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ANSI/AIAA G-095A-2017
(Revision of AIAA G-095-2004)

Guide

American National Standard

Guide to Safety of Hydrogen and Hydrogen Systems

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Guide to Safety of Hydrogen and Hydrogen Systems

Sponsored by

American Institute of Aeronautics and Astronautics

Approved 30 October 2017

American National Standards Institute

Approved 11 December 2017

Abstract

This Guide presents information that designers, builders, and users of hydrogen systems can use to ensure safe hydrogen systems or resolve hydrogen hazards. Guidance is provided on general safety systems and controls, usage, personnel training, hazard management, design, facilities, detection, storage, transportation, and emergency procedures. Pertinent research is summarized, and supporting data are presented relative to the topic. Additional information regarding codes, standards, and regulations, as well as a sample safety data sheet, extensive bibliography, and other useful material can be found in the annexes.

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Foreword

Hydrogen is a lightweight, easily ignitable element that is extremely useful in a wide range of applications. In aerospace applications, which are the focus of this guide, it is used as a propulsion fuel and as a reactant in fuel cells to provide electrical power. As with any fuel, there are hazards inherent with hydrogen's use. The users and designers of hydrogen systems must be aware of these hazards and safeguard against them. One of the goals of this technical guide is to document these hazards and the safety considerations involved in addressing them.

Although a substantial amount of information has been compiled in this guide, the user is cautioned that there are many sources of information regarding the safe use of hydrogen. New research is conducted and new applications are being developed regularly. This technical guide is released with the currently compiled information and will be periodically updated as new data are obtained. Users are encouraged to assess their individual programs and develop additional requirements as needed

The original version of this AIAA Guide replaced the "Safety Standard for Hydrogen and Hydrogen Systems," NASA Safety Standard (NSS) 1740.16, which established a uniform NASA process for hydrogen system design, materials selection, operation, storage, and transportation. This revision of the Guide provides updated information in the field including the following:

- Reorganized information to reflect the actual process
- Placed relevant figures and tables within the document for ease of reference
- Updated information regarding safety, detectors, leaks, and accidents.

In addition, information on embrittlement has been published as a separate document (NASA TM-2016-218602) and has informed key sections of this Guide.

In formulating, revising, and approving standards publications, the Hydrogen CoS will not consider patents that may apply to the subject matter. Prospective users of the publications are responsible for protecting themselves against liability for infringement of patents, or copyrights, or both.

The current members of the Hydrogen CoS acknowledge the valuable input from several original members, especially Howard Julien, William St. Cyr, and David Coote, and are grateful for the contributions of past committee members and reviewers in their efforts to improve this Guide.

At the time of approval, the members of the AIAA Hydrogen Committee on Standards (CoS) were:

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The AIAA Standards Executive Council (VP-Standards, Mr. Allen Arrington, Chairman) accepted the document for publication in October 2017.

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Introduction

This Guide contains guidelines for safely storing, handling, and using hydrogen in gaseous (GH_2), liquefied (LH_2), slush (SLH_2),or solid (SH_2) forms, whether used as a propellant or nonpropellant. Topics covered include sections on hydrogen properties and hazards, materials compatibility, facility design, design of components, detection, and transportation. It also covers various operational issues and emergency procedures. The material in these sections is supplemented by details and information in the following informative annexes in this guide:

- Annex A is the bibliography.
- Annex B gives information related to applicable codes, standards, and regulations.
- Annex C provides selected (primarily safety related) chemical, physical, and combustion properties of hydrogen, and information regarding storage siting, venting and flow, materials, hydrogen and hydrogen fire detection, and accidents involving hydrogen.
- Annex D provides guidance on training information recommended for operators.
- Annex E is the sample Safety Data Sheet (SDS).
- Annex F gives assessment examples to illustrate the use of selected requirements.
- Annex G describes scaling laws, explosions, blast effects, and fragmentation.
- Annex H provides information regarding pressure relief devices (PRDs) and requirements.

The information is arranged in an easy-to-use format. The reader will find the following useful to note:

- A numbered outline format is used so information can be readily found and easily cited.
- Acronyms are defined when introduced, and a tabulation of acronyms used in the document is provided in Section 3.1, Acronyms and Abbreviated Terms.
- Definitions of many of the terms used in this guide are given in Section 3.2, Terms and Definitions.
- All sources are referenced so the user can verify original sources as deemed necessary. References cited in the main body of the text can be found in the bibliography in Annex A. The latest revisions of codes, standards, and mandatory regulations should be used when those referenced are superseded.
- The International System of Units (SI) is used for primary units, and U.S. Customary units are given in parentheses following the SI units. Some of the tables and figures contain only one set of units.

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1 Scope

This Guide presents information that designers, builders, and users of hydrogen systems can use to manage and ensure safe hydrogen systems or resolve hazards related to the material behavior, facility storage, detection, and transportation of hydrogen as well as a review of emergency procedures. Pertinent research is summarized and supporting data are presented relative to the topic. Additional information regarding codes, standards, and regulations, as well as a sample safety data sheet, training examples, and other useful material are referenced and can be found in the annexes.

The intent of this Guide is to provide enough information that it can be used alone; at the same time, data sources that can provide much more detail, if required, are referenced and listed in Annex A (Bibliography).

1.1 Purpose

This Guide provides a minimum set of practical guidelines for safe hydrogen use. Users are encouraged to assess their individual programs and develop additional requirements as needed. The information presented here should be used as a reference to hydrogen design and practice and not as an authorizing document.

1.2 Applicability

The focus of this Guide is on molecular hydrogen formed from protium, as opposed to isotopes of hydrogen deuterium and tritium. This Guide shall apply to the design, installation, storage, use, and handling of hydrogen, in GH_2, LH_2, SLH_2, and SH_2 forms, and for all occupancies. The words "shall" and "must" are used in this Guide to indicate a mandatory requirement, and the authority for the requirement is given. The words "should" and "will" are used to indicate a recommendation or that which is advised but not mandatory.

In this Guide the use of hydrogen is separated into two categories—propellant and nonpropellant as described below.

1) The propellant category is distinguished by hydrogen usage wherein system failure could induce mixing of significant amounts of hydrogen and oxidizer, or high-pressure release, or large quantities to catastrophic effect, such as may be anticipated for failures in missile and rocket propulsion applications. The propellant category commonly involves facilities such as launch pads, static test stands, and associated propellant storage tanks at risk to physical damage by the intended operations.

2) The nonpropellant category covers the use of hydrogen in any of a multitude of laboratory, commercial, industrial, and consumer applications. The distinguishing features of these applications are that an unintended release of hydrogen can only involve air, and that hazards are minimized, either through use of small quantities or through well characterized operations whose hazards are known and mitigated.

1.3 Application

The practice and requirements of this Guide shall apply to designers, users, operators, maintainers, quality assurance personnel, and designated project managers who are responsible for incorporating the appropriate requirements of this Guide into their projects or facilities.

1.4 Responsibility

The use of this Guide does not relieve the designer, user, operator, maintainer, quality assurance person, or designated managers of professional responsibility or allow them to preclude the exercise of sound engineering judgment.