Public Input No. 207-NFPA 2-2023 [Section No. 1.3.3]

1.3.3 Exemptions.

This code shall not apply to the following:

(1) Design or components related to the transport of hydrogen or propulsion of hydrogen motor vehicles~~, including onboard hydrogen storage systems~~

(2) Mixtures of GH_2 and other gases with a hydrogen concentration of less than 95 percent by volume when in accordance with NFPA 55

(3) The storage, handling, use, or processing of metal hydride materials outside of metal hydride storage systems defined in Chapter 3

Statement of Problem and Substantiation for Public Input

Substantiation: As written, this exemption is excessively broad. While it is acknowledged that design of hydrogen vehicles is exempt from NFPA 2 and should be, there are specific components of the onboard hydrogen storage systems that are not exempt. For example, the interaction of the vehicle fuel storage systems with a dispenser are within NFPA 2 scope. Similarly, there are requirements related to the fuel storage system in Chapter 18 for repair garages. The scope of applicability is best left to the individual chapters and section rather than this global exemption. There is not a concern that NFPA 2 will regulate fuel tanks unnessesarily and it does not now.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 16:05:32 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-9-NFPA 2-2024

Statement: While it is acknowledged that design of hydrogen vehicles is exempt from NFPA 2 and should be, there are specific components of the onboard hydrogen storage systems that are not exempt. For example, the interaction of the vehicle fuel storage systems with a dispenser are within NFPA 2 scope. Similarly, there are requirements related to the fuel storage system in Chapter 18 for repair garages. The scope of applicability is best left to the individual chapters and section rather than this global exemption.

Public Input No. 221-NFPA 2-2024 [Section No. 1.3.3]

1.3.3 Exemptions.

This code shall not apply to the following:

(1) Design or components related to the transport of hydrogen or propulsion of hydrogen motor vehicles, including onboard hydrogen storage systems

(2) Mixtures of GH_2 and other gases with a hydrogen concentration of less than 95 percent by volume when in accordance with NFPA 55

(3) Mixtures of GH2 and other gases supplied as a combustion fuel for the systems defined in Chapter 14 with a hydrogen concentration of 25 percent or less by volume when in accordance with NFPA 55

(4) The storage, handling, use, or processing of metal hydride materials outside of metal hydride storage systems defined in Chapter 3

Statement of Problem and Substantiation for Public Input

Various combustion process equipment is being shifted from natural gas to blends of natural gas and hydrogen as part of the global shift to hydrogen fuel. These blends range from 5% to 95% plus hydrogen. The most common blend seen to date is 20% hydrogen enriched pipeline natural gas blend in Europe; however, mixing systems have been proposed to increase the use of hydrogen in the near future. This led directly to the formation of the Chapter 14 Task group to capture the known industrial processes on this path and provide the appropriate guidance within the chapter.

Guidance regarding the hazardous area classification of hydrogen mixtures have indicated those greater than 25% (IEC) or 30% (NFPA) are considered as “hydrogen” for the selection of electrical equipment. It is from that basis that the Task Group agreed to use 25% as the limit hydrogen concentration for inclusion of such mixtures in NFPA 2.

Since the original scope of NFPA 2 was limited to mixtures of 95% or greater hydrogen, it was clear that a separate statement regarding the Scope of NFPA 2 was required to recognize the situations covered in Chapter 14 and to point the user to NFPA 55 for blends that are at 25% hydrogen or less (similar to the original 95% exemption). This ensures consistency in the application of the Code.

This PI is submitted by Lawrence Danner, CSP on behalf of the Chapter 14 Task Group.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 222-NFPA 2-2024 [New Section after 3.3.121]	
Public Input No. 223-NFPA 2-2024 [New Section after 3.3.215]	
Public Input No. 224-NFPA 2-2024 [Chapter 14]	
Public Input No. 225-NFPA 2-2024 [Sections A.14.1.1, A.14.3.1.2, A.14.3.1.2.1, A.14.3.1.2.2, ...]	
Public Input No. 226-NFPA 2-2024 [New Section after A.3.3.120.2]	

Submitter Information Verification

Submitter Full Name: Larry Danner

Organization: GE Power
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 02 10:39:19 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: CI-128-NFPA 2-2024

Statement: The fuel being supplied to various combustion process equipment is being shifted from natural gas to blends of natural gas and hydrogen as part of the global shift to hydrogen fuel. These blends currently range from 5% to greater than 30% hydrogen and current new designs recognize the use of increasing hydrogen content with 50% near term and 100% in the long term.

There are two factors to be considered:

• Guidance regarding the hazardous area classification of hydrogen mixtures require those greater than 25% to be considered as “hydrogen” for the selection of electrical equipment(REF: IEC 60079-10-1).

• Research into the increased hazards associated with natural gas – hydrogen mixtures provide a basis for an appropriate “threshold” for the considering these hazards in industrial settings.

See the White Paper “Hydrogen use in natural gas pipeline”, Alex Di Sciullo Jones and Kai-Hsiang (Jerry) Yen, UL Solutions, 2023.

The committee is working on a rewrite of Chapter 14 where the industrial processes included in Chapter 14 rewrite are those that will specifically be using such mixtures as compared to the “pure hydrogen” uses (such as Automotive Fuel and Power Cells) it is essential to define a mixture class at less than the baseline 95% that is appropriate for the Chapter 14 industrial applications to provide the appropriate mitigation for the associated increased hazards. Given the explicit regulatory guidance for the industrial applications in Chapter 14, the 25% hydrogen threshold is the appropriate value for use in NFPA 2.

Public Input No. 56-NFPA 2-2023 [Section No. 1.3.3]

1.3.3 Exemptions.

This code shall not apply to the following:

(1) Design or components related to the transport of hydrogen or propulsion of hydrogen motor vehicles, including onboard hydrogen storage systems

(2) Mixtures of GH_2 and other gases with a hydrogen concentration of less than ~~95 percent~~ 25 percent by volume when in accordance with NFPA 55

(3) The storage, handling, use, or processing of metal hydride materials outside of metal hydride storage systems defined in Chapter 3

Statement of Problem and Substantiation for Public Input

Hydrogen as Combustion Fuel Task Group proposes change to include mixtures of 25% H2 and greater for all NFPA-2.

Submitter Information Verification

Submitter Full Name: Elizabeth Krasowski
Organization: Ramboll
Street Address:
City:
State:
Zip:
Submittal Date: Thu Oct 12 13:13:07 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: CI-128-NFPA 2-2024

Statement: The fuel being supplied to various combustion process equipment is being shifted from natural gas to blends of natural gas and hydrogen as part of the global shift to hydrogen fuel. These blends currently range from 5% to greater than 30% hydrogen and current new designs recognize the use of increasing hydrogen content with 50% near term and 100% in the long term.

There are two factors to be considered:

• Guidance regarding the hazardous area classification of hydrogen mixtures require those greater than 25% to be considered as “hydrogen” for the selection of electrical equipment(REF: IEC 60079-10-1).

• Research into the increased hazards associated with natural gas – hydrogen mixtures provide a basis for an appropriate “threshold” for the considering these hazards in industrial settings.

See the White Paper “Hydrogen use in natural gas pipeline”, Alex Di Sciullo Jones and Kai-Hsiang (Jerry) Yen, UL Solutions, 2023.

The committee is working on a rewrite of Chapter 14 where the industrial processes included in Chapter 14 rewrite are those that will specifically be using such mixtures as compared to the “pure hydrogen” uses (such as Automotive Fuel and Power Cells) it is essential to define a mixture class at less than the baseline 95% that is appropriate for the Chapter 14 industrial applications to provide the appropriate mitigation for the associated increased hazards. Given the explicit regulatory guidance for the industrial applications in Chapter 14, the 25% hydrogen threshold is the appropriate value for use in NFPA 2.

Public Input No. 9-NFPA 2-2023 [Section No. 2.2]

2.2 NFPA Publications.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1, *Fire Code,* 2021 edition.

NFPA 10, *Standard for Portable Fire Extinguishers,* 2022 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* 2020 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems,* 2022 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems,* 2022 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2022 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2022 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems,* 2021 edition.

NFPA 17A, *Standard for Wet Chemical Extinguishing Systems,* 2021 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2023 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 2021 edition.

NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages,* 2021 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment,* 2020 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals,* 2019 edition.

NFPA 54, *National Fuel Gas Code,* 2021 edition.

~~NFPA 55, *Compressed Gases and Cryogenic Fluids Code,* 2023 edition.~~

NFPA 58, *Liquefied Petroleum Gas Code,* 2020 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting,* 2018 edition.

NFPA 69, *Standard on Explosion Prevention Systems,* 2019 edition.

NFPA 70®, *National Electrical Code*®, 2023 edition.

NFPA 72®, *National Fire Alarm and Signaling Code*®, 2022 edition.

NFPA 77, *Recommended Practice on Static Electricity,* 2019 edition.

NFPA 79, *Electrical Standard for Industrial Machinery,* 2021 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives,* 2022 edition.

NFPA 86, *Standard for Ovens and Furnaces,* 2023 edition.

NFPA 88A, *Standard for Parking Structures,* 2023 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems,* 2021 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids,* 2020 edition.

NFPA *101*®, *Life Safety Code*®, 2021 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems,* 2022 edition.

NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems,* 2022 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials,* 2018 edition.

NFPA 400, *Hazardous Materials Code,* 2022 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment,* 2021

edition.

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*, 2018 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2022 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2023 edition.

NFPA 853, *Standard for the Installation of Stationary Fuel Cell Power Systems*, 2020 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2022 edition.

Statement of Problem and Substantiation for Public Input

NFPA 55 is no longer a referenced standard in NFPA 2 and should be deleted from the listing.

Only the strikethrough text is part of the public input. The underlined references have not been revised: the underlining is a Terra problem.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Affiliation: NFPA 2/55 hydrogen alignment task group
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 24 14:00:17 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: NFPA 55 is referenced in 6.4.1.4 and still needs to be listed in Section 2.2.

Public Input No. 164-NFPA 2-2023 [Section No. 2.3.6]

2.3.6 CSA Group Publications.

CSA Group, 178 Rexdale Boulevard, Toronto, ON M9W 1R3, Canada.

ANSI/CSA FC 1, *Fuel Cell Technologies — Part 3-100: Stationary fuel cell power systems — Safety*, 2014 (reaffirmed 2018).

ANSI/CSA America FC 3, *Portable Fuel Cell Power Systems*, 2004 (reaffirmed 2017).

CSA/ANSI HGV 4.3, *Test Methods for Hydrogen Fueling Parameter Evaluation*, 2019.

CSA Technical Specification HGV 4.3.5, Test Methods for Hydrogen Fueling Parameter Evaluation for Heavy Duty Vehicles

Statement of Problem and Substantiation for Public Input

When the current version of NFPA2 was published, there were no fueling protocols for medium/heavy duty vehicles. Now, SAE J2601/5 is a published standard which provides a protocol for buses, trucks, etc. CSA TS HGV 4.3.5 will be the accompanying standard which is used to validate SAE J2601/5. The language in this section matches 10.5.1.4 for light duty vehicles. Vehicles are designed to standard fueling protocols, so it is important for stations to use this as their default otherwise, damage to the vehicle and fuel supply container (vehicle tank) may occur.

This Public Input is submitted on behalf of the NFPA 2 Fueling Task Group.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 160-NFPA 2-2023 [Section No. 10.5.1.5]	Reference
Public Input No. 161-NFPA 2-2023 [New Section after A.10.1.1.5]	Reference
Public Input No. 162-NFPA 2-2023 [Section No. A.10.5.1.5.1.1]	Reference
Public Input No. 163-NFPA 2-2023 [Section No. 2.3.11]	Related Reference
Public Input No. 160-NFPA 2-2023 [Section No. 10.5.1.5]	
Public Input No. 162-NFPA 2-2023 [Section No. A.10.5.1.5.1.1]	

Submitter Information Verification

Submitter Full Name: Spencer Quong
Organization: Quong & Associates Inc.
Affiliation: Toyota
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 21 17:28:45 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-210-NFPA 2-2024

Statement: References have been updated per the NFPA reference policy.

Public Input No. 20-NFPA 2-2023 [Section No. 2.3.6]

2.3.6 CSA Group Publications.

CSA Group, 178 Rexdale Boulevard, Toronto, ON M9W 1R3, Canada.

CSA/ ANSI ~~/CSA~~ FC 1 * CSA C22.2 No. 62282-3-100 , *Fuel Cell Technologies — Part 3-100: Stationary fuel cell power systems — Safety*, ~~2014 (reaffirmed 2018)~~ 2021 .

ANSI/CSA America FC 3, *Portable Fuel Cell Power Systems*, 2004 (reaffirmed ~~2017~~ 2021).

CSA/ANSI HGV 4.3, *Test Methods for Hydrogen Fueling Parameter Evaluation*, 2019.

Statement of Problem and Substantiation for Public Input

New binational edition has been published which is an adoption of the newest edition of IEC 62282-3-100.This is the first edition of CSA/ANSI FC 1 • CSA C22.2 No. 62282-3-100, Fuel cell technologies — Part 3-100: Stationary fuel cell power systems — Safety, which is an adoption with Canadian and U.S. deviations of the identically titled IEC (International Electrotechnical Commission) Standard 62282-3-100 (second edition, 2019-02). It replaces ANSI/CSA FC 1-2014 (adopted IEC 62282-3-100:2012, with U.S. deviations).

ANSI/CSA America FC 3:2004 was reaffirmed in 2021.

Submitter Information Verification

Submitter Full Name: Mark Duda
Organization: CSA Group
Street Address:
City:
State:
Zip:
Submittal Date: Tue Aug 15 10:03:55 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-210-NFPA 2-2024
Statement: References have been updated per the NFPA reference policy.

Public Input No. 163-NFPA 2-2023 [Section No. 2.3.11]

2.3.11 SAE Publications.

SAE International, Society of Automotive Engineers, 901 15th Street, NW, Suite 520, Washington, DC 20005, www.SAE.org.

SAE J2579 201806, *Standard for Fuel Systems in Fuel Cell and Other Hydrogen Vehicles*, 2018.

SAE J2600, *Compressed Hydrogen Surface Refueling Connection Devices*, 2015.

SAE J2601-3, *Fueling Protocol for gaseous Hydrogen Powered Industrial Trucks,* 2013.

SAE J2601-5 High-Flow Prescriptive Fueling Protocols for Gaseous Hydrogen Powered Medium and Heavy-Duty Vehicles

Statement of Problem and Substantiation for Public Input

When the current version of NFPA2 was published, there were no fueling protocols for medium/heavy duty vehicles. Now, SAE J2601/5 is a published standard which provides a protocol for buses, trucks, etc. CSA TS HGV 4.3.5 will be the accompanying standard which is used to validate SAE J2601/5. The language in this section matches 10.5.1.4 for light duty vehicles. Vehicles are designed to standard fueling protocols, so it is important for stations to use this as their default otherwise, damage to the vehicle and fuel supply container (vehicle tank) may occur.

This Public Input is submitted on behalf of the NFPA 2 Fueling Task Group.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 160-NFPA 2-2023 [Section No. 10.5.1.5]	Reference
Public Input No. 161-NFPA 2-2023 [New Section after A.10.1.1.5]	Reference
Public Input No. 162-NFPA 2-2023 [Section No. A.10.5.1.5.1.1]	Reference
Public Input No. 160-NFPA 2-2023 [Section No. 10.5.1.5]	
Public Input No. 161-NFPA 2-2023 [New Section after A.10.1.1.5]	
Public Input No. 162-NFPA 2-2023 [Section No. A.10.5.1.5.1.1]	
Public Input No. 164-NFPA 2-2023 [Section No. 2.3.6]	

Submitter Information Verification

Submitter Full Name: Spencer Quong
Organization: Quong & Associates Inc.
Affiliation: Toyota
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 21 17:26:15 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-210-NFPA 2-2024

Statement: References have been updated per the NFPA reference policy.

Public Input No. 218-NFPA 2-2023 [Section No. 2.3.12]

2.3.12 UL Publications.

Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 263, *Fire Tests of Building Construction and Materials*, ~~2019~~ 2011, revised 2021 .

UL 723, *Tests for Surface Burning Characteristics of Building Materials*, 2018, revised 2023 .

UL 61010-1, *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements*, ~~2019~~ 2012, revised 2023 .

Statement of Problem and Substantiation for Public Input

Update standards to the most current publication date.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 219-NFPA 2-2023 [Section No. O.1.2.20]	

Submitter Information Verification

Submitter Full Name: Kelly Nicolello
Organization: UL Solutions
Street Address:
City:
State:
Zip:
Submittal Date: Fri Dec 29 11:40:11 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-210-NFPA 2-2024
Statement: References have been updated per the NFPA reference policy.

Public Input No. 54-NFPA 2-2023 [New Section after 3.3]

Fuel Supply Piping System

(a) **Fuel supply piping.** Piping systems upstream of the first equipment isolation valve.

(b) **Fuel train appliance piping.** Piping downstream of the first equipment isolation valve.

Statement of Problem and Substantiation for Public Input

Submitted by the Hydrogen as a Combustion Fuel Task Group to provide definitions that will match Chapter 14 guidance.

Submitter Information Verification

Submitter Full Name: Elizabeth Krasowski
Organization: Ramboll
Street Address:
City:
State:
Zip:
Submittal Date: Thu Sep 28 13:58:00 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: CI-130-NFPA 2-2024

Statement: This revision goes hand-in hand with the 6.5.1 revision in by providing a proper definition of Equipment Fuel Train piping as opposed to the Fuel Supply Piping

The requirements of the IFGC imposed in Section 6.5.1 prohibit separable connections (flanges, threaded, etc.) for piping systems containing hydrogen within a building in a hydrogen fuel gas room and requires all welded / brazed connections. While welded / brazed piping provides the best mitigation to prevent leaks and should be used when possible, the complex fuel trains associated with the industrial equipment applications covered by Chapter 14 (furnaces, ovens, turbines, etc.) rewrite which include multiple valves and flow paths cannot be assembled using only welded / brazed connections.

Public Input No. 149-NFPA 2-2023 [Section No. 3.3.7.1]

3.3.7.1 Control Area.

A building or portion of a building or outdoor area within which hazardous materials are allowed to be stored, dispensed, used, or handled ~~in quantities not exceeding the MAQ~~ . [**400,** 2022 Modified]

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

The last part of the definition, "in quantities not exceeding the MAQ", conflicts with 6.1.1.5 &, 6.4.1.1.1. Also, definitions are not allowed to include requirements.

Note: NFPA 520 has a similar definition: "An area within a building for storage and use of high-hazard materials."

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13 TG.
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 20 10:46:38 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: Control areas concepts apply below MAQs and maintaining the extract corellation with NFPA 400 is important as that code has primary scope over hazardous materials.

Public Input No. 10-NFPA 2-2023 [Section No. 3.3.18]

~~**3.3.18** – Bulk Oxygen System.~~

~~See~~ 3.3.237.4 ~~.~~

Statement of Problem and Substantiation for Public Input

The defined term is not used in the body or annex notes of NFPA 2.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Affiliation: NFPA 2/55 hydrogen alignment task group
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 24 14:04:17 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-6-NFPA 2-2024
Statement: The scope of NFPA 2 has been revised to contain all requirements for hydrogen storage, use, and handling. The scope of NFPA 55 has been revised so that it no longer contains requirements for hydrogen storage, use, and handling. With the removal of NFPA 55 extract tags from NFPA 2, the defined term is no longer used in the NFPA 2 body or annex notes.

Public Input No. 107-NFPA 2-2023 [Section No. 3.3.51.2]

3.3.51.2* Explosion Control.

A means of ~~either~~ preventing an ~~explosion through~~ explosion through the use of explosion suppression, fuel reduction, or oxidant reduction systems or a means to prevent the structural collapse of a building in the event of an explosion through the use of deflagration venting, barricades, or related construction methods.

Statement of Problem and Substantiation for Public Input

When I read the word "either" it seems you can do either (1) try to prevent an explosion or (2) manage the explosion the best you can. I think one must alway try to prevent an explosion and if the risk assessment shows a deflagration is a likely possibility then add deflagration venting. The word either is confusing and the definition reads better without the word either

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 169-NFPA 2-2023 [Section No. 3.3.81]	Use new definition
Public Input No. 170-NFPA 2-2023 [Section No. 3.3.51.2]	point to 3.3.81
Public Input No. 169-NFPA 2-2023 [Section No. 3.3.81]	
Public Input No. 170-NFPA 2-2023 [Section No. 3.3.51.2]	
Public Input No. 215-NFPA 2-2023 [Section No. A.3.3.51.2]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control TG
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 13 14:00:14 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-28-NFPA 2-2024
Statement: The sentence pointing to NFPA 69 is moved to the beginning of the annex material to to clarify the intent of prevention first and protection as a secondary layer . Further annex material has been added to explain the hazards explosion control is protecting against. The definition is moving out from under control to be listed alphabetically.

Public Input No. 170-NFPA 2-2023 [Section No. 3.3.51.2]

3.3.51.2* Explosion Control.

