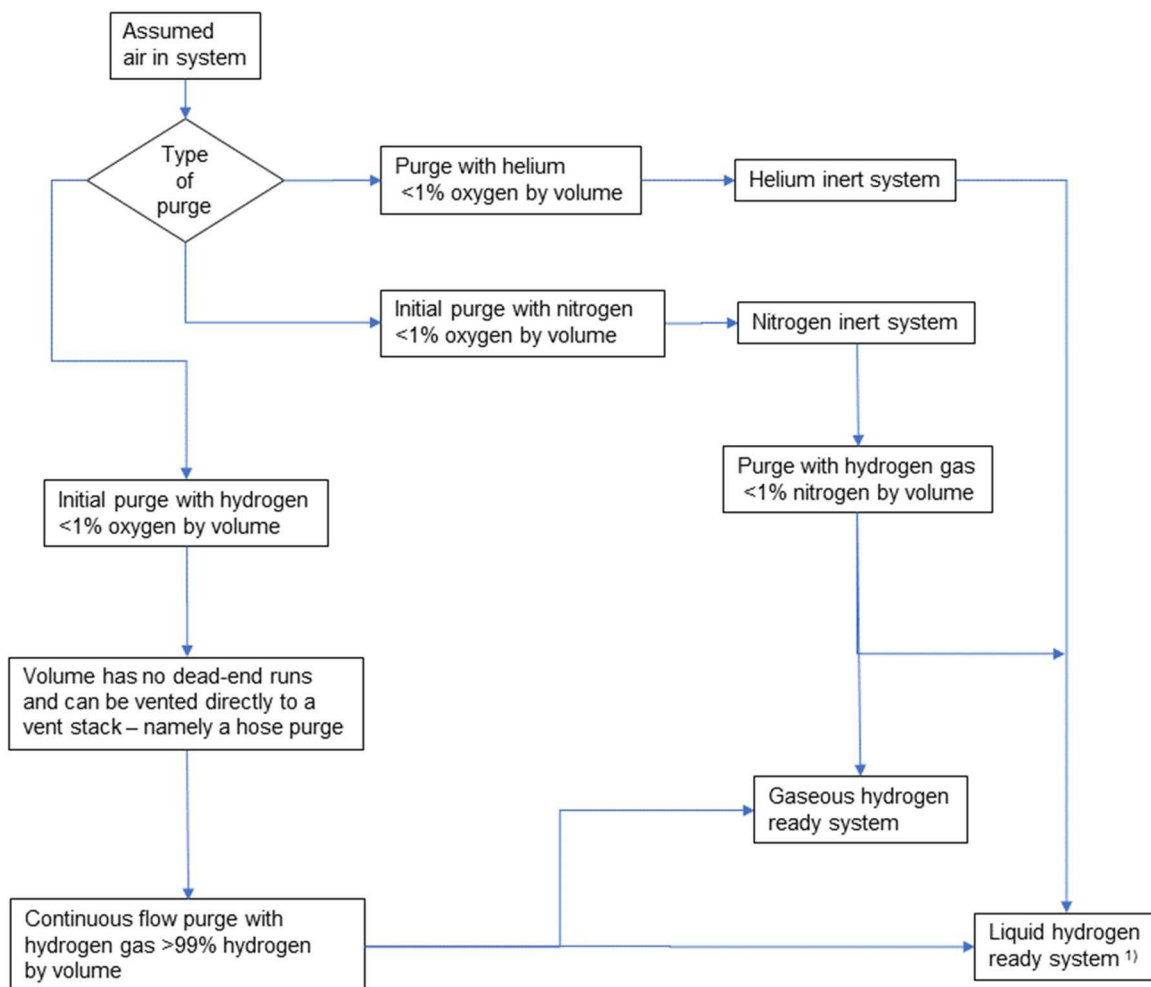
A continuous flow purge is acceptable when there are no branch connections. The minimum flow rate should be 10 volumes of the equipment storage.

Where a flow purge is not possible, such as working on tanks, receivers, or other vessels, a pressure purge can be used with the following process, see Figure 1 and Figure 2:

- Pressurize to 30 psi (200 kPa);²
- Allow pressure to “soak” for 5 minutes;
- Soak time can start at first positive pressure;
- Vent to less than 1 psi (7 kPa);
- Repeat until vented gas is in specification; and
- Repeat no fewer than 7 times.

See CGA H-5 and NFPA 2 for more information about purging requirements [7, 6].

² psi, bar, and kPa shall indicate gauge pressure unless otherwise noted as (psia; bar, abs; and kPa, abs) for absolute pressure or (psid; bar, dif; and kPa, dif) for differential pressure. All kPa values are rounded off per CGA P-11, *Guideline for Metric Practice in the Compressed Gas Industry* [9].



¹⁾ Only introduce liquid hydrogen to systems specifically designed for liquid hydrogen cryogenic service.

Figure 1—Purging hydrogen supply systems into service