~~A means of either preventing an explosion through the use of explosion suppression, fuel reduction, or oxidant reduction systems or a means to prevent the structural collapse of a building in the event of an explosion through the use of deflagration venting, barricades, or related construction methods.~~ see 3.3.81

Statement of Problem and Substantiation for Public Input

move the definition of Explosion Control out from under "Control"

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 169-NFPA 2-2023 [Section No. 3.3.81]	revised definition in "proper" location
Public Input No. 107-NFPA 2-2023 [Section No. 3.3.51.2]	revise definition : remove "either"
Public Input No. 107-NFPA 2-2023 [Section No. 3.3.51.2]	
Public Input No. 169-NFPA 2-2023 [Section No. 3.3.81]	
Public Input No. 215-NFPA 2-2023 [Section No. A.3.3.51.2]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control TG
Street Address:
City:
State:
Zip:
Submittal Date: Fri Dec 22 12:17:26 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-28-NFPA 2-2024
Statement: The sentence pointing to NFPA 69 is moved to the beginning of the annex material to to clarify the intent of prevention first and protection as a secondary layer . Further annex material has been added to explain the hazards explosion control is protecting against. The definition is moving out from under control to be listed alphabetically.

Public Input No. 171-NFPA 2-2023 [New Section after 3.3.61]

Deflagration

Propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium. [**68**, 2023] ..

Statement of Problem and Substantiation for Public Input

adding definitions to support chapter 9

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 172-NFPA 2-2023 [New Section after 3.3.61]	New definition : Detonation
Public Input No. 173-NFPA 2-2023 [New Section after 3.3.68]	New definition : Enclosure
Public Input No. 172-NFPA 2-2023 [New Section after 3.3.61]	
Public Input No. 173-NFPA 2-2023 [New Section after 3.3.68]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control TG
Street Address:
City:
State:
Zip:
Submittal Date: Fri Dec 22 12:29:48 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-110-NFPA 2-2024
Statement: The term appears in the new language of Chapter 9 and needs to be defined.

Public Input No. 172-NFPA 2-2023 [New Section after 3.3.61]

Detonation.

Propagation of a combustion zone at a velocity that is greater than the speed of sound in the unreacted medium. [**68**, 2023] .

Statement of Problem and Substantiation for Public Input

add definition to support Chapter 9

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 171-NFPA 2-2023 [New Section after 3.3.61]	New definition : Deflagration
Public Input No. 173-NFPA 2-2023 [New Section after 3.3.68]	New definition : Enclosure
Public Input No. 171-NFPA 2-2023 [New Section after 3.3.61]	
Public Input No. 173-NFPA 2-2023 [New Section after 3.3.68]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control TG
Street Address:
City:
State:
Zip:
Submittal Date: Fri Dec 22 12:34:53 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-109-NFPA 2-2024
Statement: The term appears in the new language of Chapter 9 and needs to be defined.

Public Input No. 60-NFPA 2-2023 [Section No. 3.3.63.1]

~~**3.3.63.1** – Emergency Shutdown Device (ESD) [Vehicle Fueling].~~

~~A device that brings all operations to a fail-safe condition within the fueling facility from either local or remote locations.~~

Statement of Problem and Substantiation for Public Input

see PC 58 for revision to ESD definition

The confusing use of the terms ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV. The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.
Emergency Shutoff Valve (ESV)* -- A designated valve designed to shut off the flow of fluid in the event of an emergency

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 61-NFPA 2-2023 [Section No. 3.3.252]	
Public Input No. 62-NFPA 2-2023 [Section No. 8.3.1.2.8.3]	
Public Input No. 63-NFPA 2-2023 [Section No. 8.3.1.2.9]	
Public Input No. 64-NFPA 2-2023 [New Section after A.3.3.64]	

Submitter Information Verification

Submitter Full Name:	Robert Boyd
Organization:	Boyd Hydrogen LLC
Affiliation:	This is one of a series of leftover PCs that came out of the previous cycle HEE TG that were too late for the first draft
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Oct 23 13:38:33 EDT 2023
Committee:	HYD-AAA

Committee Statement

Resolution: FR-127-NFPA 2-2024

Statement: The confusing use of the terms ESD and ESD System [Emergency Shutdown System (ESS)] has been clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together (e.g., ESS, ESD, and ESV).

A new definition for ESD has been adopted with a separate committee action.

Public Input No. 84-NFPA 2-2023 [Section No. 3.3.63.1]

3.3.63.1 Emergency Shutdown Device (ESD) [~~Vehicle Fueling~~].

~~A device that brings all operations to a fail-safe condition within the fueling facility from either local or remote locations.~~

see 3.3.69

Additional Proposed Changes

File Name	Description	Approved
PC_No._82_Rejected_but_Held.pdf	NFPA 2 PC No. 82 Rejected but held	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as "Rejected but Held" in Public Comment No. 82 of A2022 Second Draft Report for NFPA 2 and per Regs. at 4.4.8.3.1 and needs to be reconsidered by the TC for the next edition of the document.

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS.

This Public Comment is part of series of public comments that will provide consistency in the definitions and use of the terms ESS an ESD trough out the document.

These proposals also harmonizes the definition and use of these terms in CSA-HGV-4.1 and CSA-HGV-4.6.

Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).

Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Submitter Information Verification

Submitter Full Name:
Organization: Holds
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 09:14:08 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-127-NFPA 2-2024

Statement: The confusing use of the terms ESD and ESD System [Emergency Shutdown System (ESS)] has been clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together (e.g., ESS, ESD, and ESV).

A new definition for ESD has been adopted with a separate committee action.

Public Comment No. 82-NFPA 2-2021 [Section No. 3.3.63.1]

3.3.63.1 Emergency Shutdown Device (ESD)- ~~[Vehicle Fueling].~~

~~A device that brings all operations to a fail-safe condition within the fueling facility from either local or remote locations. [**52,** 2019]~~

see 3.3.69

Additional Proposed Changes

File Name	Description	Approved
ESD-ESS_-_Rev5.pdf	Clarification of ESS and ESD and definition of ESS in NFPA-2	

Statement of Problem and Substantiation for Public Comment

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS.

This Public Comment is part of series of public comments that will provide consistency in the definitions and use of the terms ESS an ESD trough out the document.

These proposals also harmonizes the definition and use of these terms in CSA-HGV-4.1 and CSA-HGV-4.6.

Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).

Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 80-NFPA 2-2021 [New Section after 3.3.69]	

Related Item

- PI-230

Submitter Information Verification

Submitter Full Name: Robert Boyd

Organization: Boyd Hydrogen LLC

Affiliation:	This proposal was developed during parallel discussions by members of the NFPA-HEE Task Group
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Jun 02 18:22:17 EDT 2021
Committee:	HYD-AAA

Committee Statement

Committee Action:	Rejected but held
Resolution:	The proposed revisions were not discussed during the First Draft meeting and are considered to be new material which cannot be acted upon at the Second Draft meeting.

Clarification of ESS and ESD and definition of ESS in NFPA-2

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comments will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This series of Public Comments also harmonizes the use of these terms with what is defined in CSA-HGV-4.1 *Hydrogen Dispensers,* and CSA-HGV-4.9 *Hydrogen Fueling Stations*

This document supports public comments: PC-79 , PC-80, PC-81, PC-82, PC-83, PC-84, PC-87 and PC-90

Problem Statement

The confusing use of the term ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Annex notes (new)

A.3.3.69. Emergency Shutdown Device (ESD).

Emergency Shutdown Devices (ESDs) may be any of the following devices that will "trip" the Emergency Shutdown System (ESS) to shut down the system into a safe mode:

1. A manually operated red pushbutton switch with a yellow background in compliance with NFPA-79,
2. A low pressure switch measuring hydrogen compressor suction pressure,
3. An UV/IR or hydrogen detector,
4. Or any other safety related input device that has a switch for electrical conductivity of signal or other means of connection to the ESS.

Most hydrogen Fueling station modules will include a separate ESS to stop the process of the module (production, compression, dispensing) in the event of an ESS activation.

Each hydrogen fueling station site will typically have all operating modules connected to a site-wide Emergency Shutdown System.

Emergency Shutdown System (ESS): The ESS responds to any activation of an ESD and shuts down the system safely.

Actions to take in NFPA-2

- Delete 3.3.63.1 (ESD definition, extract from NFPA 52)
- Modify 3.3.69 (ESD- use definition from ANSI/CSA HGV 4.1)

- Add new section after 3.3.69 (ESS-use definition from ANSI/CSA HGV 4.1) – this will go between ESD and Emergency Shutoff Valve
- Modify 3.3.70 Emergency Shutoff Valve drop link to see 3.3.250.1 and adopt current language: A designated valve designed to shut off the flow of liquids or gases

The following shows how the use of ESD and ESS need to be cleaned up and how important it is to define ESS

- 8.3.1.2.8.3 – propose to change "ESD" to "ESS" and "ESD system" change to "ESS"
  - Proposed language: "When an emergency shutdown is required, activation of the ESS shall shut down operation of all pumps and compressors. 55:11.2.8.3
- 8.3.1.2.9- propose to add acronym (ESS)
- 8.3.1.2.9.2- propose to change "system" to "device:
  - Proposed language: "An emergency shutdown device (ESD) shall be provided at the bulk source to stop the flow of liquid and gas into the use line when actuated."
- 8.3.2.1.9.4- Proposed language: "Reactivation of the ESS after activation shall require that the ESS be manually reset."
-
- 8.3.1.2.9.5- Proposed language: "The ESD manual activation shall be identified by means of a sign."
- 11.3.1.8: change "(ESD)" to "(ESS)". Revise language

This proposal was developed during parallel discussions by members of the NFPA-2-HEE Task Group

The following change was developed after a further review of NFPA-2 first draft are shown below:

8.3.1.2.8.3 Emergency Shutdown System Operation.
When an emergency shutdown (ESD) is required, activation of the **Emergency Shutdown System (ESS)** ~~**ESD** system~~ shall shut down operation of all pumps and compressors. [~~**55:**11.2.8.3~~]

Public Input No. 173-NFPA 2-2023 [New Section after 3.3.68]

Enclosure

A confined or partially confined volume. [**68**, 2023]

A.3.3.XX Enclosure.

Examples of enclosures include a room, building, vessel, silo, bin, pipe, or duct. [**68**, 2023]

Statement of Problem and Substantiation for Public Input

add definitions that support chapter 9

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 171-NFPA 2-2023 [New Section after 3.3.61]	New definition : Deflagration
Public Input No. 172-NFPA 2-2023 [New Section after 3.3.61]	New definition : Detonation
Public Input No. 171-NFPA 2-2023 [New Section after 3.3.61]	
Public Input No. 172-NFPA 2-2023 [New Section after 3.3.61]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control TG
Street Address:
City:
State:
Zip:
Submittal Date: Fri Dec 22 12:38:10 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The term enclosure appears multiple times in NFPA 2 not in the context of explosion protection and cannot be added without further evaluation of where the term is used in the document.

Public Input No. 59-NFPA 2-2023 [New Section after 3.3.69]

TITLE OF NEW CONTENT

Emergency Shutdown System (ESS)*

The system that responds to ESD activation and closes Emergency Shutdown Valves (ESVs), issues alarms and other actions according to the site safety plan.

Statement of Problem and Substantiation for Public Input

The confusing use of the terms ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 61-NFPA 2-2023 [Section No. 3.3.252]	
Public Input No. 62-NFPA 2-2023 [Section No. 8.3.1.2.8.3]	
Public Input No. 63-NFPA 2-2023 [Section No. 8.3.1.2.9]	
Public Input No. 64-NFPA 2-2023 [New Section after A.3.3.64]	
Public Input No. 73-NFPA 2-2023 [Section No. 3.3.70]	
Public Input No. 74-NFPA 2-2023 [New Section after 3.3.70]	
Public Input No. 75-NFPA 2-2023 [Section No. 3.3.252]	

Submitter Information Verification

Submitter Full Name:	Robert Boyd
Organization:	Boyd Hydrogen LLC
Affiliation:	This is one of a series of leftover PC that came out of the previous cycle HEE TG that were too late for the first draft
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Oct 23 13:24:24 EDT 2023
Committee:	HYD-AAA

Committee Statement

Resolution: FR-176-NFPA 2-2024

Statement: This revision harmonizes the use of these terms with what is defined in CSA HGV- 4.1 Hydrogen Dispensers, and CSA-HGV-4.9 Hydrogen Fueling Stations

Public Input No. 82-NFPA 2-2023 [New Section after 3.3.69]

TITLE OF NEW CONTENT

The Emer g ency Shutdown System (ESS)*

A system that responds to any acvaon of an ESD and shut down the system safel y Related Annex Material

The Emer g ency Shutdown System (ESS) responds to any acvaon of an ESD and shut down the system safel y

Additional Proposed Changes

File Name	Description	Approved
PC_No._80_Rejected_but_Held.pdf	NFPA 2 PC No. 80 Rejected but held	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as "Rejected but Held" in Public Comment No. 80 of A2022 Second Draft Report for NFPA 2 and per Regs. at 4.4.8.3.1 and needs to be reconsidered by the TC for the next edition of the document.

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comments will provide consistency in the definitions and use of the terms ESS an ESD trough out the document.

This is one of a series of Public Comments also harmonizes the use of these terms with what is defined in CSA-HGV-4.1 Hydrogen Dispensers, and CSA-HGV-4.9 Hydrogen Fueling Stations

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).

Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Submitter Information Verification

Submitter Full Name: Yiu Lee
Organization: holds@nfpa.org
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 08:58:02 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-176-NFPA 2-2024

Statement: This revision harmonizes the use of these terms with what is defined in CSA HGV- 4.1 Hydrogen Dispensers, and CSA-HGV-4.9 Hydrogen Fueling Stations

Public Comment No. 80-NFPA 2-2021 [New Section after 3.3.69]

TITLE OF NEW CONTENT

The Emergency Shutdown System (ESS)*

A system that responds to any activation of an ESD and shut down the system safely__

Related Annex Material

The Emergency Shutdown System (ESS) responds to any activation of an ESD and shut down the system safely__

Additional Proposed Changes

File Name	Description	Approved
ESD-ESS_-_Rev5.docx	Clarification of ESS and ESD and definition of ESS in NFPA-2	

Statement of Problem and Substantiation for Public Comment

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comments will provide consistency in the definitions and use of the terms ESS an ESD trough out the document.

This is one of a series of Public Comments also harmonizes the use of these terms with what is defined in CSA-HGV-4.1 Hydrogen Dispensers, and CSA-HGV-4.9 Hydrogen Fueling Stations

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).

Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 82-NFPA 2-2021 [Section No. 3.3.63.1]	

Related Item

• PI-230.

Submitter Information Verification

Submitter Full Name:	Robert Boyd
Organization:	Boyd Hydrogen LLC
Affiliation:	This proposal was developed during parallel discussions by members of the NFPA-HEE Task Group
Street Address:	
City:	

State:
Zip:
Submittal Date: Wed Jun 02 17:59:07 EDT 2021
Committee: HYD-AAA

Committee Statement

Committee Action: Rejected but held

Resolution: The proposed revisions were not discussed during the First Draft meeting and are considered to be new material which cannot be acted upon at the Second Draft meeting.The proposed revisions were not discussed during the First Draft meeting and are considered to be new material which cannot be acted upon at the Second Draft meeting.

Clarification of ESS and ESD and definition of ESS in NFPA-2

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comments will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This series of Public Comments also harmonizes the use of these terms with what is defined in CSA-HGV-4.1 *Hydrogen Dispensers,* and CSA-HGV-4.9 *Hydrogen Fueling Stations*

This document supports public comments: PC-79 , PC-80, PC-81, PC-82, PC-83, PC-84, PC-87 and PC-90

Problem Statement

The confusing use of the term ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Annex notes (new)

A.3.3.69. Emergency Shutdown Device (ESD).

Emergency Shutdown Devices (ESDs) may be any of the following devices that will "trip" the Emergency Shutdown System (ESS) to shut down the system into a safe mode:

1. A manually operated red pushbutton switch with a yellow background in compliance with NFPA-79,
2. A low pressure switch measuring hydrogen compressor suction pressure,
3. An UV/IR or hydrogen detector,
4. Or any other safety related input device that has a switch for electrical conductivity of signal or other means of connection to the ESS.

Most hydrogen Fueling station modules will include a separate ESS to stop the process of the module (production, compression, dispensing) in the event of an ESS activation.

Each hydrogen fueling station site will typically have all operating modules connected to a site-wide Emergency Shutdown System.

Emergency Shutdown System (ESS): The ESS responds to any activation of an ESD and shuts down the system safely.

Actions to take in NFPA-2

- Delete 3.3.63.1 (ESD definition, extract from NFPA 52)
- Modify 3.3.69 (ESD- use definition from ANSI/CSA HGV 4.1)

- Add new section after 3.3.69 (ESS-use definition from ANSI/CSA HGV 4.1) – this will go between ESD and Emergency Shutoff Valve
- Modify 3.3.70 Emergency Shutoff Valve drop link to see 3.3.250.1 and adopt current language: A designated valve designed to shut off the flow of liquids or gases

The following shows how the use of ESD and ESS need to be cleaned up and how important it is to define ESS

- 8.3.1.2.8.3 – propose to change "ESD" to "ESS" and "ESD system" change to "ESS"
  - Proposed language: "When an emergency shutdown is required, activation of the ESS shall shut down operation of all pumps and compressors. 55:11.2.8.3
- 8.3.1.2.9- propose to add acronym (ESS)
- 8.3.1.2.9.2- propose to change "system" to "device:
  - Proposed language: "An emergency shutdown device (ESD) shall be provided at the bulk source to stop the flow of liquid and gas into the use line when actuated."
- 8.3.2.1.9.4- Proposed language: "Reactivation of the ESS after activation shall require that the ESS be manually reset."
-
- 8.3.1.2.9.5- Proposed language: "The ESD manual activation shall be identified by means of a sign."
- 11.3.1.8: change "(ESD)" to "(ESS)". Revise language

This proposal was developed during parallel discussions by members of the NFPA-2-HEE Task Group

The following change was developed after a further review of NFPA-2 first draft are shown below:

8.3.1.2.8.3 Emergency Shutdown System Operation.
When an emergency shutdown (ESD) is required, activation of the **Emergency Shutdown System (ESS)** ~~**ESD** system~~ shall shut down operation of all pumps and compressors. [~~**55:**11.2.8.3~~]

Public Comment No. 80-NFPA 2-2021 [New Section after 3.3.69]

TITLE OF NEW CONTENT

The Emergency Shutdown System (ESS)*

A system that responds to any activation of an ESD and shut down the system safely__

Related Annex Material

The Emergency Shutdown System (ESS) responds to any activation of an ESD and shut down the system safely__

Additional Proposed Changes

File Name	Description	Approved
ESD-ESS_-_Rev5.docx	Clarification of ESS and ESD and definition of ESS in NFPA-2	

Statement of Problem and Substantiation for Public Comment

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comments will provide consistency in the definitions and use of the terms ESS an ESD trough out the document.

This is one of a series of Public Comments also harmonizes the use of these terms with what is defined in CSA-HGV-4.1 Hydrogen Dispensers, and CSA-HGV-4.9 Hydrogen Fueling Stations

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).

Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Related Public Comments for This Document

Related Comment	Relationship
Public Comment No. 82-NFPA 2-2021 [Section No. 3.3.63.1]	

Related Item

• PI-230.

Submitter Information Verification

Submitter Full Name:	Robert Boyd
Organization:	Boyd Hydrogen LLC
Affiliation:	This proposal was developed during parallel discussions by members of the NFPA-HEE Task Group
Street Address:	
City:	

State:
Zip:
Submittal Date: Wed Jun 02 17:59:07 EDT 2021
Committee: HYD-AAA

Committee Statement

Committee Action: Rejected but held

Resolution: The proposed revisions were not discussed during the First Draft meeting and are considered to be new material which cannot be acted upon at the Second Draft meeting.The proposed revisions were not discussed during the First Draft meeting and are considered to be new material which cannot be acted upon at the Second Draft meeting.

Clarification of ESS and ESD and definition of ESS in NFPA-2

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comments will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This series of Public Comments also harmonizes the use of these terms with what is defined in CSA-HGV-4.1 *Hydrogen Dispensers,* and CSA-HGV-4.9 *Hydrogen Fueling Stations*

This document supports public comments: PC-79 , PC-80, PC-81, PC-82, PC-83, PC-84, PC-87 and PC-90

Problem Statement

The confusing use of the term ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Annex notes (new)

A.3.3.69. Emergency Shutdown Device (ESD).

Emergency Shutdown Devices (ESDs) may be any of the following devices that will "trip" the Emergency Shutdown System (ESS) to shut down the system into a safe mode:

1. A manually operated red pushbutton switch with a yellow background in compliance with NFPA-79,
2. A low pressure switch measuring hydrogen compressor suction pressure,
3. An UV/IR or hydrogen detector,
4. Or any other safety related input device that has a switch for electrical conductivity of signal or other means of connection to the ESS.

Most hydrogen Fueling station modules will include a separate ESS to stop the process of the module (production, compression, dispensing) in the event of an ESS activation.

Each hydrogen fueling station site will typically have all operating modules connected to a site-wide Emergency Shutdown System.

Emergency Shutdown System (ESS): The ESS responds to any activation of an ESD and shuts down the system safely.

Actions to take in NFPA-2

- Delete 3.3.63.1 (ESD definition, extract from NFPA 52)
- Modify 3.3.69 (ESD- use definition from ANSI/CSA HGV 4.1)

- Add new section after 3.3.69 (ESS-use definition from ANSI/CSA HGV 4.1) – this will go between ESD and Emergency Shutoff Valve
- Modify 3.3.70 Emergency Shutoff Valve drop link to see 3.3.250.1 and adopt current language: A designated valve designed to shut off the flow of liquids or gases

The following shows how the use of ESD and ESS need to be cleaned up and how important it is to define ESS

- 8.3.1.2.8.3 – propose to change "ESD" to "ESS" and "ESD system" change to "ESS"
  - Proposed language: "When an emergency shutdown is required, activation of the ESS shall shut down operation of all pumps and compressors. 55:11.2.8.3
- 8.3.1.2.9- propose to add acronym (ESS)
- 8.3.1.2.9.2- propose to change "system" to "device:
  - Proposed language: "An emergency shutdown device (ESD) shall be provided at the bulk source to stop the flow of liquid and gas into the use line when actuated."
- 8.3.2.1.9.4- Proposed language: "Reactivation of the ESS after activation shall require that the ESS be manually reset."
-
- 8.3.1.2.9.5- Proposed language: "The ESD manual activation shall be identified by means of a sign."
- 11.3.1.8: change "(ESD)" to "(ESS)". Revise language

This proposal was developed during parallel discussions by members of the NFPA-2-HEE Task Group

The following change was developed after a further review of NFPA-2 first draft are shown below:

8.3.1.2.8.3 Emergency Shutdown System Operation.
When an emergency shutdown (ESD) is required, activation of the **Emergency Shutdown System (ESS)** ~~**ESD** system~~ shall shut down operation of all pumps and compressors. [~~**55:**11.2.8.3~~]

Public Input No. 57-NFPA 2-2023 [Section No. 3.3.69]

3.3.69 Emergency Shutdown Device (ESD)* .

~~See~~ ~~3.3.63.1~~ . a device that activates the emergency shutdown system (ESS).

Statement of Problem and Substantiation for Public Input

The confusing use of the term ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 61-NFPA 2-2023 [Section No. 3.3.252]	
Public Input No. 62-NFPA 2-2023 [Section No. 8.3.1.2.8.3]	
Public Input No. 63-NFPA 2-2023 [Section No. 8.3.1.2.9]	
Public Input No. 64-NFPA 2-2023 [New Section after A.3.3.64]	
Public Input No. 73-NFPA 2-2023 [Section No. 3.3.70]	
Public Input No. 74-NFPA 2-2023 [New Section after 3.3.70]	
Public Input No. 75-NFPA 2-2023 [Section No. 3.3.252]	

Submitter Information Verification

Submitter Full Name:	Robert Boyd
Organization:	Boyd Hydrogen LLC
Affiliation:	this is one of a series of leftover PC that came out of the previous cycle HEE TG that were too late for the first draft
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Oct 23 12:38:59 EDT 2023
Committee:	HYD-AAA

Committee Statement

Resolution: FR-94-NFPA 2-2024

Statement: This revision harmonizes the use of these terms with what is defined in CSA-HGV-4.1 Hydrogen Dispensers, and CSA-HGV-4.9 Hydrogen Fueling Stations.

Public Input No. 81-NFPA 2-2023 [Section No. 3.3.69]

3.3.69 Emergency Shutdown Device (ESD).

~~See~~ A device that activates the emergency shutdown system (ESS).

A. 3.3. ~~63.1~~ 69. Emergency Shutdown Device (ESD).

Emergency Shutdown Devices (ESDs) may be any of the following devices that will "trip" the Emergency Shutdown System (ESS) to shut down the system into a safe mode:

(1) A manually operated Red push button switch with a yellow background in compliance with NFPA-79,

(2) A low pressure switch measuring hydrogen compressor suction pressure,

(3) An UV/IR or hydrogen detector

(4) An y other safety related input device that has a switch for electrical conductivity of signal or other means of connection to the ESS.

Most hydrogen Fueling station modules will include a separate ESS to stop the process of the module (production, compression, dispensing) in the event of an ESS activation.

Each hydrogen fueling station site will typically have all operating modules connected to a site-wide Emergency Shutdown System.

Additional Proposed Changes

File Name	Description	Approved
PC_No._79_Rejected_but_Held.pdf	NFPA 2 PC No. 79 Rejected but held	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as "Rejected but Held" in Public Comment No. 79 of A2022 Second Draft Report for NFPA 2 and per Regs. at 4.4.8.3.1 and needs to be reconsidered by the TC for the next edition of the document.

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comment will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This proposal also harmonizes the use of these term in CSA-HGV-4.1 and CSA-HGV-4.6.

Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:
Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Submitter Information Verification

Submitter Full Name: Yiu Lee

Organization: holds@nfpa.org
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 08:05:22 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-94-NFPA 2-2024
Statement: This revision harmonizes the use of these terms with what is defined in CSA-HGV-4.1 Hydrogen Dispensers, and CSA-HGV-4.9 Hydrogen Fueling Stations.

Public Comment No. 79-NFPA 2-2021 [Section No. 3.3.69]

3.3.69– * Emergency Shutdown Device (ESD).

~~See~~ A device that activates the emergency shutdown system (ESS).

A. 3.3. ~~63.1.~~ 69. Emergency Shutdown Device (ESD).

Emergency Shutdown Devices (ESDs) may be any of the following devices that will "trip" the Emergency Shutdown System (ESS) to shut down the system into a safe mode:

1. A manually operated Red pushbutton switch with a yellow background in compliance with NFPA-79,

2. A low pressure switch measuring hydrogen compressor suction pressure,

3. An UV/IR or hydrogen detector

4. Any other safety related input device that has a switch for electrical conductivity of signal or other means of connection to the ESS.

Most hydrogen Fueling station modules will include a separate ESS to stop the process of the module (production, compression, dispensing) in the event of an ESS activation.

Each hydrogen fueling station site will typically have all operating modules connected to a site-wide Emergency Shutdown System.

-

Additional Proposed Changes

File Name	Description	Approved
ESD-ESS_-_Rev5.pdf	Clarification of ESS and ESD and definition of ESS in NFPA-2	

Statement of Problem and Substantiation for Public Comment

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comment will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This proposal also harmonizes the use of these term in CSA-HGV-4.1 and CSA-HGV-4.6.

Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:
Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Related Item

• PI-230 (NFPA 2)

Submitter Information Verification

Submitter Full Robert Boyd

Name:	
Organization:	Boyd Hydrogen LLC
Affiliation:	This proposal was developed during parallel discussions by members of the NFPA-HEE Task Group
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Jun 02 17:50:36 EDT 2021
Committee:	HYD-AAA

Committee Statement

Committee Action:	Rejected but held
Resolution:	The proposed revisions were not discussed during the First Draft meeting and are considered to be new material which cannot be acted upon at the Second Draft meeting.

Clarification of ESS and ESD and definition of ESS in NFPA-2

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comments will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This series of Public Comments also harmonizes the use of these terms with what is defined in CSA-HGV-4.1 *Hydrogen Dispensers,* and CSA-HGV-4.9 *Hydrogen Fueling Stations*

This document supports public comments: PC-79 , PC-80, PC-81, PC-82, PC-83, PC-84, PC-87 and PC-90

Problem Statement

The confusing use of the term ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Annex notes (new)

A.3.3.69. Emergency Shutdown Device (ESD).

Emergency Shutdown Devices (ESDs) may be any of the following devices that will "trip" the Emergency Shutdown System (ESS) to shut down the system into a safe mode:

1. A manually operated red pushbutton switch with a yellow background in compliance with NFPA-79,
2. A low pressure switch measuring hydrogen compressor suction pressure,
3. An UV/IR or hydrogen detector,
4. Or any other safety related input device that has a switch for electrical conductivity of signal or other means of connection to the ESS.

Most hydrogen Fueling station modules will include a separate ESS to stop the process of the module (production, compression, dispensing) in the event of an ESS activation.

Each hydrogen fueling station site will typically have all operating modules connected to a site-wide Emergency Shutdown System.

Emergency Shutdown System (ESS): The ESS responds to any activation of an ESD and shuts down the system safely.

Actions to take in NFPA-2

- Delete 3.3.63.1 (ESD definition, extract from NFPA 52)
- Modify 3.3.69 (ESD- use definition from ANSI/CSA HGV 4.1)

- Add new section after 3.3.69 (ESS-use definition from ANSI/CSA HGV 4.1) – this will go between ESD and Emergency Shutoff Valve
- Modify 3.3.70 Emergency Shutoff Valve drop link to see 3.3.250.1 and adopt current language: A designated valve designed to shut off the flow of liquids or gases

The following shows how the use of ESD and ESS need to be cleaned up and how important it is to define ESS

- 8.3.1.2.8.3 – propose to change "ESD" to "ESS" and "ESD system" change to "ESS"
  - Proposed language: "When an emergency shutdown is required, activation of the ESS shall shut down operation of all pumps and compressors. 55:11.2.8.3
- 8.3.1.2.9- propose to add acronym (ESS)
- 8.3.1.2.9.2- propose to change "system" to "device:
  - Proposed language: "An emergency shutdown device (ESD) shall be provided at the bulk source to stop the flow of liquid and gas into the use line when actuated."
- 8.3.2.1.9.4- Proposed language: "Reactivation of the ESS after activation shall require that the ESS be manually reset."
-
- 8.3.1.2.9.5- Proposed language: "The ESD manual activation shall be identified by means of a sign."
- 11.3.1.8: change "(ESD)" to "(ESS)". Revise language

This proposal was developed during parallel discussions by members of the NFPA-2-HEE Task Group

The following change was developed after a further review of NFPA-2 first draft are shown below:

8.3.1.2.8.3 Emergency Shutdown System Operation.
When an emergency shutdown (ESD) is required, activation of the **Emergency Shutdown System (ESS)** ~~**ESD** system~~ shall shut down operation of all pumps and compressors. [~~**55:**11.2.8.3~~]

Public Input No. 58-NFPA 2-2023 [Sections 3.3.69, 3.3.70]

Sections 3.3.69, 3.3.70

3.3.69 Emergency Shutdown Device (ESD)* .

~~See 3.3.63.1 .~~ a device that activates the Emergency Shutdown System (ESS).

3.3.70 Emergency Shutoff Valve ~~.~~

~~See 3.3.252.1 .~~

(ESV)*.

A designated valve designed to shut off the flow of fluid in the event of an emergency

3.3.71 Emergency Shutdown System (ESS)*

The system that responds to ESD activation and closes Emergency Shutdown Valves (ESVs), issues alarms and other actions according to the site safety plan.

Statement of Problem and Substantiation for Public Input

The confusing use of the term ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV

remove circular definitions

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 61-NFPA 2-2023 [Section No. 3.3.252]	
Public Input No. 62-NFPA 2-2023 [Section No. 8.3.1.2.8.3]	
Public Input No. 63-NFPA 2-2023 [Section No. 8.3.1.2.9]	
Public Input No. 64-NFPA 2-2023 [New Section after A.3.3.64]	
Public Input No. 73-NFPA 2-2023 [Section No. 3.3.70]	
Public Input No. 74-NFPA 2-2023 [New Section after 3.3.70]	
Public Input No. 75-NFPA 2-2023 [Section No. 3.3.252]	

Submitter Information Verification

Submitter Full Name:	Robert Boyd
Organization:	Boyd Hydrogen LLC
Affiliation:	this is one of a series of leftover PC that came out of the previous cycle HEE TG that were too late for the first draft
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Oct 23 13:13:16 EDT 2023

Committee: HYD-AAA

Committee Statement

Resolution: FR-94-NFPA 2-2024

Statement: This revision harmonizes the use of these terms with what is defined in CSA-HGV-4.1 Hydrogen Dispensers, and CSA-HGV-4.9 Hydrogen Fueling Stations.

Public Input No. 74-NFPA 2-2023 [New Section after 3.3.70]

E-Stop

A manually operated, red push button switch which will initiate an emergency system shutdown

Statement of Problem and Substantiation for Public Input

the definition of this term will help with understanding how the Emergency Shutdown System can be initiated by human intervention.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 57-NFPA 2-2023 [Section No. 3.3.69]	
Public Input No. 58-NFPA 2-2023 [Sections 3.3.69, 3.3.70]	
Public Input No. 59-NFPA 2-2023 [New Section after 3.3.69]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: BoydH2
Street Address:
City:
State:
Zip:
Submittal Date: Fri Dec 01 15:41:02 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The term E-Stop does not appear in the text of NFPA 2 and therefore a definition cannot be adopted per the NFPA manual of style.

Public Input No. 73-NFPA 2-2023 [Section No. 3.3.70]

3.3.70 Emergency Shutoff Valve.

~~See~~ ~~3.3.252.1~~ . A designated fail-safe automatic closing valve designed to shut off the flow of gases or liquids that is held open by the Emergency Shutdown System (ESS) and is closed when the ESS is activated by either manual or automatic means.

Statement of Problem and Substantiation for Public Input

moves this definition from the back of the document up to front were similar emergency stop system definitions are located

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 57-NFPA 2-2023 [Section No. 3.3.69]	
Public Input No. 58-NFPA 2-2023 [Sections 3.3.69, 3.3.70]	
Public Input No. 59-NFPA 2-2023 [New Section after 3.3.69]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: BoydH2
Street Address:
City:
State:
Zip:
Submittal Date: Fri Dec 01 15:36:09 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-135-NFPA 2-2024

Statement: The confusing use of the terms ESD and ESD System [Emergency Shutdown System (ESS)] has been clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together (e.g., ESS, ESD, and ESV).

The safety shutoff valve definition has been revised to reflect how it is used in Chapter 14 and to remain consistent with other NFPA documents, including NFPA 86.

Public Input No. 83-NFPA 2-2023 [Section No. 3.3.70]

3.3.70 Emergency Shutoff Valve.

~~See 3.3.252.1 .~~

(ESV).

A des ig nated valve desi g ned to shut off the flow of liquids or g ases

Additional Proposed Changes

File Name	Description	Approved
PC_No._81_Rejected_but_Held.pdf	NFPA 2 PC No. 81 Rejected but held	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as "Rejected but Held" in Public Comment No. 81 of A2022 Second Draft Report for NFPA 2 and per Regs. at 4.4.8.3.1 and needs to be reconsidered by the TC for the next edition of the document.

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comment will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This proposal also harmonizes the use of these term in CSA-HGV-4.1 and CSA-HGV-4.6.

Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

Submitter Information Verification

Submitter Full Name: Yiu Lee
Organization: holds@nfpa.org
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 09:01:43 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-135-NFPA 2-2024

Statement: The confusing use of the terms ESD and ESD System [Emergency Shutdown System (ESS)] has been clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together (e.g., ESS, ESD, and ESV).

The safety shutoff valve definition has been revised to reflect how it is used in Chapter 14 and to remain consistent with other NFPA documents, including NFPA 86.

Public Comment No. 81-NFPA 2-2021 [Section No. 3.3.70]

3.3.~~70~~ – 70 _ Emergency Shutoff Valve ~~.~~

~~See 3.3.250.1 .~~

(ESV).

A designated valve designed to shut off the flow of liquids or gases

Additional Proposed Changes

File Name	Description	Approved
ESD-ESS_-_Rev5.pdf	Clarification of ESS and ESD and definition of ESS in NFPA-2	

Statement of Problem and Substantiation for Public Comment

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comment will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This proposal also harmonizes the use of these term in CSA-HGV-4.1 and CSA-HGV-4.6.

Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

Related Item

• PI-230

Submitter Information Verification

Submitter Full Name:	Robert Boyd
Organization:	Boyd Hydrogen LLC
Affiliation:	This proposal was developed during parallel discussions by members of the NFPA-HEE Task Group
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Jun 02 18:06:52 EDT 2021
Committee:	HYD-AAA

Committee Statement

Committee Action:	Rejected but held

Resolution:	The proposed revisions were not discussed during the First Draft meeting and are considered to be new material which cannot be acted upon at the Second Draft meeting.

Clarification of ESS and ESD and definition of ESS in NFPA-2

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comments will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This series of Public Comments also harmonizes the use of these terms with what is defined in CSA-HGV-4.1 *Hydrogen Dispensers,* and CSA-HGV-4.9 *Hydrogen Fueling Stations*

This document supports public comments: PC-79 , PC-80, PC-81, PC-82, PC-83, PC-84, PC-87 and PC-90

Problem Statement

The confusing use of the term ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Annex notes (new)

A.3.3.69. Emergency Shutdown Device (ESD).

Emergency Shutdown Devices (ESDs) may be any of the following devices that will "trip" the Emergency Shutdown System (ESS) to shut down the system into a safe mode:

1. A manually operated red pushbutton switch with a yellow background in compliance with NFPA-79,
2. A low pressure switch measuring hydrogen compressor suction pressure,
3. An UV/IR or hydrogen detector,
4. Or any other safety related input device that has a switch for electrical conductivity of signal or other means of connection to the ESS.

Most hydrogen Fueling station modules will include a separate ESS to stop the process of the module (production, compression, dispensing) in the event of an ESS activation.

Each hydrogen fueling station site will typically have all operating modules connected to a site-wide Emergency Shutdown System.

Emergency Shutdown System (ESS): The ESS responds to any activation of an ESD and shuts down the system safely.

Actions to take in NFPA-2

- Delete 3.3.63.1 (ESD definition, extract from NFPA 52)
- Modify 3.3.69 (ESD- use definition from ANSI/CSA HGV 4.1)

- Add new section after 3.3.69 (ESS-use definition from ANSI/CSA HGV 4.1) – this will go between ESD and Emergency Shutoff Valve
- Modify 3.3.70 Emergency Shutoff Valve drop link to see 3.3.250.1 and adopt current language: A designated valve designed to shut off the flow of liquids or gases

The following shows how the use of ESD and ESS need to be cleaned up and how important it is to define ESS

- 8.3.1.2.8.3 – propose to change "ESD" to "ESS" and "ESD system" change to "ESS"
  - Proposed language: "When an emergency shutdown is required, activation of the ESS shall shut down operation of all pumps and compressors. 55:11.2.8.3
- 8.3.1.2.9- propose to add acronym (ESS)
- 8.3.1.2.9.2- propose to change "system" to "device:
  - Proposed language: "An emergency shutdown device (ESD) shall be provided at the bulk source to stop the flow of liquid and gas into the use line when actuated."
- 8.3.2.1.9.4- Proposed language: "Reactivation of the ESS after activation shall require that the ESS be manually reset."
-
- 8.3.1.2.9.5- Proposed language: "The ESD manual activation shall be identified by means of a sign."
- 11.3.1.8: change "(ESD)" to "(ESS)". Revise language

This proposal was developed during parallel discussions by members of the NFPA-2-HEE Task Group

The following change was developed after a further review of NFPA-2 first draft are shown below:

8.3.1.2.8.3 Emergency Shutdown System Operation.
When an emergency shutdown (ESD) is required, activation of the **Emergency Shutdown System (ESS)** ~~**ESD** system~~ shall shut down operation of all pumps and compressors. [~~**55:**11.2.8.3~~]

Public Input No. 169-NFPA 2-2023 [Section No. 3.3.81]

3.3.81 Explosion Control.

~~See~~

A means of preventing an explosion **through the use of explosion suppression, fuel reduction, or oxidant reduction systems or a means to prevent the structural collapse of a building in the event of an explosion through the use of deflagration venting, barricades, or related construction methods**

A. 3.3.

~~51.2.~~

81. Explosion Control

Explosion control is provided to prevent formation of flammable mixtures, prevent ignition, protect against deflagration, and prevent detonation conditions from developing when there is the potential to exceed 1 percent hydrogen concentration in enclosures.

NFPA 69 provides guidance on the use of suppression, ventilation systems, and the limiting of oxidants as a means to prevent the occurrence of an explosion.

NFPA 68 provides guidance on the use of deflagration venting systems in buildings and other enclosures. The primary purpose of a venting system is to relieve overpressure produced in an explosion to limit the potential damage to the building where the explosion occurs. Although some structural damage can be anticipated, the use of relief venting is expected to prevent massive building failure and collapse. In cases where detonation is probable, venting is often used in conjunction with barricade construction where the pressure-resistant portions of the building have been constructed to resist the pressures anticipated should an explosive event occur.

When relief vents are to be used as a means to provide deflagration relief, the fundamental requirements of the adopted building code for structural elements, including snow, wind, and seismic events, should be considered. In some instances, the requirements for wind resistance can impose more rigorous requirements on the relief vents than required by the engineering analysis used to determine the relief pressure. Users must demonstrate that the relief vents will not become airborne or release in such a manner as to create secondary hazards within or external to the building in which they are installed. Specific designs might require approval by the AHJ.

Statement of Problem and Substantiation for Public Input

this brings Explosion Control to the proper order of definitions out from under "Control"

add revised annex note

Related Public Inputs for This Document

Related Input	Relationship

Public Input No. 107-NFPA 2-2023 [Section No. 3.3.51.2]	Revise definition : remove "either"
Public Input No. 170-NFPA 2-2023 [Section No. 3.3.51.2]	Point to 3.3.81
Public Input No. 215-NFPA 2-2023 [Section No. A.3.3.51.2]	Delete Old annex note
Public Input No. 106-NFPA 2-2023 [Section No. A.3.3.51.2]	Revise Annex note for Explosion Control
Public Input No. 107-NFPA 2-2023 [Section No. 3.3.51.2]	
Public Input No. 170-NFPA 2-2023 [Section No. 3.3.51.2]	
Public Input No. 175-NFPA 2-2023 [Chapter 9]	
Public Input No. 215-NFPA 2-2023 [Section No. A.3.3.51.2]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control TG
Street Address:
City:
State:
Zip:
Submittal Date: Fri Dec 22 11:54:22 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-28-NFPA 2-2024
Statement: The sentence pointing to NFPA 69 is moved to the beginning of the annex material to to clarify the intent of prevention first and protection as a secondary layer . Further annex material has been added to explain the hazards explosion control is protecting against. The definition is moving out from under control to be listed alphabetically.

Public Input No. 29-NFPA 2-2023 [New Section after 3.3.117]

3.3.118 (new) Hazardous occupancy

The use of a building or structure, or a portion thereof, that involves the manufacturing, processing, generation or storage of materials in quantities that exceed the maximum allowable quantity per control area.

Statement of Problem and Substantiation for Public Input

The term is used in section 6.11 and is undefined.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 12:37:01 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: The term is only used once in section 6.11, so any clarity that is needed should be applied to the mandatory language or annex section of the code.

Public Input No. 222-NFPA 2-2024 [New Section after 3.3.121]

TITLE OF NEW CONTENT

Type your

3.3.X* __ **Hydrogen Enriched Fuel** . A gas fuel that contains a hydrogen concentration greater than 25% by volume. **(37:** 3.3.10 **)**

Statement of Problem and Substantiation for Public Input

Various combustion process equipment is being shifted from natural gas to blends of natural gas and hydrogen as part of the global shift to hydrogen fuel. These blends range from 5% to 95% plus hydrogen. The most common blend seen to date is 20% hydrogen enriched pipeline natural gas blend in Europe; however, mixing systems have been proposed to increase the use of hydrogen in the near future. This led directly to the formation of the Chapter 14 Task group to capture the known industrial processes on this path and provide the appropriate guidance within the chapter.

Guidance regarding the hazardous area classification of hydrogen mixtures have indicated those greater than 25% (IEC) or 30% (NFPA) are considered as “hydrogen” for the selection of electrical equipment. It is from that basis that the Task Group agreed to use 25% as the limit hydrogen concentration for inclusion of such mixtures in NFPA 2.

To properly separate these mixtures from the original 95% or greater hydrogen content defined in the original NFPA 2 scope an additional definition that recognizes these mixtures as used in Chapter 14 is essential. For clarity, this discussion was taken on by an NFPA 37 Task Group that developed the definition of “Hydrogen Enriched Fuel” for the 2024 edition and that definition is being proposed for NFPA 2 to ensure consistency.

This PI is submitted by Lawrence Danner, CSP on behalf of the Chapter 14 Task Group.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 221-NFPA 2-2024 [Section No. 1.3.3]	
Public Input No. 223-NFPA 2-2024 [New Section after 3.3.215]	
Public Input No. 224-NFPA 2-2024 [Chapter 14]	
Public Input No. 225-NFPA 2-2024 [Sections A.14.1.1, A.14.3.1.2, A.14.3.1.2.1, A.14.3.1.2.2, ...]	
Public Input No. 226-NFPA 2-2024 [New Section after A.3.3.120.2]	

Submitter Information Verification

Submitter Full Name: Larry Danner
Organization: GE Power
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 02 11:06:56 EST 2024

Committee: HYD-AAA

Committee Statement

Resolution: CI-131-NFPA 2-2024

Statement: The industrial applications defined in the Chapter 14 rewrite will be using GH2 – fuel gas mixtures that, within the scope of the chapter, will have a GH2 content of greater than 25% by volume. A specific term for such mixtures was published in the latest edition of NFPA 37 that is consistent with the PI 221 requirements and is proposed here for consistency and clear understanding of the intent as used in Chapter 14.

Public Input No. 278-NFPA 2-2024 [New Section after 3.3.197.7]

TITLE OF NEW CONTENT

Type your content here ...

3.3.197.X Nominal Working Pressure: The settled pressure of a fuel container at a uniform gas temperature of 59 F (15 C) and full gas content and for which the container, under normal conditions, has been constructed.

Statement of Problem and Substantiation for Public Input

Service Pressure as defined by NFPA 2 in 3.3.197.7 with a 70 F reference point is incorrect for H2 fuel vessels. H2 fuel container standards use a reference termperature of 59 F (15C). It is not advisable to change the definition of Service Pressure in NFPA 2 since Service Pressure is also a DOT term for containers which uses 70 F as the reference point. Changing the Service Pressure definition could be confusing for those vessels used for hazmat transportation. A better approach would be to use a different term, "nominal working pressure", for H2 fuel containers @ 59 F. NWP is also in common use and is defined in CSA standards for this purpose. Service pressure remains the correct term and definition for DOT vessels and NWP is the correct term and definition for fuel containers.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 279-NFPA 2-2024 [Section No. 3.3.197.7]	
Public Input No. 280-NFPA 2-2024 [Section No. 10.3.2.3]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 00:42:36 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-121-NFPA 2-2024

Statement: Service Pressure as defined by NFPA 2 in 3.3.197.7 with a 70 F reference point is incorrect for H2 fuel vessels. H2 fuel container standards use a reference temperature of 59 F (15C). Service Pressure is also a DOT term for containers which uses 70 F as the reference point. Changing the Service Pressure definition could be confusing for those vessels used for hazmat transportation. NWP is also in common use and is defined in CSA and SAE standards for this purpose. Service pressure remains the correct term and definition for DOT vessels and NWP is the correct term and definition for hydrogen vehicle fuel containers.

Public Input No. 279-NFPA 2-2024 [Section No. 3.3.197.7]

3.3.197.7 Service Pressure.

The settled pressure of ~~the fuel~~ a gas container at a uniform gas temperature of 70°F (21°C) and full gas content and for which the container, under normal conditions, has been constructed.

Statement of Problem and Substantiation for Public Input

See related PI for more explanation, but Service Pressure as defined at 70 F is not correct for a hydrogen fuel container, so the word "fuel" is being deleted from this reference. The appropriate term for a fuel container is nominal working pressure.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 278-NFPA 2-2024 [New Section after 3.3.197.7]	Parallel definitions

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 00:54:14 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-90-NFPA 2-2024
Statement: Service Pressure as defined at 70 F is not correct for a hydrogen fuel container, so the word "fuel" is being deleted from this reference. The appropriate term for a fuel container is nominal working pressure.

Public Input No. 42-NFPA 2-2023 [New Section after 3.3.214]

3.3.215 risk assessment (new)
The overall process of risk identification, risk analysis, and risk evaluation.

Statement of Problem and Substantiation for Public Input

The term is used but not defined. The definition is taken from NFPA 55:2023 section 3.3.89.1.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 14:01:51 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: Risk assessment is a wide ranging topic with multiple references throughout the code and the proposed definition does not accurately encompass the use of the term.

Public Input No. 223-NFPA 2-2024 [New Section after 3.3.215]

TITLE OF NEW CONTENT

3.3.X _ **Safety Blowout.** A device or combination of devices that quench a flame, relieve pressure, and provide a means for automatic shutoff of the air–gas mixture flow in the event of a flashback in air–fuel gas mixture piping. (**86** 3.3.66)

Statement of Problem and Substantiation for Public Input

Various combustion process equipment is being shifted from natural gas to blends of natural gas and hydrogen as part of the global shift to hydrogen fuel. These blends range from 5% to 95% plus hydrogen. The most common blend seen to date is 20% hydrogen enriched pipeline natural gas blend in Europe; however, mixing systems have been proposed to increase the use of hydrogen in the near future. This led directly to the formation of the Chapter 14 Task group to capture the known industrial processes on this path and provide the appropriate guidance within the chapter.

In the development of the expanded Chapter 14, it was determined that a “Safety Blowout” device was required where pre-mixed air-fuel gas mixtures are used. The definition is added here for completeness.

This PI is submitted by Lawrence Danner, CSP on behalf of the Chapter 14 Task Group.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 222-NFPA 2-2024 [New Section after 3.3.121]	
Public Input No. 221-NFPA 2-2024 [Section No. 1.3.3]	
Public Input No. 224-NFPA 2-2024 [Chapter 14]	
Public Input No. 225-NFPA 2-2024 [Sections A.14.1.1, A.14.3.1.2, A.14.3.1.2.1, A.14.3.1.2.2, ...]	
Public Input No. 226-NFPA 2-2024 [New Section after A.3.3.120.2]	

Submitter Information Verification

Submitter Full Name: Larry Danner
Organization: GE Power
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 02 11:13:44 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: CI-132-NFPA 2-2024

Statement: After a review of the NFPA documents associated with the technologies, it was discovered that the concept of fuel premixed with air to is included in NFPA 85, NFPA 86 and NFPA 87. With respect to the premix situation, a “Safety Blowout” is identified as a mitigation in NFPA 86. In developing the text for the Chapter 14 rewrite which provides the appropriate additional considerations due to the hydrogen flammability and potential deflagration characteristics it was deemed appropriate to include a discussion of the premix situation to include the application of the Safety Blowout.

Since the Safety Blowout term is used in the 14.3.1.6 discussion of fuel premix considerations, inclusion of the definition extracted from NFPA 86 is deemed necessary.

Public Input No. 12-NFPA 2-2023 [Section No. 3.3.237.4]

~~**3.3.237.4** * – Bulk Oxygen System.~~

~~An assembly of equipment, such as oxygen storage containers, pressure regulators, pressure relief devices, vaporizers, manifolds, and interconnecting piping, that has a storage capacity of more than 20,000 scf (566 Nm^3) of oxygen and that terminates at the source valve.~~

Statement of Problem and Substantiation for Public Input

The defined term is no longer used in the body or annex notes of NFPA 2.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Affiliation: NFPA 2/55 alignment task group
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 24 14:13:50 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-7-NFPA 2-2024

Statement: The scope of NFPA 2 has been revised to contain all requirements for hydrogen storage, use, and handling. The scope of NFPA 55 has been revised so that it no longer contains requirements for hydrogen storage, use, and handling. With the removal of NFPA 55 extract tags from NFPA 2, the defined term is no longer used in the NFPA 2 body or annex notes.

Public Input No. 61-NFPA 2-2023 [Section No. 3.3.252]

3.3.252 Valve.

3.3.252.1 Emergency Shutoff Valve (ESV) .

A designated ~~valve designed to shut off the flow of gases or liquids.~~

~~**3.3.252.1.1** – Automatic Emergency Shutoff Valve.~~

~~A designated~~

fail-safe automatic closing valve designed to shut off the flow of gases or liquids that is

~~initiated by a control system where the control system is~~

held open by the Emergency Shutdown System (ESS) and is closed when the ESS is activated by either manual or automatic means.

~~– See~~ ~~3.3.~~

~~252.2~~ ~~Shutoff Valve.~~

~~69. 3. 3. 70 and~~ ~~3.~~

~~252.2.1 *~~ – ~~Safety Shutoff Valve.~~

~~A normally closed valve installed in the piping that closes automatically to shut off the fuel, atmosphere gas, or oxygen in the event of abnormal conditions or during shutdown. [**86,** 2023]~~

~~3.71~~

3.3.252.3* Source Valve.

A shutoff valve on the piping system serving a bulk gas supply system where the gas supply, at service pressure, first enters the supply line.

Statement of Problem and Substantiation for Public Input

The confusing use of the terms ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV. The harmonized definitions are show below:
Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.
Emergency Shutoff Valve (ESV)* -- A designated valve designed to shut off the flow of fluid in the event of an emergency

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 57-NFPA 2-2023 [Section No. 3.3.69]	
Public Input No. 58-NFPA 2-2023 [Sections 3.3.69, 3.3.70]	
Public Input No. 59-NFPA 2-2023 [New Section after 3.3.69]	

Public Input No. 60-NFPA 2-2023 [Section No. 3.3.63.1]
Public Input No. 62-NFPA 2-2023 [Section No. 8.3.1.2.8.3]
Public Input No. 63-NFPA 2-2023 [Section No. 8.3.1.2.9]
Public Input No. 64-NFPA 2-2023 [New Section after A.3.3.64]

Submitter Information Verification

Submitter Full Name:	Robert Boyd
Organization:	Boyd Hydrogen LLC
Affiliation:	This is one of a series of leftover PCs that came out of the previous cycle HEE TG that were too late for the first draft
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Oct 23 13:58:21 EDT 2023
Committee:	HYD-AAA

Committee Statement

Resolution: FR-134-NFPA 2-2024

Statement: The confusing use of the terms ESD and ESD System (Emergency Shutdown System ESS) has been clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together (e.g., ESS, ESD, and ESV).

The safety shutoff valve definition has been revised to reflect how it is used in Chapter 14 and to remain consistent with other NFPA documents, including NFPA 86.

Public Input No. 75-NFPA 2-2023 [Section No. 3.3.252]

3.3.252 Valve.

3.3.252.1 Emergency Shutoff Valve.

~~A designated valve designed to shut off the flow of gases or liquids.~~

see 3.3.

~~252.1.1 Automatic Emergency Shutoff Valve.~~

~~A designated fail-safe automatic closing valve designed to shut off the flow of gases or liquids that is initiated by a control system where the control system is activated by either manual or automatic means.~~

~~70~~

3.3.252.2 Shutoff Valve.

3.3.252.2.1* Safety Shutoff Valve.

A normally closed valve installed in the piping that closes automatically to shut off the fuel, atmosphere gas, or oxygen in the event of abnormal conditions or during shutdown. [**86,** 2023]

3.3.252.3* Source Valve.

A shutoff valve on the piping system serving a bulk gas supply system where the gas supply, at service pressure, first enters the supply line.

Statement of Problem and Substantiation for Public Input

move the definition Emergency Shutoff Valve to the front of the document with ESD, ESS and E-Stop

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 57-NFPA 2-2023 [Section No. 3.3.69]	
Public Input No. 58-NFPA 2-2023 [Sections 3.3.69, 3.3.70]	
Public Input No. 59-NFPA 2-2023 [New Section after 3.3.69]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Street Address:
City:
State:
Zip:
Submittal Date: Fri Dec 01 15:52:21 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-134-NFPA 2-2024

Statement: The confusing use of the terms ESD and ESD System (Emergency Shutdown System ESS) has been clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together (e.g., ESS, ESD, and ESV).

The safety shutoff valve definition has been revised to reflect how it is used in Chapter 14 and to remain consistent with other NFPA documents, including NFPA 86.

Public Input No. 117-NFPA 2-2023 [Section No. 4.4 [Excluding any Sub-Sections]]

~~Compliance~~

To demonstrate compliance with the code both fire and explosion scenarios and shall be considered. Compliance with the goals and objectives of Section 4.2 shall be provided in accordance with either of the following:

(1) The prescriptive-based provisions per 4.4.1 – to be used for fire scenarios only

(2) The performance-based provisions per 4.4.2 – to be used for explosion scenarios and fire scenarios

[**1:** 4.3]

Statement of Problem and Substantiation for Public Input

While the use of look-up tables to determine separation distance can be employed when considering fire scenarios, the risk related to delayed ignition is far more complex (determined by such factors as release rate and duration; atmospheric conditions, dispersion, and cloud formation; site specific layout i.e., presence of congestion and/or confinement). Simplistic look-up tables should not be used to assess the risk due to VCE.
VCE scenarios should only be assessed using a performance-based approach.

Submitter Information Verification

Submitter Full Name: Lee Phillips
Organization: Shell
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 08:04:56 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: This is extract text from NFPA 1 which sets up the methodology and maintaining the extract is important in the context for the use of performance based design . Mandates use of 4.4.2 for all explosion and fire scenarios which is not the code intent. No basis given for why VCE scenarios can only be regulated using performance based methods.

Public Input No. 179-NFPA 2-2023 [Section No. 4.13.2.3]

4.13.2.3 Identification of ~~Gas~~ Rooms and Cabinets Containing Compressed Hydrogen .

Rooms or cabinets containing compressed ~~gases~~ hydrogen shall be conspicuously labeled as follows:

COMPRESSED GAS

Statement of Problem and Substantiation for Public Input

Substantiation: The term gas room is defined as:
2023 NFPA 2 3.3.111 Gas Room. A separately ventilated, fully enclosed room in which only compressed gases, cryogenic fluids, associated equipment, and supplies are stored or used.
The title of 4.13.2.3 was modified to avoid the defined term “gas room” because the intent of 4.13.2.3 is to require a compressed gas sign on any room containing compressed gas, not just a specialized gas room.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 12:36:08 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-95-NFPA 2-2024
Statement: The title of 4.13.2.3 was modified to avoid the defined term “gas room” because the intent of 4.13.2.3 is to require a compressed gas sign on any room containing compressed gas, not just a specialized gas room. Hydrogen was added to specify the gas rather than generally include all gases

Public Input No. 69-NFPA 2-2023 [Section No. 5.1.2]

5.1.2 Goals and Objectives.

The performance-based design shall meet the goals and objectives of this code in accordance with Section 4.~~3~~ 2 .

Statement of Problem and Substantiation for Public Input

Fixes cross-references to wrong sub-section. 4.2 contains the goals and objectives.

Submitter Information Verification

Submitter Full Name: Achim Wechsung
Organization: Exponent, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Thu Nov 16 09:01:36 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-96-NFPA 2-2024
Statement: Fixes cross-references to wrong sub-section. 4.2 contains the goals and objectives.

Public Input No. 121-NFPA 2-2023 [Section No. 5.4.3]

5.4.3 Required Design Scenarios — Explosion.

5.4.3.1 Explosion Design Scenario 1 — Hydrogen Pressure Vessel Burst Scenario.

Explosion Design Scenario 1 shall be the prevention or mitigation of a ruptured hydrogen pressure vessel.

5.4.3.1.1

Explosion Design Scenario 1 shall identify the various pressure vessel failure prevention measures in relation to both expected and potential abnormal vessel fill and operating conditions.

5.4.3.1.2

Mitigation measures, if applicable, shall address the safety of individuals at various distances from the pressure vessel.

5.4.3.2 Explosion Design Scenario 2 — Hydrogen Deflagration.

Explosion Design Scenario 2 shall be the deflagration of a hydrogen-air or hydrogen-oxidant mixture within an enclosure such as a room or within large process equipment containing hydrogen.

5.4.3.2.1

Explosion Design Scenario 2 shall identify the specific gas mixture formed in relation to both expected and potential abnormal operating conditions and ventilation in the enclosure.

5.4.3.2.2

Mitigation measures, such as deflagration venting, shall address the hazards to any individuals within the enclosure and in the vicinity of the enclosure.

5.4.3.3 Explosion Design Scenario 3 — Hydrogen Detonation.

Explosion Design Scenario 3 shall be the detonation of a hydrogen-air or hydrogen-oxidant mixture within an enclosure such as a room or a process vessel or within piping containing hydrogen.

5.4.3.3.1

The specific enclosure selected shall be the enclosure that has the greatest potential for a detonation.

5.4.3.3.2

Explosion Design Scenario 3 shall identify the specific gas mixture formed in relation to both expected and potential abnormal operating conditions and ventilation in the enclosure.

5.4.3.3.3

Mitigation measures, such as detonation containment, shall address the hazards to any individuals in the vicinity of the enclosure.

5.4.3.4 Explosion Design Scenario 4 – Unconfined Vapour Cloud Explosion

Explosion Design Explosion Scenario 4 shall be the unconfined vapor cloud explosion (deflagration or detonation) following the delayed ignition of a release of hydrogen to the atmosphere outside of an enclosure.

5.4.3.4.1 Explosion Design Scenario 4 shall identify the size of the flammable gas cloud formed and interaction with the site, such as presence of congestion within the flammable cloud or partial confinement such as fire walls.

Statement of Problem and Substantiation for Public Input

Several industry incidents have demonstrated that delayed ignition of a hydrogen release in the open (outside of an enclosure) resulting in vapor cloud explosion (VCE) is credible. Such events may produce high overpressure capable of causing serious injury and damage to infrastructure that extend

significant distance. Despite this, such scenarios are not adequately considered within current codes and standards. As a result, the safety distances proposed for hydrogen installations may be based on overly simplistic scenarios that underestimate, or worse, overlook explosion/overpressure risk. Unconfined VCE is not currently reflected in NFPA 2.
Adding a new unconfined explosion scenario for performance based assessment would close this gap.

Submitter Information Verification

Submitter Full Name: Lee Phillips
Organization: Shell
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 08:12:28 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-97-NFPA 2-2024

Statement: Several industry incidents have demonstrated that delayed ignition of a hydrogen release in the open (outside of an enclosure) resulting in vapor cloud explosion (VCE) is credible. Such events may produce high overpressure capable of causing serious injury and damage to infrastructure that extend significant distance. Despite this, such scenarios are not adequately considered within current codes and standards. As a result, the safety distances proposed for hydrogen installations may be based on overly simplistic scenarios that underestimate, or worse, overlook explosion/overpressure risk. Unenforceable text was deleted as it was examples of scenarios.

Whilst the performance-based approach does require explosions to be considered, the design scenarios specified (5.4.3.2. Explosion Design Scenario 2 – Hydrogen Deflagration & 5.4.3.3. Explosion Design Scenario 3 – Hydrogen Detonation) are limited as they consider only confined explosions (i.e., within an enclosure, equipment, or piping).

Public Input No. 118-NFPA 2-2023 [Section No. 5.4.3.2]

5.4.3.2 Explosion Design Scenario 2 — Confined Hydrogen Deflagration.

Explosion Design Scenario 2 shall be the confined deflagration of a hydrogen-air or hydrogen-oxidant mixture within an enclosure such as a room or within large process equipment containing hydrogen.

5.4.3.2.1

Explosion Design Scenario 2 shall identify the specific gas mixture formed in relation to both expected and potential abnormal operating conditions and ventilation in the enclosure.

5.4.3.2.2

Mitigation measures, such as deflagration venting, shall address the hazards to any individuals within the enclosure and in the vicinity of the enclosure.

Statement of Problem and Substantiation for Public Input

Whilst the performance-based approach does require explosions to be considered, the design scenarios specified (5.4.3.2. Explosion Design Scenario 2 – Hydrogen Deflagration & 5.4.3.3. Explosion Design Scenario 3 – Hydrogen Detonation) are limited as they consider only confined explosions (i.e., within an enclosure, equipment, or piping).
Consideration of unconfined VCE scenarios that may occur following release and formation of a gas cloud to the environment, amongst equipment/congestion or where partial confinement may be present (such as fire-walls) is currently missing.

Submitter Information Verification

Submitter Full Name: Lee Phillips
Organization: Shell
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 08:09:15 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-97-NFPA 2-2024

Statement: Several industry incidents have demonstrated that delayed ignition of a hydrogen release in the open (outside of an enclosure) resulting in vapor cloud explosion (VCE) is credible. Such events may produce high overpressure capable of causing serious injury and damage to infrastructure that extend significant distance. Despite this, such scenarios are not adequately considered within current codes and standards. As a result, the safety distances proposed for hydrogen installations may be based on overly simplistic scenarios that underestimate, or worse, overlook explosion/overpressure risk. Unenforceable text was deleted as it was examples of scenarios.

Whilst the performance-based approach does require explosions to be considered, the design scenarios specified (5.4.3.2. Explosion Design Scenario 2 – Hydrogen

Deflagration & 5.4.3.3. Explosion Design Scenario 3 – Hydrogen Detonation) are limited as they consider only confined explosions (i.e., within an enclosure, equipment, or piping).

Public Input No. 119-NFPA 2-2023 [Section No. 5.4.3.3]

5.4.3.3 Explosion Design Scenario 3 — Confined Hydrogen Detonation.

Explosion Design Scenario 3 shall be the confined detonation of a hydrogen-air or hydrogen-oxidant mixture within an enclosure such as a room or a process vessel or within piping containing hydrogen.

5.4.3.3.1

The specific enclosure selected shall be the enclosure that has the greatest potential for a detonation.

5.4.3.3.2

Explosion Design Scenario 3 shall identify the specific gas mixture formed in relation to both expected and potential abnormal operating conditions and ventilation in the enclosure.

5.4.3.3.3

Mitigation measures, such as detonation containment, shall address the hazards to any individuals in the vicinity of the enclosure.

Statement of Problem and Substantiation for Public Input

Whilst the performance-based approach does require explosions to be considered, the design scenarios specified (5.4.3.2. Explosion Design Scenario 2 – Hydrogen Deflagration & 5.4.3.3. Explosion Design Scenario 3 – Hydrogen Detonation) are limited as they consider only confined explosions (i.e., within an enclosure, equipment, or piping).

Consideration of unconfined VCE scenarios that may occur following release and formation of a gas cloud to the environment, amongst equipment/congestion or where partial confinement may be present (such as fire-walls) is currently missing. This change would make it clear that this scenario does not reflect unconfined vapor cloud explosions.

Submitter Information Verification

Submitter Full Name: Lee Phillips
Organization: Shell
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 08:10:21 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-97-NFPA 2-2024

Statement: Several industry incidents have demonstrated that delayed ignition of a hydrogen release in the open (outside of an enclosure) resulting in vapor cloud explosion (VCE) is credible. Such events may produce high overpressure capable of causing serious injury and damage to infrastructure that extend significant distance. Despite this, such scenarios are not adequately considered within current codes and standards. As a result, the safety

distances proposed for hydrogen installations may be based on overly simplistic scenarios that underestimate, or worse, overlook explosion/overpressure risk. Unenforceable text was deleted as it was examples of scenarios.

Whilst the performance-based approach does require explosions to be considered, the design scenarios specified (5.4.3.2. Explosion Design Scenario 2 – Hydrogen Deflagration & 5.4.3.3. Explosion Design Scenario 3 – Hydrogen Detonation) are limited as they consider only confined explosions (i.e., within an enclosure, equipment, or piping).

Public Input No. 180-NFPA 2-2023 [Section No. 6.1.1.4]

6.1.1.4 Quantities Less Than or Equal to the MAQ.

Indoor control areas with GH_2 or LH_2 stored or used in quantities less than or equal to those shown in Table 6.4.1.1.1 shall be in accordance with Sections 6.1 , 6.2, 6.3, 6. 4 , 6 . ~~1.~~ 5 ~~and Sections~~ , 6. ~~1~~ 6 , 6. ~~8~~ 7 , 6.~~9~~ 8 , 6.13, ~~and~~ 6.17, 6 . 19, 6.20 and 6.22. .

Statement of Problem and Substantiation for Public Input

Not sure if the TERRA printout will be clear, so here is what I am proposing for 6.1.1.4 look like when done.

6.1.1.4 Quantities Less Than or Equal to the MAQ.
Indoor control areas with GH2 or LH2 stored or used in quantities less than or equal to those shown in Table 6.4.1.1.1 shall be in accordance Sections 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.13, 6.17, 6.19, 6.20 and 6.22.

Substantiation: The requirements for areas that are below MAQ are incomplete. Adding reference to the added sections makes those sections applicable both above and below MAQ. Currently they are only applicable above MAQ. Section 6.9 should not apply below MAQ. The basis for each addition or deletion is provided below.
Please note: This was previously submitted during the 2023 cycle as PC-22. The substantiation was similar to that presented below and well explained, perhaps a bit lengthy. The TC rejected this PC with the following reason statement: “The technical reason intended for referencing the additional sections is not clear to the committee.” This is a good example of a weak committee statement. The reason was clearly stated previously and is expanded on in this re-submittal. Section 6.1.1.4 is nearly incomprehensible to the average user, but should be understood by TC members. This PI deals with which sections are in or out for below MAQ. Once the TC gets through that, we can deal with a related PI (or PC) that rearranges the code to make it comprehensible.
For clarity and TC member convenience, all the sections of 6.X are listed below with 3 possible actions recommended. 1) Retained. This is for sections that are correct now, apply both above and below MAQ, and must be retained. This is a “no change” item. 2) Added. This is for sections that need to apply both below and above MAQ but currently only apply above MAQ. 3) Deleted. This is for sections that currently apply both above and below MAQ but need to apply only above MAQ.
6.4.1.5 – This is retained with section 6.4 which is added in its entirety.
6.1 Charging language. Retained. This section is needed both above and below MAQ. No change.
6.2 – Design and construction. Added. This requires compliance with the building code and applies both above and below MAQ. For 6.2 to apply below MAQ, it must be added to here.
6.3 – Control Areas. Added. This must apply below MAQ because control areas are only used below MAQ.
6.4 – Occupancy Classification. Added. This section needs to apply both above and below MAQ. Among the sections of 6.4 that need to apply below MAQ but would be missed if not included in the 6.1.1.4 list: 6.4.1.2, 6.4.1.3, 6.4.1.2, 6.4.2 and 6.4.2.1. So nearly all of them. 6.4.1.1.1 is a pointer that only needs to apply above MAQ but also contains its own language that excludes just this section from below MAQ, so there is no problem including it. 6.4.1.1.2 and 6.4.1.3 have other issues that are the subject of a separate PI and best not discussed here.
6.5 – Piping. Added. This section contains basic requirements for hydrogen piping that ensure the robustness and integrity the code counts on are included. This needs to apply to piping systems connected to below MAQ quantities as well as above.
6.6 Gas Rooms. Added. Gas rooms are used to allow hydrogen in excess of 250 cubic feet (per the limitation of 6.4.1.5.1.1) and up to but not exceeding MAQ in sensitive occupancies (other than Storage, Industrial). Additional protections are required. At greater than MAQ the area changes occupancy classification to high hazard. (Group H-2 per IBC or Protection Level 1 per NFPA 1). Gas rooms are a useful option for below MAQ and must be made applicable below MAQ.

6.7 Weather Protection. Added. This is often used to make sure an outside storage area both above or below MAQ does actually qualify as outdoors (not indoors) even though a roof may be installed. This must apply below MAQ as well as above.
6.8 Electrical Equipment. Retained. No change.
6.9 Employee Alarm System. Deleted. This was removed because Employee Alarm Systems are only needed above MAQ. They are intended to provide a means of notifying employees of a need to exit or stay out of a HAZMAT room. Currently, this conflicts with the IFC (ref. 2013 IFC 5004.9) which has the same requirement, but it only applies above MAQ. They are not warranted below MAQ. This change makes them only required above MAQ not both.
6.10 Explosion Control. No change. Only applies above MAQ. Agrees with IFC.
6.11 Fire Protection Systems. No change. Only applies above MAQ. Agrees with IFC.
6.12 Fire Alarm System. No change. Only applies above MAQ. Agrees with IFC.
6.13 GH2 Detection Systems. Retained. No change. Only applies above MAQ. Agrees with IFC.
6.14 Lighting. No change. Not clearly needed because lighting is addressed by the building code. Currently only required by NFPA 2 for above MAQ but is always required by the Building Code.
6.15 Spill Control. Retained. No change. Only applies above MAQ. Agrees with IFC.
6.16 Shelving. No change. Applies only above MAQ.
6.17 Vent System termination. Retained. No change. Applies both above and below MAQ.
6.18 Ventilation. No change. Applies only above MAQ.
6.19 Gas Cabinets. Added. For flammable gas, gas cabinets can be useful to increase the MAQ threshold and remain below it.
6.20 Exhausted Enclosures. Added. Similar to gas cabinets, exhausted enclosures can be used to increase the MAQ but only if they are applicable below the MAQ. Adding 6.20 fixes that.
6.21 Source Valve. No change. Only applies above MAQ. Only applies to bulk systems which are always above MAQ anyway.
6.22 Cleaning, Purging, Repairing of Piping Systems. Added.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 12:41:03 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-98-NFPA 2-2024

Statement: The requirements for areas that are below MAQ are incomplete. Adding reference to the added sections makes those sections applicable both above and below MAQ. Currently they are only applicable above MAQ. Section 6.9 should not apply below MAQ. The basis for each addition or deletion is provided below.

6.4.1.5 – This is retained with section 6.4 which is added in its entirety.

6.1 Charging language. This section is needed both above and below MAQ. No change.

6.2 – Design and construction. This requires compliance with the building code and applies both above and below MAQ.

6.3 – Control Areas. This must apply below MAQ because control areas are only used below MAQ.

6.4 – Occupancy Classification. Added. This section needs to apply both above and below MAQ. Among the sections of 6.4 that need to apply below MAQ but would be missed if not included in the 6.1.1.4 list: 6.4.1.2, 6.4.1.3, 6.4.1.2, 6.4.2 and 6.4.2.1.

6.5 – Piping.This section contains basic requirements for hydrogen piping that ensure the robustness and integrity the code counts on are included. This needs to apply to piping systems connected to below MAQ quantities as well as above.

6.6 Gas Rooms. Gas rooms are used to allow hydrogen in excess of 250 cubic feet (per the limitation of 6.4.1.5.1.1) and up to but not exceeding MAQ in sensitive occupancies (other than Storage, Industrial). Additional protections are required. At greater than MAQ the area changes occupancy classification to high hazard. (Group H-2 per IBC or Protection Level 1 per NFPA 1). Gas rooms are a useful option for below MAQ and must be made applicable below MAQ.

6.9 Employee Alarm System. Deleted. This was removed because Employee Alarm Systems are only needed above MAQ. They are intended to provide a means of notifying employees of a need to exit or stay out of a HAZMAT room. Currently, this conflicts with the IFC (ref. 2013 IFC 5004.9) which has the same requirement, but it only applies above MAQ. They are not warranted below MAQ. This change makes them only required above MAQ not both.

6.19 Gas Cabinets. For flammable gas, gas cabinets can be useful to increase the MAQ threshold and remain below it.

6.20 Exhausted Enclosures. Similar to gas cabinets, exhausted enclosures can be used to increase the MAQ but only if they are applicable below the MAQ.

6.22 Cleaning, Purging, Repairing of Piping Systems. This section applies both above and below the MAQ.

Public Input No. 181-NFPA 2-2023 [Section No. 6.3.1]

6.3.1 Construction Requirements.

Control areas, if used, shall be separated from each other ~~'s~~ with fire barriers in accordance with the adopted building code.

Statement of Problem and Substantiation for Public Input

Substantiation: Using control areas as a hazardous material management strategy is not mandatory. Adding “if used” to text clarifies this. The addition of “other with” just fixes a grammatical error with no change in code intent.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 12:55:19 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-107-NFPA 2-2024
Statement: This revision fixes a grammatical error with no change in code intent.

Public Input No. 182-NFPA 2-2023 [Section No. 6.4.1]

6.4.1

~~Quantity Thresholds for GH 2 or LH 2 Requiring Special Provisions~~

:

~~6.4.~~

1

~~.1~~

_ Threshold Exceedences.

6.4.1.1.1 _

Where the quantities of GH 2 or LH 2 stored or used within an indoor control area exceed those shown in Table 6.4.1.1.1 , the area shall meet the requirements for the occupancy classification in accordance with the adopted building code, based on the requirements of 6.4.2 .

Table 6.4.1.1.1 Maximum Allowable Quantity of Hydrogen per Control Area (Quantity Thresholds Requiring Special Provisions)

-

	Unsprinklered Areas	
-		
	Sprinklered Areas	
Material	**No Gas Cabinet, Gas Room, or Exhausted Enclosure**	**Gas Cabinet, Gas Room, or Exhausted Enclosure**
-		
	No Gas Cabinet, Gas Room, or Exhausted Enclosure	**Gas Cabinet, Gas Room, or Exhausted Enclosure**
LH 2	0 gal (0 L)	45 gal (170 L) *
-		
	45 gal (170 L)	45 gal (170 L)
- - - - - -		
GH 2	1000 scf (26.3 Nm 3)	2000 scf (52.6 Nm 3)
-		
	2000 scf (52.6 Nm 3)	4000 scf (105.1 Nm 3)

For SI units: 1 ft = 304.8 mm; 1 scf = 0.02832 Nm 3 .

Note: None allowed in unsprinklered buildings unless stored or used in gas rooms or in approved gas cabinets or exhausted enclosures, as specified in this code, and pressure-relief devices for stationary or portable containers vented directly outdoors or to an exhaust hood.

*A gas cabinet or exhausted enclosure is required *(see also 6.4.1.1.2)* .

6.4.1.1.2 _

Pressure relief devices or stationary or portable containers shall be vented directly outdoors or to an exhaust hood.

6.4.1.2 _ Aggregate Allowable Quantities.

The aggregate quantity in use and storage shall not exceed the quantity listed for storage.

6.4.1.3 _ Incompatible Materials.

When the classification of materials in individual containers requires the area to be placed in more than one occupancy classification, the separation of occupancies shall not be required, provided the area is constructed to meet the requirements of the most restrictive occupancy classification and that the incompatible materials are separated as required by 7.2.1.1 .

6.4.1.4 _ Multiple Hazards.

GH_2 blended with other gases having multiple hazards shall also comply with NFPA 55.

6.4.1.5 _ GH_2 .

6.4.1.5.1 * _

GH_2 shall not be stored or used in other than industrial or storage occupancies, or laboratory work areas of business occupancies.

6.4.1.5.1.1 _

Cylinders, containers, or tanks not exceeding 250 scf (7.1 Nm^3) content at normal temperature and pressure (NTP) and used for maintenance purposes, patient care, or operation of equipment shall be permitted.

6.4.1.5.1.2 _

Piping systems used to supply GH_2 in accordance with 6.5.1 shall be allowed.

6.4.1.5.1.3 _

Hydrogen gas systems located in a hydrogen gas room that meet the requirements of Section 6.6 are permissible in quantities up to those allowed by Table 6.4.1.1.1 for assembly, educational, institutional, residential, or business occupancies.

Statement of Problem and Substantiation for Public Input

Substantiation: Section 6.4 contains provisions that apply both above and below MAQ. Therefore, the header in 6.4.1 is incorrect. The text is also likely in conflict with the Manual of Style as an orphan heading with no enforceable language. All remaining sections of 6.4.1.1 to be renumbered.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 13:09:35 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-181-NFPA 2-2024
Statement: The header of 6.4.1 has been deleted since Section 6.4 contains provisions that apply both above and below MAQ. All remaining sections of 6.4.1.1 to be renumbered.

Public Input No. 187-NFPA 2-2023 [New Section after 6.4.1.1.1]

New Section after 6.4.1.1.1.

6.4.1.1.1.1 The following shall not be included in determining the GH2 quantity requiring special provisions:

A) GH2 fuel in fuel tanks on motor vehicles.

B) GH2 fuel in fuel tanks on hydrogen powered industrial trucks in compliance with Chapter 19 of this code.

C) GH2 in piping systems in compliance with this code.

D) GH2 and Oxygen in electrolyzers that are in compliance with Chapter 13 of this code.

E) GH2 in fuel cells that are in compliance with Chapter 12 of this code.

Statement of Problem and Substantiation for Public Input

Substantiation:
This addresses an inconsistency between NFPA 2 and both NFPA 1 and the IFC which are the top-level fire codes used in the US. The tables known as the “MAQ Tables” in both NFPA 1 (2024 NFPA Table 60.4.2.1.1.3 Footnote g) and the IFC (2021 IFC Table 5003.1.1(1) Footnote p) exclude flammable gases like GH2 from MAQ considerations under specified conditions. NFPA 2 also has an “MAQ Table” but does not include the important exemptions that are part of the top-level fire codes (NFPA 1 and IFC). This PI adds them.

Below is the 2024 NFPA 1 table title and footnote:
Table 60.4.2.1.1.3 Maximum Allowable Quantities (MAQ) of Hazardous Materials per Control Area
g Flammable gases in the fuel tanks of mobile equipment or vehicles are permitted to exceed the MAQ where the equipment is stored and operated in accordance with this Code.

Below is the 2021 IFC table title and footnote:
TABLE 5003.1.1(1)
MAXIMUM ALLOWABLE QUANTITY PER CONTROL AREA OF HAZARDOUS MATERIALS POSING A PHYSICAL HAZARDa, j, m, n, p
p. The following shall not be included in determining the maximum allowable quantities:
1. Liquid or gaseous fuel in fuel tanks on vehicles.
2. Liquid or gaseous fuel in fuel tanks on motorized equipment operated in accordance with this code.
3. Gaseous fuels in piping systems and fixed appliances regulated by the International Fuel Gas Code.
Adding these exclusions to NFPA 2 makes the intended application of the MAQ tallying process for applicability of High Hazard level occupancy requirements clear. Minor edits were made to make the text applicable to GH2 (LH2 was intentionally excluded).
New section C) has been edited to apply specifically to electrolyzers and fuel cells which is the intent of the IFC rather than the ambiguous term “appliances” which sounds like a small washing machine.
Exempting the GH2 in electrolyzers and fuel cell is justified because NFPA 2 requires significant safety features for them that reduce the likelihood of significant leaks.
Electrolyzers that comply with Chapter 13 have sufficient safety features that MAQ provisions are not needed.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 14:33:13 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: CI-108-NFPA 2-2024

Statement: This Committee Input is looking at an inconsistency between NFPA 2 and both NFPA 1 and the IFC. The tables known as the “MAQ Tables” in both NFPA 1 (2024 NFPA Table 60.4.2.1.1.3 Footnote g) and the IFC (2021 IFC Table 5003.1.1(1) Footnote p) exclude flammable gases like GH2 from MAQ considerations under specified conditions. NFPA 2 also has an “MAQ Table” but does not include the important exemptions that are part of the top-level fire codes (NFPA 1 and IFC).

Public Input No. 116-NFPA 2-2023 [Section No. 6.4.1.1.1]

6.4.1.1.1

Where the quantities of GH_2 or LH_2 stored or used within an indoor control area exceed those shown in Table 6.4.1.1.1, the area shall meet the requirements for the occupancy classification in accordance with the adopted building code, based on the requirements of 6.4.2.

Table 6.4.1.1.1 Maximum Allowable Quantity of Hydrogen per Control Area (Quantity Thresholds Requiring Special Provisions)

	Unsprinklered Areas		Sprinklered Areas	
Material	No Gas Cabinet, Gas Room, or Exhausted Enclosure	Gas Cabinet, Gas Room, or Exhausted Enclosure	No Gas Cabinet, Gas Room, or Exhausted Enclosure	Gas Cabinet, Gas Room, or Exhausted Enclosure
LH_2	0 gal (0 L)	45 gal (170 L) *	45 gal (170 L)	45 gal (170 L)
GH_2	1000 scf (26.3 Nm^3)	2000 scf (52.6 Nm^3)	2000 scf (52.6 Nm^3)	4000 scf (105.1 Nm^3)

For SI units: 1 ft = 304.8 mm; 1 scf = 0.02832 Nm^3.

Note: ~~None allowed in unsprinklered buildings unless stored or used in gas rooms or in approved gas cabinets or exhausted enclosures, as specified in this code, and pressure-relief devices for stationary or portable containers vented directly outdoors or to an exhaust hood~~ The maximum quantity indicated is the aggregate quantity of materials in storage and use combined .

*A gas cabinet or exhausted enclosure is required *(see also 6.4.1.1.2)*.

Statement of Problem and Substantiation for Public Input

This table note was revised in the 2023 edition of NFPA 2. However, the new table note seems to just describe in words what the first row of the table specifies; i.e., the MAQ of 0 gal (0 L) for LH2 in an unsprinklered area with no gas cabinet or exhausted enclosure. This is confusing when the note appears to apply to the whole table and so can cause confusion with the second row of the table which refers to GH2.
Instead, the original pre-2023 table note that was removed in the 2023 Edition specifies that the MAQ is the aggregate quantity in storage and use combined; this table note still exists in NFPA 55 2023 Table 6.3.1.1, which appears to have been the original source of the hydrogen-specific table in NFPA 2. Since the 2023 table note appears to simply describe information already contained in the table, it is not clear why the 2023 change was made. So this proposed change simply undoes the change made in 2023, which may have been an oversight.

Submitter Information Verification

Submitter Full Name: Brian Ehrhart
Organization: Sandia National Laboratories
Street Address:
City:

State:
Zip:
Submittal Date: Fri Dec 15 16:19:14 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-116-NFPA 2-2024

Statement: Section 3.3.237.3 defines a bulk liquefied hydrogen system as one with more than 39.7 gallons (150 L) and the MAQ is lowered to match that defined limit

The other change is to replace "areas" with "buildings" for sprinklered and sprinklered buildings to be consistent with NFPA 55, the source of this table, and to maintain consistency within the table: the note at the bottom used the term "building."

This note is incorrect. Below MAQ (1000 SCF) amounts of GH2 are allowed in unsprinklered buildings. As written this note applies to the entire table and it is only applies for LH2.

Delete * note regarding gas cabinets. This text repeats what is in the header of the column and serves no purpose.

The cross-reference to sub-section 6.4.2 has been deleted due to a separate action that deleted 6.4.2.

Public Input No. 186-NFPA 2-2023 [Section No. 6.4.1.1.1]

6.4.1.1.1

Where the quantities of GH_2 or LH_2 stored or used within an indoor control area exceed those shown in Table 6.4.1.1.1, the area shall meet the requirements for the occupancy classification in accordance with the adopted building code, based on the requirements of 6.4.2.

Table 6.4.1.1.1 Maximum Allowable Quantity of Hydrogen per Control Area (Quantity Thresholds Requiring Special Provisions)

	Unsprinklered Areas		Sprinklered Areas	
Material	No Gas Cabinet, Gas Room, or Exhausted Enclosure	Gas Cabinet, Gas Room, or Exhausted Enclosure	No Gas Cabinet, Gas Room, or Exhausted Enclosure	Gas Cabinet, Gas Room, or Exhausted Enclosure
LH_2	0 gal (0 L)	45 gal (170 L) *	45 gal (170 L)	45 gal (170 L)
GH_2	1000 scf (26.3 Nm^3)	2000 scf (52.6 Nm^3)	2000 scf (52.6 Nm^3)	4000 scf (105.1 Nm^3)

For SI units: 1 ft = 304.8 mm; 1 scf = 0.02832 Nm^3.

~~Note: None allowed in unsprinklered buildings unless stored or used in gas rooms or in approved gas cabinets or exhausted enclosures, as specified in this code, and pressure-relief devices for stationary or portable containers vented directly outdoors or to an exhaust hood.~~

~~*A gas cabinet or exhausted enclosure is required *(see also 6.4.1.1.2)*~~ .

Statement of Problem and Substantiation for Public Input

Substantiation: Delete note. This note is incorrect. Below MAQ (1000 SCF) amounts of GH2 are allowed in unsprinklered buildings. As written this note applies to the entire table but per 2023 PC-96 was intended to explain further the limitation on LH2. The entire note is unnecessary. If it does contain new requirements it should be a code section not a note to a table. But the note is explanatory, not mandatory. So it should be deleted. Is a TIA to 2023 NFPA 2 needed?
Substantiation: Delete * note regarding gas cabinets. This text repeats what is in the header of the column and serves no purpose.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 13:24:41 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-116-NFPA 2-2024

Statement: Section 3.3.237.3 defines a bulk liquefied hydrogen system as one with more than 39.7 gallons (150 L) and the MAQ is lowered to match that defined limit

The other change is to replace "areas" with "buildings" for sprinklered and sprinklered buildings to be consistent with NFPA 55, the source of this table, and to maintain consistency within the table: the note at the bottom used the term "building."

This note is incorrect. Below MAQ (1000 SCF) amounts of GH2 are allowed in unsprinklered buildings. As written this note applies to the entire table and it is only applies for LH2.

Delete * note regarding gas cabinets. This text repeats what is in the header of the column and serves no purpose.

The cross-reference to sub-section 6.4.2 has been deleted due to a separate action that deleted 6.4.2.

Public Input No. 30-NFPA 2-2023 [Section No. 6.4.1.1.1]

6.4.1.1.1

Where the quantities of GH_2 or LH_2 stored or used within an indoor control area exceed those shown in Table 6.4.1.1.1, the area shall meet the requirements for the occupancy classification in accordance with the adopted building code, based on the requirements of 6.4.2.

Table 6.4.1.1.1 Maximum Allowable Quantity of Hydrogen per Control Area (Quantity Thresholds Requiring Special Provisions)

	Unsprinklered Buildings		~~Unsprinklered Areas~~		Sprinklered ~~Areas~~ Building	
Material	No Gas Cabinet, Gas Room, or Exhausted Enclosure	Gas Cabinet, Gas Room, or Exhausted Enclosure		No Gas Cabinet, Gas Room, or Exhausted Enclosure	Gas Cabinet, Gas Room, or Exhausted Enclosure	
LH_2	0 gal (0 L)~~45 gal~~	~~(170 L~~ 39.7 gal (150 L) *		~~45 gal (170 L)~~	~~45 gal (170 L)~~	
	39.7 gal (150 L)	39.7 gal (150 L)				
GH_2	1000 scf (26.3 Nm^3)	2000 scf (52.6 Nm^3)		2000 scf (52.6 Nm^3)	4000 scf (105.1 Nm^3)	

For SI units: 1 ft = 304.8 mm; 1 scf = 0.02832 Nm^3.

Note: None allowed in unsprinklered buildings unless stored or used in gas rooms or in approved gas cabinets or exhausted enclosures, as specified in this code, and pressure-relief devices for stationary or portable containers vented directly outdoors or to an exhaust hood.

*A gas cabinet or exhausted enclosure is required *(see also 6.4.1.1.2)*.

Statement of Problem and Substantiation for Public Input

Section 3.3.237.3 defines a bulk liquefied hydrogen system as one with more than 39.7 gallons (150 L). This public input is to create consistency within NFPA 2.

The formatting of the revised table may look strange due to Terra. The PI leaves the first (left-most) column as is with 0 gallons (0 L) and revised the next three columns to 39.7 gallons (150 L) to replace the 45 gallons (170 L) listing.

The other change is to replace "areas" with "buildings" for sprinklered and sprinklered buildings to be consistent with NFPA 55, the source of this table, and to maintain consistency within the table: the note at the bottom used the term "building."

The formatting of he revised header may look strange due to Terra. The header for the first two columns should read "unsprinklered buildings" and the header for the third and fourth column should read "sprinklered buildings."

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 12:43:21 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-116-NFPA 2-2024

Statement: Section 3.3.237.3 defines a bulk liquefied hydrogen system as one with more than 39.7 gallons (150 L) and the MAQ is lowered to match that defined limit

The other change is to replace "areas" with "buildings" for sprinklered and sprinklered buildings to be consistent with NFPA 55, the source of this table, and to maintain consistency within the table: the note at the bottom used the term "building."

This note is incorrect. Below MAQ (1000 SCF) amounts of GH2 are allowed in unsprinklered buildings. As written this note applies to the entire table and it is only applies for LH2.

Delete * note regarding gas cabinets. This text repeats what is in the header of the column and serves no purpose.

The cross-reference to sub-section 6.4.2 has been deleted due to a separate action that deleted 6.4.2.

Public Input No. 183-NFPA 2-2023 [Section No. 6.4.1.1.2]

~~6.4.1.1.2~~ –

~~Pressure relief devices or stationary or portable containers shall be vented directly outdoors or to an exhaust hood.~~

Statement of Problem and Substantiation for Public Input

Substantiation: This requirement about pressure relief devices is misplaced in a section addressing occupancy classification. Where this is located, the requirement applies to both GH2 and LH2. This text can be deleted from here and relocated to Ch 7 for GH2 and CH 8 for as part of a separate PI. The text in 7.1.5.5 deals with PRDs for GH2 and 8.1.4 deals with PRDs for LH2. Separate PIs have been submitted to relocate these if needed.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 184-NFPA 2-2023 [New Section after 7.1.5.5.6]	
Public Input No. 185-NFPA 2-2023 [New Section after 8.1.5.5]	

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 13:12:31 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-136-NFPA 2-2024

Statement: This revision relocates 6.4.1.1.2, where it was to this new location in the GH2 PRD section.

Containers are separate from cylinders and tanks. A related change has been made separately to address LH2 in a similar manner. An editorial change was also made to correct a typo.

Public Input No. 188-NFPA 2-2023 [Section No. 6.4.1.3]

6.4.1.3 ~~Incompatible Materials~~ _ Multiple Hazard Categories .

When the classification of materials in individual containers results in multiple hazard categories and requires the area to be placed in more than one occupancy classification, the separation of occupancies shall not be required, provided the area is constructed to meet the requirements of the most restrictive occupancy classification and that the incompatible materials are separated as required by 7.2.1.1.

Statement of Problem and Substantiation for Public Input

Substantiation: These edits to make the title of the section match its contents. The section does not deal with incompatible materials but rather mixed hazardous materials with hydrogen and something else, such as a toxic gas that requires different occupancy classification (when > MAQ) and different treatment.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 14:37:45 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-228-NFPA 2-2024
Statement: These revisions make the title of the section match its contents. The section does not deal with incompatible materials but rather mixed hazardous materials with hydrogen and something else, such as a toxic gas that requires different occupancy classification (when > MAQ) and different treatment.

Public Input No. 189-NFPA 2-2023 [Section No. 6.4.2]

~~**6.4.2** – Classification of Occupancy.~~

~~The occupancy classification required shall be based on the hazard class of the material involved as indicated in 6.4.2.1 .~~

~~**6.4.2.1** – Occupancy Classification.~~

~~Occupancies used for the storage or use of GH~~ $_2$ ~~or LH~~ $_2$ ~~in quantities that exceed the quantity thresholds for gases requiring special provisions shall be classified in accordance with the adopted building code.~~

Statement of Problem and Substantiation for Public Input

Substantiation: Not needed. Redundant to 6.4.1.1.1.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 14:40:52 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-139-NFPA 2-2024
Statement: This is a redundant requirement to 6.4.1.1.1 and it not needed to be restated.

Public Input No. 53-NFPA 2-2023 [New Section after 6.5.1]

Fuel Gas Supply Piping Systems

(a) Fuel supply piping systems which are upstream of the first equipment isolation valve shall follow the guidance of section 6.5.1.

(b) Fuel train appliance downstream of the equipment isolation valve shall meet the requirements of Chapter 14.

Statement of Problem and Substantiation for Public Input

Suggestion from the Hydrogen as a Combustion Fuel Task Group to clarify the separation of the supply system from the appliance gas train. This is aligned with the wording in the IFGC.

Submitter Information Verification

Submitter Full Name: Elizabeth Krasowski
Organization: Ramboll
Street Address:
City:
State:
Zip:
Submittal Date: Thu Sep 28 13:45:39 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: CI-177-NFPA 2-2024

Statement: The requirements of the IFGC imposed in Section 6.5.1 prohibit separable connections (flanges, threaded, etc.) for piping systems containing hydrogen within a building outside of a hydrogen fuel gas room and requires all welded / brazed connections. While welded / brazed piping provides the best mitigation to prevent leaks, the complex fuel trains associated with the industrial equipment applications covered by Chapter 14 (furnaces, ovens, turbines, etc.) which include multiple valves and flow paths cannot be assembled using only welded / brazed connections.

This change provides an appropriate “separation” point (the “equipment isolation valve”) between the supply piping and the complex industrial equipment fuel train that complies with specific requirements provided for such equipment in the Chapter 14 rewrite and the associated equipment specific NFPA standards referenced in the Chapter 14 rewrite.

Public Input No. 122-NFPA 2-2023 [Section No. 6.5.1 [Excluding any Sub-Sections]]

Piping, tubing, valves, and fittings shall be designed and installed in accordance with applicable sections of ASME B31, *Code for Pressure Piping*~~, and Sections 704~~ . ~~1.2.3, 704.1.2.4, and 704.1.2.5 of the ICC *International Fuel Gas Code (IFGC)* .~~ Cast, ductile, malleable, or high-silicon iron pipe, valves, and fittings shall not be used.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

Piping systems for hydrogen systems should be designed and constructed to minimize the likelihood of a release (leak). Welded connections are generally considered the best way to achieve this, however, they are not always practical.

In addition many types of hydrogen systems include piping for fluids other than hydrogen. For example electrolyzer based hydrogen generators include piping for water and reformer based hydrogen generators often include piping for natural gas.

The Code for Pressure Piping, ASME B31, addresses the design, fabrication, assembly, and testing of piping systems for all types of fluid including hydrogen. ASME B31.12, Hydrogen Piping and Pipelines, addresses piping system for hydrogen in particular.

ASME B31 has been used successfully in hydrogen system for many decades. And, many product safety standards for hydrogen equipment such as CSA FC 1 for fuel cells and CSA B22734 for electrolyzers refer specifically to ASME B31.

Note: These standards and Codes such as NFPA 2 require additional safeguards to provide protection in the event of a release (leak). This includes measures such as ventilation to dilute or remove the hydrogen, elimination of effective ignition sources, hydrogen detectors to initiate safety systems, etc. Hydrogen systems do not rely solely on piping for safety.

The addition of the requirement to also meet sections of IFCG is both redundant and likely to cause confusion and possibly reduced safety as it has prohibitions and exceptions that are difficult to navigate.

And, the limitations of the IFGC sections are not appropriate for the piping for other fluids used in hydrogen systems and conflict with standard practices for that piping.

Finally, hydrogen is very often not used as a fuel gas which brings into doubt the applicability of any part of the IFGC.

ASME B31 is both necessary and sufficient.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 124-NFPA 2-2023 [Section No. A.6.5.1]	Annex A explanatory information for 6.5.1.
Public Input No. 123-NFPA 2-2023 [Section No. 6.5.1.1]	Subsection to 6.5.1 that also has a reference to the IFGC.

Public Input No. 123-NFPA 2-2023 [Section No. 6.5.1.1]

Public Input No. 124-NFPA 2-2023 [Section No. A.6.5.1]

Public Input No. 131-NFPA 2-2023 [New Section after 13.2.5]

Public Input No. 152-NFPA 2-2023 [New Section after 12.2.1.3]

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13 TG
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 20:34:42 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-25-NFPA 2-2024

Statement: Piping systems for hydrogen systems should be designed and constructed to minimize the likelihood of a release (leak). Welded connections are generally considered the best way to achieve this, however, they are not always practical.

In addition, many types of hydrogen systems include piping for fluids other than hydrogen. For example, electrolyzer based hydrogen generators include piping for water and reformer-based hydrogen generators often include piping for natural gas.

The Code for Pressure Piping, ASME B31, addresses the design, fabrication, assembly, and testing of piping systems for all types of fluid including hydrogen. ASME B31.12, Hydrogen Piping and Pipelines, addresses piping system for hydrogen in particular.

ASME B31 has been used successfully in hydrogen systems for many decades. And, many product safety standards for hydrogen equipment such as CSA FC 1 for fuel cells and CSA/ANSI B22734 for electrolyzers refer specifically to ASME B31.

For the renumbered 6.5.1.2 is a contradiction between the International Fuel Gas Code (IFGC) and the American Society of Mechanical Engineers (ASME) B31 piping codes in the pressure testing requirements of hydrogen systems for high-pressure applications. The contradiction concerns the acceptable resultant hoop (circumferential) stress from a pneumatic or hydrostatic pressure test. The requirement in the IFGC is limiting and would require a lower test pressure and, in some cases, below the MAWP, where the B31 codes state that no test pressure reduction is required. B31 allows for testing up to the yield. For example, a 1" stainless steel tube has a wall thickness of 0.083". If they follow the IFGC Section 705, it limits the pressure test based on 50% of the hoop stress, resulting in a pressure test at 2507psig.

Meanwhile, the Barlow formula provided by B31 can establish an MAWP of 3100psig. ASME B31 would require a pressure test at 1.1xMAWP.

Public Input No. 190-NFPA 2-2023 [Section No. 6.5.1 [Excluding any Sub-Sections]]

NFPA has updated this Public Input by removing copyrighted material where NFPA is not the copyright owner or has not been provided with the proper permission to share or use the copyrighted material.

Piping, tubing, valves, and fittings shall be designed and installed in accordance with applicable sections of ASME B31, *Code for Pressure Piping* and this code. Cast , ductile, malleable, or high-silicon iron pipe, valves, and fittings shall not be used.

6.5.1 * Piping Systems.

Piping, tubing, valves, and fittings shall be designed and installed in accordance with applicable sections of ASME B31, Code for Pressure Piping , and this code . ~~Sections 704.1.2.3, 704.1.2.4, and 704.1.2.5 of the ICC~~ ~~International Fuel Gas Code (IFGC)~~ . Cast, ductile, malleable, or high-silicon iron pipe, valves, and fittings shall not be used.

6.5.1.1 (NEW. Insert after existing 6.5.1 and renumber rest of section) Piping design.

6.5.1.2 Piping construction.

6.5.1.3 Prohibited locations.

6.5.1.4 Interior piping.

6.5.1.5 Protection against physical damage.

6.5.1.8 Settlement.

6.5.1.9 Joints.

6.5.1.9.4 Brazed joints.

6.5.1.9.5 Electrical continuity.

6.5.1.10 Valves and piping components.

Additional Proposed Changes

File Name	Description	Approved
PI_190_Original.pdf		
2_PI-190_Redacted.pdf		

Statement of Problem and Substantiation for Public Input

NFPA has updated this Public Input by removing copyrighted material where NFPA is not the copyright owner or has not been provided with the proper permission to share or use the copyrighted material.

This change imports piping requirements to make sure they do not get missed and can be edited as needed by NFPA 2 TC. IFGC text regarding shield plate specifications was deleted and a 500 psi threshold was added for applicability of the flanges and threaded joints prohibition.
For convenience the full text of the referenced IFGC sections is inserted below:

IFGC Sections 704.1.2.3,4,5 in their entirety.
704.1.2.3 Piping design and construction.
704.1.2.3.1 Prohibited locations.
704.1.2.3.2 Interior piping.
704.1.2.3.3 Underground piping.
704.1.2.3.4 Piping through foundation wall.
704.1.2.3.5 Protection against physical damage.
704.1.2.3.6 Piping outdoors.
704.1.2.3.7 Settlement.
704.1.2.4 Joints.
704.1.2.4.1 Brazed joints.
704.1.2.4.2 Electrical continuity.
704.1.2.5 Valves and piping components.
704.1.2.5.1 Shutoff valves on storage containers and tanks.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 14:46:09 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The proposed text is unactionable as it contains no requirement language. The submitter is welcome to resubmit their proposal with requirement language that is not copyrighted.

Public Input No. 190-NFPA 2-2023 [Section No. 6.5.1 [Excluding any Sub-Sections]]

Piping, tubing, valves, and fittings shall be designed and installed in accordance with applicable sections of ASME B31, *Code for Pressure Piping* and this code. Cast , ductile, malleable, or high-silicon iron pipe, valves, and fittings shall not be used.

6.5.1 * Piping Systems.

Piping, tubing, valves, and fittings shall be designed and installed in accordance with applicable sections of ASME B31, Code for Pressure Piping , and this code . ~~Sections 704.1.2.3, 704.1.2.4, and 704.1.2.5 of the ICC International Fuel Gas Code (IFGC)~~ . Cast, ductile, malleable, or high-silicon iron pipe, valves, and fittings shall not be used.

6.5.1.1 (NEW. Insert after existing 6.5.1 and renumber rest of section) Piping design. Piping and tubing materials shall be 300 series stainless steel or materials listed or approved for hydrogen service and the use intended through the full range of operating conditions to which they will be subjected.

6.5.1.2 Piping construction. Piping systems shall be designed and constructed to provide allowance for expansion, contraction, vibration, settlement and fire exposure.

6.5.1.3 Prohibited locations. Piping shall not be installed in or through a circulating air duct; clothes chute; chimney or gas vent; ventilating duct; dumbwaiter; or elevator shaft. Piping shall not be concealed or covered by the surface of any wall, floor or ceiling.

6.5.1.4 Interior piping. Except for through penetrations, piping located inside of buildings shall be installed in exposed locations and provided with ready access for visual inspection.

6.5.1.5 Protection against physical damage. Where piping other than stainless steel piping, stainless steel tubing or black steel is installed through holes or notches in wood studs, joists, rafters or similar members less than 11/2 inches (38 mm) from the nearest edge of the member, the pipe shall be protected by shield plates in accordance with the applicable building code. ~~. Shield plates shall be a minimum of 1/16-inch-thick (1.6 mm) steel, shall cover the area of the pipe where the member is notched or bored and shall extend a minimum of 4 inches (102 mm) above sole plates, below top plates and to each side of a stud, joist or rafter.~~

6.5.1.6 Piping installed above ground, outdoors, shall be securely supported and located where it will be protected from physical damage.

6.5.1.7 Piping passing through an exterior wall of a building shall be encased in a protective pipe sleeve.

6.5.1.7.1 The annular space between the piping and the sleeve shall be sealed from the inside such that the sleeve is ventilated to the outdoors.

6.5.1.7.2 Where passing through an exterior wall of a building, the piping shall be protected against corrosion by coating or wrapping with an inert material. ~~Below-ground piping shall be protected against corrosion.~~

6.5.1.8 Settlement. Piping passing through concrete or masonry walls shall be protected against differential settlement.

6.5.1.9 Joints.

6.5.1.9.1 Joints in piping and tubing in hydrogen service shall be listed as complying with ASME B31.3 to include the use of welded, brazed, flared, socket, slip and compression fittings.

6.5.1.9.2 Gaskets and sealants used in hydrogen service shall be listed as complying with ASME B31.12.

6.5.1.9.3 Threaded and flanged connections shall not be used in areas other than hydrogen cutoff rooms and outdoors for systems rated for 500 psi and above.

6.5.1.9.4 Brazed joints. Brazing alloys shall have a melting point greater than 1,000°F (538°C).

6.5.1.9.5 Electrical continuity. Mechanical joints shall maintain electrical continuity through the joint or a bonding jumper shall be installed around the joint.

6.5.1.10 Valves and piping components.

6.5.1.10.1 Valves, regulators and piping components shall be listed or approved for hydrogen service.

6.5.1.10.2 Valves, regulators and piping components shall be provided with access.

6.5.1.10.3 Valves, regulators and piping components shall be designed and constructed to with-stand the maximum pressure to which such components will be subjected.

6.5.1.11 Shutoff valves with ready access, shall be provided on all storage container and tank connections except for pressure relief devices.

Statement of Problem and Substantiation for Public Input

This change imports piping requirements to make sure they do not get missed and can be edited as needed by NFPA 2 TC. IFGC text regarding shield plate specifications was deleted and a 500 psi threshold was added for applicability of the flanges and threaded joints prohibition.
For convenience the full text of the referenced IFGC sections is inserted below:

IFGC Sections 704.1.2.3,4,5 in their entirety.
704.1.2.3 Piping design and construction.
Piping and tubing materials shall be 300 series stainless steel or materials listed or approved for hydrogen service and the use intended through the full range of operating conditions to which they will be subjected. Piping systems shall be designed and constructed to provide allowance for expansion, contraction, vibration, settlement and fire exposure.
704.1.2.3.1 Prohibited locations.
Piping shall not be installed in or through a circulating air duct; clothes chute; chimney or gas vent; ventilating duct; dumbwaiter; or elevator shaft. Piping shall not be concealed or covered by the surface of any wall, floor or ceiling.
704.1.2.3.2 Interior piping.
Except for through penetrations, piping located inside of buildings shall be installed in exposed locations and provided with ready access for visual inspection.
704.1.2.3.3 Underground piping.
Underground piping, including joints and fittings, shall be protected from corrosion and installed in accordance with approved engineered methods.
704.1.2.3.4 Piping through foundation wall.
Underground piping shall not penetrate the outer foundation or basement wall of a building.
704.1.2.3.5 Protection against physical damage.
Where piping other than stainless steel piping, stainless steel tubing or black steel is installed through holes or notches in wood studs, joists, rafters or similar members less than 11/2 inches (38 mm) from the nearest edge of the member, the pipe shall be protected by shield plates. Shield plates shall be a minimum of 1/16-inch-thick (1.6 mm) steel, shall cover the area of the pipe where the member is notched or bored and shall extend a minimum of 4 inches (102 mm) above sole plates, below top plates and to each side of a stud, joist or rafter.
704.1.2.3.6 Piping outdoors.
Piping installed above ground, outdoors, shall be securely supported and located where it will be protected from physical damage. Piping passing through an exterior wall of a building shall be encased in a protective pipe sleeve. The annular space between the piping and the sleeve shall be sealed from the inside such that the sleeve is ventilated to the outdoors. Where passing through an exterior wall of a building, the piping shall be protected against corrosion by coating or wrapping with an inert material. Below-ground piping shall be protected against corrosion.
704.1.2.3.7 Settlement.
Piping passing through concrete or masonry walls shall be protected against differential settlement.
704.1.2.4 Joints.
Joints in piping and tubing in hydrogen service shall be listed as complying with ASME B31.3 to include the use of welded, brazed, flared, socket, slip and compression fittings. Gaskets and seal-ants used in hydrogen service shall be listed as complying with ASME B31.12. Threaded and flanged connections shall not be used in areas other than hydrogen cutoff rooms and outdoors.
704.1.2.4.1 Brazed joints.
Brazing alloys shall have a melting point greater than 1,000°F (538°C).
704.1.2.4.2 Electrical continuity.
Mechanical joints shall maintain electrical continuity through the joint or a bonding jumper shall be installed around the joint.
704.1.2.5 Valves and piping components.

Valves, regulators and piping components shall be listed or approved for hydrogen service, shall be provided with access and shall be designed and constructed to with-stand the maximum pressure to which such components will be subjected.
704.1.2.5.1 Shutoff valves on storage containers and tanks.
Shutoff valves shall be provided on all storage container and tank connections except for pressure relief devices. Shutoff valves shall be provided with ready access.

Submitter Information Verification

Submitter Full Name:	Martin Gresho
Organization:	FP2Fire, Inc.
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Tue Dec 26 14:46:09 EST 2023
Committee:	HYD-AAA Change Committee

Copyright Assignment

I, Martin Gresho, hereby irrevocably grant and assign to the National Fire Protection Association (NFPA) all and full rights in copyright in this Public Input (including both the Proposed Change and the Statement of Problem and Substantiation). I understand and intend that I acquire no rights, including rights as a joint author, in any publication of the NFPA in which this Public Input in this or another similar or derivative form is used. I hereby warrant that I am the author of this Public Input and that I have full power and authority to enter into this copyright assignment.

☑ By checking this box I affirm that I am Martin Gresho, and I agree to be legally bound by the above Copyright Assignment and the terms and conditions contained therein. I understand and intend that, by checking this box, I am creating an electronic signature that will, upon my submission of this form, have the same legal force and effect as a handwritten signature

Public Input No. 190-NFPA 2-2023 [Section No. 6.5.1 [Excluding any Sub-Sections]]

Piping, tubing, valves, and fittings shall be designed and installed in accordance with applicable sections of ASME B31, *Code for Pressure Piping* and this code. Cast , ductile, malleable, or high-silicon iron pipe, valves, and fittings shall not be used.

6.5.1 * Piping Systems.

Piping, tubing, valves, and fittings shall be designed and installed in accordance with applicable sections of ASME B31, Code for Pressure Piping , and this code . ~~Sections 704.1.2.3, 704.1.2.4, and 704.1.2.5 of the ICC International Fuel Gas Code (IFGC)~~ . Cast, ductile, malleable, or high-silicon iron pipe, valves, and fittings shall not be used.

6.5.1.1 (NEW. Insert after existing 6.5.1 and renumber rest of section) Piping design.

6.5.1.2 Piping construction.

6.5.1.3 Prohibited locations.

6.5.1.4 Interior piping.

6.5.1.5 Protection against physical damage.

6.5.1.8 Settlement.

6.5.1.9 Joints.

6.5.1.9.4 Brazed joints.

6.5.1.9.5 Electrical continuity.

[redacted]

6.5.1.10 Valves and piping components.

[redacted]

Statement of Problem and Substantiation for Public Input

This change imports piping requirements to make sure they do not get missed and can be edited as needed by NFPA 2 TC. IFGC text regarding shield plate specifications was deleted and a 500 psi threshold was added for applicability of the flanges and threaded joints prohibition.
For convenience the full text of the referenced IFGC sections is inserted below:

IFGC Sections 704.1.2.3,4,5 in their entirety.
704.1.2.3 Piping design and construction.

[redacted]

704.1.2.3.1 Prohibited locations.

[redacted]

704.1.2.3.2 Interior piping.

[redacted]

704.1.2.3.3 Underground piping.

[redacted]

704.1.2.3.4 Piping through foundation wall.

[redacted]

704.1.2.3.5 Protection against physical damage.

[redacted]

704.1.2.3.6 Piping outdoors.

[redacted]

704.1.2.3.7 Settlement.

[redacted]

704.1.2.4 Joints.

[redacted]

704.1.2.4.1 Brazed joints.

[redacted]

704.1.2.4.2 Electrical continuity.

[redacted]

704.1.2.5 Valves and piping components.

[redacted]

704.1.2.5.1 Shutoff valves on storage containers and tanks.

[redacted]

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 14:46:09 EST 2023
Committee: HYD-AAA

Public Input No. 52-NFPA 2-2023 [Section No. 6.5.1 [Excluding any Sub-Sections]]

Piping, tubing, valves, and fittings shall be designed and installed in accordance with applicable sections of ASME B31, *Code for Pressure Piping*, and Sections 704.1.2.3, 704.1.2.4, and 704.1.2.5 of the ICC *International Fuel Gas Code (IFGC)*. Cast, ductile, malleable, or high-silicon iron pipe, valves, and fittings shall not be used.

(a) Indoor flanges and threaded pipe shall only be permitted in a Hydrogen Fuel Gas Room as defined in IBC Section 421.

(b) The Hydrogen Fuel Gas Room requirements are not applicable for rooms with equipment as defined in Chapter 14.

Additional Proposed Changes

File Name	Description	Approved
NFPA_2_Chapter_6_Justification.docx		

Statement of Problem and Substantiation for Public Input

The current code points from NFPA 2 6.5.1 to IFGC 704 to IBC section 421 as shown in the attachment. Without having more explicit direction, this could be missed by the user.

Submitter Information Verification

Submitter Full Name: Elizabeth Krasowski
Organization: Ramboll
Street Address:
City:
State:
Zip:
Submittal Date: Thu Sep 28 12:31:10 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: The indoor use of small bore threaded and flanged joints is a common practice particularly on systems below MAQ and they have a long history of safe and successful use when not within gas rooms. ASME B31 addresses the piping connection requirements sufficiently. ASME B31.12 specifically addresses hydrogen piping and connections and was developed by piping experts. The proposed additions are not consistent with a built environment. See Chapter 14 for use of threaded connections and flange in the fuel train.

1) NFPA 2 6.5.1 points to IFGC Chapter 7 states no flanged or threaded piping indoors unless Hydrogen Fuel Gas Room (HFGR). This would mean that regardless of MAQ and regardless of usage, if there is 95%+ hydrogen piping systems, that indoor use requires HFGR characteristics.
    a. NFPA 2 →

> **Δ 6.5.1* Piping Systems.** Piping, tubing, valves, and fittings shall be designed and installed in accordance with applicable sections of ASME B31, *Code for Pressure Piping*, and Sections 704.1.2.3, 704.1.2.4, and 704.1.2.5 of the ICC *International Fuel Gas Code (IFGC)*. Cast, ductile, malleable, or high-silicon iron pipe, valves, and fittings shall not be used.

    i.
    b. IFGC Chapter 7 →

704.1.2.4 Joints.

Joints in *piping* and tubing in hydrogen service shall be *listed* as complying with ASME B31.3 to include the use of welded, brazed, flared, socket, slip and compression fittings. Gaskets and seal-ants used in hydrogen service shall be *listed* as complying with ASME B31.12. Threaded and flanged connections shall not be used in areas other than hydrogen cutoff rooms and outdoors.

    c. IFGC says "Hydrogen Cutoff room" in the text but the definition section was changed from "Hydrogen Cutoff room" to "Hydrogen Fuel Gas Room" in 2015, but the 704.1.2.4 text wasn't updated. IBC defines "Hydrogen Fuel Gas Rooms" in section 421 →

SECTION 421
HYDROGEN FUEL GAS ROOMS

[F] 421.1 General.

Where required by the *Fire Code of New York State*, hydrogen fuel gas rooms shall be designed and constructed in accordance with Sections 421.1 through 421.7.

[F] 421.2 Location.

Hydrogen fuel gas rooms shall not be located below grade.

[F] 421.3 Design and construction.

Hydrogen fuel gas rooms not classified as Group H shall be separated from other areas of the building in accordance with Section 509.1.

[F] 421.3.1 Pressure control.

Hydrogen fuel gas rooms shall be provided with a ventilation system designed to maintain the room at a negative pressure in relation to surrounding rooms and spaces.

[F] 421.3.2 Windows.

Operable windows in interior walls shall not be permitted. Fixed windows shall be permitted where in accordance with Section 716.

[F] 421.4 Exhaust ventilation.

Hydrogen fuel gas rooms shall be provided with mechanical exhaust ventilation in accordance with the applicable provisions of Section 502.16.1 of the *Mechanical Code of New York State*.

[F] 421.5 Gas detection system.

Hydrogen fuel gas rooms shall be provided with a *gas detection system* that complies with Sections 421.5.1, 421.5.2, and 916.

[F] 421.5.1 System activation.

Activation of a gas detection alarm shall result in both of the following:

1. Initiation of distinct audible and visible alarm signals both inside and outside of the hydrogen fuel gas room.
2. Automatic activation of the mechanical exhaust ventilation system.

[F] 421.5.2 Failure of the gas detection system.

Failure of the *gas detection system* shall automatically activate the mechanical exhaust ventilation system, stop hydrogen generation, and cause a trouble signal to sound at an approved location.

        i. This includes:
            1. **negative pressure**
            2. separated
            3. gas detection
            4. explosion control
            5. standby power

Public Input No. 123-NFPA 2-2023 [Section No. 6.5.1.1]

6.5.1.1

Prior to acceptance and initial operation, all piping installations shall be inspected and pressure tested in accordance with ASME B31, *Code for Pressure Piping*~~, and Section 705 of the ICC *International Fuel Gas Code (IFGC)*~~ .

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.
The problem statement & rationale are the same as for PI122:

Piping systems for hydrogen systems should be designed and constructed to minimize the likelihood of a release (leak). Welded connections are generally considered the best way to achieve this, however, they are not always practical.

In addition many types of hydrogen systems include piping for fluids other than hydrogen. For example electrolyzer based hydrogen generators include piping for water and reformer based hydrogen generators often include piping for natural gas.

The Code for Pressure Piping, ASME B31, addresses the design, fabrication, assembly, and testing of piping systems for all types of fluid including hydrogen. ASME B31.12, Hydrogen Piping and Pipelines, addresses piping system for hydrogen in particular.

ASME B31 has been used successfully in hydrogen system for many decades. And, many product safety standards for hydrogen equipment such as CSA FC 1 for fuel cells and CSA B22734 for electrolyzers refer specifically to ASME B31.

Note: These standards and Codes such as NFPA 2 require additional safeguards to provide protection in the event of a release. This include measures such as ventilation to dilute or remove the hydrogen, elimination of effective ignition sources, hydrogen detectors to initiate safety systems, etc. Hydrogen systems do not rely solely on piping for safety.

Adding the requirement to also meet sections of IFCG is both redundant and likely to cause confusion and possibly reduced safety as it has prohibitions and exceptions that are difficult to navigate.

And, the limitations of the IFGC sections are not appropriate for the piping for other fluids used in hydrogen systems and conflict with standard practices for that piping.

Finally, hydrogen is very often not used as a fuel gas which brings into doubt the applicability of any part of the IFGC.

ASME B31 is both necessary and sufficient.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 122-NFPA 2-2023 [Section No. 6.5.1 [Excluding any Sub-Sections]]	Delete reference to IFGC from both sections.
Public Input No. 122-NFPA 2-2023 [Section No. 6.5.1 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13 TG
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 20:40:07 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-25-NFPA 2-2024

Statement: Piping systems for hydrogen systems should be designed and constructed to minimize the likelihood of a release (leak). Welded connections are generally considered the best way to achieve this, however, they are not always practical.

In addition, many types of hydrogen systems include piping for fluids other than hydrogen. For example, electrolyzer based hydrogen generators include piping for water and reformer-based hydrogen generators often include piping for natural gas.

The Code for Pressure Piping, ASME B31, addresses the design, fabrication, assembly, and testing of piping systems for all types of fluid including hydrogen. ASME B31.12, Hydrogen Piping and Pipelines, addresses piping system for hydrogen in particular.

ASME B31 has been used successfully in hydrogen systems for many decades. And, many product safety standards for hydrogen equipment such as CSA FC 1 for fuel cells and CSA/ANSI B22734 for electrolyzers refer specifically to ASME B31.

For the renumbered 6.5.1.2 is a contradiction between the International Fuel Gas Code (IFGC) and the American Society of Mechanical Engineers (ASME) B31 piping codes in the pressure testing requirements of hydrogen systems for high-pressure applications. The contradiction concerns the acceptable resultant hoop (circumferential) stress from a pneumatic or hydrostatic pressure test. The requirement in the IFGC is limiting and would require a lower test pressure and, in some cases, below the MAWP, where the B31 codes state that no test pressure reduction is required. B31 allows for testing up to the yield. For example, a 1" stainless steel tube has a wall thickness of 0.083". If they follow the IFGC Section 705, it limits the pressure test based on 50% of the hoop stress, resulting in a pressure test at 2507psig.

Meanwhile, the Barlow formula provided by B31 can establish an MAWP of 3100psig. ASME B31 would require a pressure test at 1.1xMAWP.

Public Input No. 308-NFPA 2-2024 [Section No. 6.5.1.1]

6.5.1.1

Prior to acceptance and initial operation, all piping installations shall be inspected and pressure tested in accordance with ASME B31, *Code for Pressure Piping*, ~~and~~ or Section 705 of the ICC *International Fuel Gas Code (IFGC)*.

Statement of Problem and Substantiation for Public Input

There is a contradiction between the International Fuel Gas Code (IFGC) and the American Society of Mechanical Engineers (ASME) B31 piping codes in the pressure testing requirements of hydrogen systems for high-pressure applications. The contradiction concerns the acceptable resultant hoop (circumferential) stress from a pneumatic or hydrostatic pressure test. The requirement in the IFGC is more limiting and would require a lower test pressure and, in some cases, below the MAWP, where the B31 codes state that no test pressure reduction is required. B31 allows for testing up to the yield. For example, a 1" stainless steel tube has a wall thickness of 0.083". If they follow the IFGC Section 705, it limits the pressure test based on 50% of the hoop stress, resulting in a pressure test at 2507psig. Meanwhile, the Barlow formula provided by B31 can establish an MAWP of 3100psig. ASME B31 would require a pressure test at 1.1xMAWP. This section should be made to be an "or" to allow one to choose IFGC or ASME B31.

Submitter Information Verification

Submitter Full Name: Allen Adriani
Organization: Plug Power
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 14:05:44 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-27-NFPA 2-2024

Statement: This is a contradiction between the International Fuel Gas Code (IFGC) and the American Society of Mechanical Engineers (ASME) B31 piping codes in the pressure testing requirements of hydrogen systems for high-pressure applications. The contradiction concerns the acceptable resultant hoop (circumferential) stress from a pneumatic or hydrostatic pressure test. The requirement in the IFGC is limiting and would require a lower test pressure and, in some cases, below the MAWP, where the B31 codes state that no test pressure reduction is required. B31 allows for testing up to the yield. For example, a 1" stainless steel tube has a wall thickness of 0.083". If they follow the IFGC Section 705, it limits the pressure test based on 50% of the hoop stress, resulting in a pressure test at 2507psig.

Meanwhile, the Barlow formula provided by B31 can establish an MAWP of 3100psig. ASME B31 would require a pressure test at 1.1xMAWP.

Public Input No. 150-NFPA 2-2023 [Section No. 6.5.2.1]

6.5.2.1

Valves, gauges, regulators, and other accessories ~~used for~~ wetted with hydrogen ~~systems~~ shall be ~~specified~~ suitable for hydrogen service as rated by the component manufacturer or determined by the hydrogen supplier.

Statement of Problem and Substantiation for Public Input

Hydrogen systems often include these types of components for piping fluids other than hydrogen; those components do not need to be compatible with hydrogen.
Only components wetted with hydrogen need to be suitable for hydrogen service.
Additional editorial changes were added to clarify the requirement.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 20 11:00:35 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-140-NFPA 2-2024
Statement: Hydrogen systems often include these types of components for piping fluids other than hydrogen; those components do not need to be compatible with hydrogen.

Only components in contact with hydrogen need to be suitable for hydrogen service.

Additional editorial changes were added to clarify the requirement.

Public Input No. 151-NFPA 2-2023 [Section No. 6.5.2.2]

6.5.2.2

Storage containers, piping, valves, regulating equipment, and other appurtenances serving hydrogen ~~systems shall be accessible and shall be~~ systems shall be protected against physical damage and tampering.

Statement of Problem and Substantiation for Public Input

Many if not most hydrogen systems have piping, valves, regulators, etc. that are not and do not need to be readily accessible.
In fact, protecting them against physical harm and especially against tampering means they should not be accessible.

Note: Source valves are addressed separately in 6.21.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 20 11:12:39 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: Removing the language for accessibility has not been adopted since all the components need to be accessible for maintenance.

Public Input No. 191-NFPA 2-2023 [New Section after 6.5.3.1.3]

New Section

6.5.3.1.3 Underground piping shall not penetrate the outer foundation or basement wall of a building. (NEW)

Statement of Problem and Substantiation for Public Input

Relocates IFGC requirement to the section on underground piping.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 14:57:06 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: Requirements from another document that is developed by another standard organization can not be directly adopted into NFPA 2. However, a requirement from NFPA 54, which closely aligns with the IFGC, can be directly adopted into NFPA 2 if proposed.

Public Input No. 192-NFPA 2-2023 [New Section after 6.8.2.1]

6.8.1.3 Fail-safe engineered systems.

Standby power for mechanical ventilation, treatment systems and temperature control systems shall not be required where an approved fail-safe engineered system is installed. .

Statement of Problem and Substantiation for Public Input

Improves correlation with higher level fire codes. This change mirrors an existing logical alternative requirement to standby power in the IFC (2021 IFC 5004.7.2). If a powered mechanical ventilation system, treatment system, or temperature control system fails to a safe condition, continued operation of these systems during a loss of offsite power has little benefit but can cause the need for a separate generator (like a diesel generator) when typically, a small battery will suffice for detection and alarm systems (still required to have emergency power)

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 15:01:06 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-202-NFPA 2-2024
Statement: This extract from 5000 provides an alternative to requiring for standby power, where a system will fail in a safe condition. Where a powered mechanical ventilation system, treatment system, or temperature control system fails to a safe condition, continued operation of these systems during a loss of offsite power has little benefit but can cause the need for a separate generator (like a diesel generator) when typically, a small battery will suffice for detection and alarm systems (still required to have emergency power).

Public Input No. 65-NFPA 2-2023 [Section No. 6.8.2.1]

6.8.2.1

When standby power is required, the system shall meet the requirements for a Level 2 system in accordance with NFPA 111.

When standby power is required, the system shall meet the requirements for a Level 1 system in accordance with NFPA 111

Statement of Problem and Substantiation for Public Input

As per the definitions below, the standby power system should be a Level 1.

4.5 * Level.
The level of equipment installation, performance, and maintenance shall be as specified in 4.5.1 through 4.5.5.

4.5.1 *
Level 1 systems shall be installed where failure of the equipment to perform could result in loss of human life or serious injuries.

4.5.2 *
Level 2 systems shall be installed where failure of the EPSS to perform is less critical to human life and safety.

Submitter Information Verification

Submitter Full Name: Steven Wheaton
Organization: Choshu Industry Corporation of America
Street Address:
City:
State:
Zip:
Submittal Date: Tue Oct 24 16:23:34 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: Level 1 and Level 2 are defined terms for life safety equipment. Level 1 is analogous to emergency power, while Level 2 is analogous to standby power. Since 6.8.2.1 is a requirement for standby power, this revision has not been adopted.

Public Input No. 193-NFPA 2-2023 [Section No. 6.9]

6.9* ~~Employee~~ Emergency Alarm System.

~~Where required by government regulations, an employee~~

6.9.1 An approved manual emergency alarm system shall be provided

~~to allow warning for necessary emergency action as called for in the emergency action plan required by 4.6.1 , or for reaction time for safe egress of employees from the workplace or the immediate work area, or both.~~

in buildings, rooms or areas used for storage of hydrogen in excess of MAQ.

6.9.2 Emergency alarm-initiating devices shall be installed outside of each interior exit or exit access door of storage buildings, rooms or areas.

6.9.3 Activation of an emergency alarm-initiating device shall sound a local alarm to alert occupants of an emergency situation involving hazardous materials.

Statement of Problem and Substantiation for Public Input

Substantiation: NFPA 2 is not an enforcement tool for OSHA and serves all occupants and firefighters, not just employees, like OSHA does. OSHA does their own enforcement through a separate series of relatively static (compared to NFPA 2) series of federal laws. OSHA does not need NFPA 2 to serve its mission and vice-versa. NFPA 2 is a dynamic fire code document and needs to focus on hydrogen related fire safety requirements. An emergency alarm system as described in the proposed text, provides a needed fire safety alert to occupants and firefighters of a possible increased fire hazard in rooms containing greater then MAQ amounts of hydrogen. The existing reference to 4.6.1 is not needed. This aligns NFPA 2 with the IFC.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 194-NFPA 2-2023 [Section No. A.6.9]	

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 15:05:21 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-142-NFPA 2-2024

Statement: NFPA 2 is not an enforcement tool for OSHA and serves all occupants and firefighters, not just employees, like OSHA does. OSHA does their own enforcement through a separate series of relatively static (compared to NFPA 2) series of federal laws. OSHA does not need NFPA 2 to serve its mission and vice-versa. NFPA 2 is a dynamic fire code document and needs to focus on hydrogen related fire safety requirements. An emergency alarm system as described in the proposed text, provides a needed fire safety alert to occupants and firefighters of a possible increased fire hazard in rooms containing greater then MAQ amounts of hydrogen. The existing reference to 4.6.1 is not needed. This aligns NFPA 2 with the IFC.

Public Input No. 157-NFPA 2-2023 [Section No. 6.10]

6.10* Explosion Control.

6.10.1

Explosion control shall be provided where the quantity of GH_2 or LH_2 in storage or use exceeds the quantity thresholds requiring special provisions as listed in Table 6.4.1.1.1 or where otherwise required.

6.10.2

Where explosion control is required, it shall be provided ~~by one or both of~~ the ~~following~~ methods ~~:~~

(1) ~~Explosion prevention in accordance with~~ ~~6.10.3~~

(2) ~~Deflagration venting in accordance with~~ ~~6.10.4~~

~~**6.10.3** * – Explosion Prevention.~~

~~Where~~ provided ~~, explosion prevention shall be in accordance with one or more of the methods specified in NFPA 69.~~

~~**6.10.4** – Deflagration Venting.~~

~~Where provided, explosion protection by the use of deflagration venting shall be in accordance with NFPA 68.~~

in Chapter 9

Statement of Problem and Substantiation for Public Input

redirect the user to Chapter 9

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 175-NFPA 2-2023 [Chapter 9]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: NFPA-2 Explosion Control Task Group
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 20 15:11:31 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-80-NFPA 2-2024

Statement: Explosion control methods are in the new chapter 9 and cross reference is being made to those methods.

Public Input No. 195-NFPA 2-2023 [Section No. 6.10.1]

6.10.1

Explosion control shall be provided where the quantity of GH_2 or LH_2 in ~~storage or use~~ a structure, room or space occupied for purposes involving hydrogen explosion hazards exceeds the quantity thresholds requiring special provisions as listed in Table 6.4.1.1.1 or where otherwise required.

Statement of Problem and Substantiation for Public Input

Substantiation: This adds clarity on where explosion control is mandated. This aligns NFPA 2 better with 2021 IFC 911.1. The enclosure must be occupied (by people) for explosion control to be mandated. The word occupied here is better defined and occupiable or enterable by people and also containing an explosion hazard. If that is not the case, explosion control is not mandatory, but can still be installed as long as it is code compliant (optional). For example, this makes it clear that explosion control is not mandatory on enclosures or cabinets that are not enterable where the risk benefit balance becomes questionable for a mandatory requirement. Explosion control prevents building collapse and is intended to protect building occupants outside the room of explosion origin.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 15:12:26 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: There is some confusion as to what is meant by explosion protection for spaces occupied and if unoccupied spaces that have explosion hazards require explosion protection. It is also unclear what occupied for purposes involving hydrogen explosion hazards involves.

Public Input No. 196-NFPA 2-2023 [Section No. 6.10.4]

6.10.4 Deflagration Venting.

Where provided, explosion protection by the use of deflagration venting shall be in accordance with NFPA 68.

6.10.4.1 Deflagration venting shall not be utilized as a means to protect structures, rooms or spaces from detonation hazards.

6.10.4.2 Deflagration venting shall be provided only in exterior walls and roofs.

6.10.4.3 Discharge from deflagration vents shall not be into the interior of the building.

Statement of Problem and Substantiation for Public Input

Substantiation: Clarifies the known fact that deflagration venting cannot protect a building from detonation hazards. Improves correlation with 2021 IFC 911.1-2. Makes clear the existing requirement that deflagration venting must be direct to the exterior. Prevents the situation of an enclosure with deflagration vents being installed in a room without them.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 15:17:37 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: A previous action by the committer revised Section 6.10 to direct users to Chapter 9, which now addresses deflagration and the concerns raised by the submitter in proposed 6.10.4.1. A encourages the submitter to address the concerns of proposed 6.10.4.2 and 6.10.4.3 in Chapter 9, where appropriate.

Public Input No. 31-NFPA 2-2023 [Section No. 6.11 [Excluding any Sub-Sections]]

Buildings, or portions thereof, ~~required to comply with the requirements for~~ classified as hazardous occupancies shall be protected by an approved automatic fire sprinkler system complying with NFPA 13.

Statement of Problem and Substantiation for Public Input

To clarify wording to point out that when the MAQ is exceeded, the code triggers a classified hazardous occupancy and the requirement for a fire protection system.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 13:02:03 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-145-NFPA 2-2024
Statement: This revision clarifies that when the MAQ is exceeded, the code triggers a classified hazardous occupancy and the requirement for a fire protection system.

Public Input No. 197-NFPA 2-2023 [Section No. 6.11.1]

6.11.1 Sprinkler System Design.

When sprinkler protection is required, the area in which GH_2 or LH_2 is stored or used shall be protected with a sprinkler system designed to be not less than that required by 19.2.3 of NFPA 13 for the ~~Extra~~ Ordinary Hazard Group ~~1~~ II density/area curve.

Statement of Problem and Substantiation for Public Input

Substantiation: The fire control goal for fire exposing cylinders or tanks with hydrogen storage is to suppress a possible exposure fire and also to cool the storage vessels. In cylinder or tank storage areas, accumulations of ordinary combustibles are possible. Trash and vegetation are prevented elsewhere in the code, but ordinary combustibles are not and are sometimes needed. OH2 desity is more than conservative for expected combustibles.

The relevant definitions from 2022 NFPA 13 are pasted below:
4.3.2 * Light Hazard.
The following shall be protected with light hazard occupancy criteria in this standard:
(1) Spaces with low quantity and combustibility of contents
4.3.3 * Ordinary Hazard Occupancies.
4.3.3.1 * Ordinary Hazard (Group 1).
The following shall be protected with OH1 occupancy criteria in this standard:
(1) Spaces with moderate quantity and low combustibility of contents
(2) Stockpiles of contents with low combustibility that do not exceed 8 ft (2.4 m)
4.3.3.2 * Ordinary Hazard (Group 2).
The following shall be protected with OH2 occupancy criteria in this standard:
(1) Spaces with moderate to high quantity and combustibility of contents
(2) Stockpiles of contents with moderate rates of heat release rate that do not exceed 12 ft (3.7 m) and stockpiles of contents with high rates of heat release that do not exceed 8 ft (2.4 m)
4.3.4 * Extra Hazard (Group 1) (EH1).
The following shall be protected with EH1 occupancy criteria in this standard:
(1) Spaces with very high quantity and combustibility of contents
(2) Spaces where dust, lint, or other materials are present, introducing the probability of rapidly developing fires
4.3.5 * Extra Hazard (Group 2) (EH2).
The following shall be protected with EH2 occupancy criteria in this standard:
(1) Spaces with very high quantity and combustibility of contents
(2) Spaces with substantial amounts of combustible or flammable liquids
(3) Spaces where shielding of combustibles is extensive
END OF CITATION

The anticipated combustible loading around hydrogen storage areas could qualify as light hazard per NFPA 13 definitions. Thus application of Ordinary Hazard Group 2 requirements maintains significant conservatism in terms of expected combustible loading, while reducing the possibility of extinguishing a jet flame and avoiding unwarranted cost for Extra Hazard Group 1 water supply requirements.

This requirement was extracted from NFPA 55 which covers all gases including those that may be shock sensitive or other more hazardous categories than hydrogen. So it may (arguable) make more sense there than in NFPA 2 which is hydrogen specific.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 15:20:15 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-150-NFPA 2-2024

Statement: The fire control goal for fire exposing cylinders or tanks with hydrogen storage is to suppress a possible exposure fire and also to cool the storage vessels. In cylinder or tank storage areas, accumulations of ordinary combustibles are possible. Trash and vegetation are prevented elsewhere in the code, but ordinary combustibles are not and are sometimes needed. OH2 density is more than conservative for expected combustibles.

The anticipated combustible loading around hydrogen storage areas could qualify as light hazard per NFPA 13 definitions. Thus application of Ordinary Hazard Group 2 requirements maintains significant conservatism in terms of expected combustible loading, while reducing the possibility of extinguishing a jet flame and avoiding unwarranted cost for Extra Hazard Group 1 water supply requirements.

This requirement originated from NFPA 55 which covers all gases including those that may be shock sensitive or other more hazardous categories than hydrogen. As a hydrogen specific code, it is appropriate that this requirements be limited to Ordinary Hazard Group II in NFPA 2.

The cross reference to NFPA 13 has been deleted to avoid the need in updating the cross-reference in future editions.

Public Input No. 94-NFPA 2-2023 [Section No. 6.11.1]

6.11.1 Sprinkler System Design.

When sprinkler protection is required, the area in which GH_2 or LH_2 is stored or used shall be protected with a sprinkler system designed to be not less than that required by 19.2.3 of NFPA 13 for the Extra Hazard Group 1 density/area curve.

Additional Proposed Changes

File Name	Description	Approved
TIA_2_23_2.pdf	NFPA 2 TIA Log No. 23-2 Log No.1701	

Statement of Problem and Substantiation for Public Input

NOTE: This public input originates from Tentative Interim Amendment No. 2 Log No.1701 issued by the Standards Council on August 25, 2023, and per the NFPA Regs., needs to be reconsidered by the Technical Committee for the next edition of the Document.

Substantiation: The current language references the incorrect section of NFPA 13. The 2023 version of NFPA 2 needs to be corrected.

Emergency Nature: The standard contains an error or an omission that was overlooked during the regular revision process.

The emergency nature of this TIA is that the current wording is wrong. Users of the code who try to follow the refence will be led to the incorrect paragraphs in NFPA 13 and not know where the proper information is located in NFPA 13.

Submitter Information Verification

Submitter Full Name:
Organization: TIA
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 10:57:44 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-150-NFPA 2-2024

Statement: The fire control goal for fire exposing cylinders or tanks with hydrogen storage is to suppress a possible exposure fire and also to cool the storage vessels. In cylinder or tank storage areas, accumulations of ordinary combustibles are possible. Trash and vegetation are prevented elsewhere in the code, but ordinary combustibles are not and are sometimes needed. OH2 density is more than conservative for expected combustibles.

The anticipated combustible loading around hydrogen storage areas could qualify as light hazard per NFPA 13 definitions. Thus application of Ordinary Hazard Group 2 requirements maintains significant conservatism in terms of expected combustible loading, while reducing the possibility of extinguishing a jet flame and avoiding unwarranted cost for Extra Hazard Group 1 water supply requirements.

This requirement originated from NFPA 55 which covers all gases including those that may be shock sensitive or other more hazardous categories than hydrogen. As a hydrogen specific code, it is appropriate that this requirements be limited to Ordinary Hazard Group II in NFPA 2.

The cross reference to NFPA 13 has been deleted to avoid the need in updating the cross-reference in future editions.

Tentative Interim Amendment

NFPA® 2

Hydrogen Technologies Code

2023 Edition

Reference: 6.11.1
TIA 23-2
(SC 23-8-44 / TIA Log #1701)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 2, *Hydrogen Technologies Code*, 2023 edition. The TIA was processed by the Technical Committee on Hydrogen Technology and was issued by the Standards Council on August 25, 2023, with an effective date of September 14, 2023.

1. Revise paragraph 6.11.1 to read as follows:

6.11.1 Sprinkler System Design. When sprinkler protection is required, the area in which GH_2 or LH_2 is stored or used shall be protected with a sprinkler system designed to be not less than that required by ~~11.2.3.11~~19.2.3 of NFPA 13 for the Extra Hazard Group 1 density/area curve.

Issue Date: August 25, 2023

Effective Date: September 14, 2023

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**
Copyright © 2023 All Rights Reserved
NATIONAL FIRE PROTECTION ASSOCIATION

Public Input No. 198-NFPA 2-2023 [Section No. 6.12.1]

6.12.1

A manual fire alarm system shall be provided in accordance with the adopted ~~building~~ fire code.

Statement of Problem and Substantiation for Public Input

Substantiation: The requirements for a fire alarm system originate in the fire code (IFC or NFPA 1) not the building code. The building code extracts them from the fire code. Better to point to the source.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 15:25:23 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-151-NFPA 2-2024
Statement: The requirements for a fire alarm system originate in the fire code (IFC or NFPA 1) and not the building code. Therefore it is more appropriate to point the user to the source document.

Public Input No. 177-NFPA 2-2023 [Section No. 6.17 [Excluding any Sub-Sections]]

Hydrogen-venting systems ~~serving pressure relief devices discharging~~ for the purpose of operational or emergency venting discharging hydrogen to the atmosphere shall be in accordance with CGA G-5.5, *Hydrogen Vent Systems*.

Statement of Problem and Substantiation for Public Input

The language should include vents for the purpose of operational or emergency venting. This will be consistent with 7.1.16.2.2, "purpose of operational or emergency venting".

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 176-NFPA 2-2023 [Section No. 8.3.1.2.2.3]	
Public Input No. 253-NFPA 2-2024 [Section No. 8.3.1.2.6.1]	

Submitter Information Verification

Submitter Full Name: Allen Adriani
Organization: Plug Power
Street Address:
City:
State:
Zip:
Submittal Date: Sun Dec 24 11:46:44 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-152-NFPA 2-2024
Statement: This revision updates the language to include vents for the purpose of operational or emergency venting. This makes the sub-section consistent with 7.1.16.2.2, "purpose of operational or emergency venting".

Public Input No. 41-NFPA 2-2023 [Section No. 6.17.1]

6.17.1

Exits of vent stacks shall be located outdoors and away from personnel areas, ignition sources, air intakes, building openings, and overhangs in accordance with an approved risk assessment and 6 .17.2.

Statement of Problem and Substantiation for Public Input

Safe vent termination encroaching on personnel areas, ignition sources, air intakes, building openings, and overhangs should be in accordance with an approved risk assessment to provide a more robust plan of action. The provisions of 6.17.2 determine classified areas but other factors like building openings and air intakes etc. need evaluation based on other factors like wind and temperature.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 13:58:19 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: This revision has not been adopted since section 6.17 applies to both to systems above the MAQ and outdoors systems both bulk and nonbulk . This revision would also require a risk assessment for all systems but would be overly burdensome for smaller systems without a minimal threshold.

Public Input No. 105-NFPA 2-2023 [Section No. 6.17.2]

6.17.2*

The area classifications and extent of the hazardous (classified) volume surrounding the vent pipe termination shall be determined using IEC 60079-10-1, *Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres*. The definitions for Unclassified and Class I, Division 1 and Division 2 locations in Article 500 of NPFA-70 can be used to for the Classifications of Locations. Descriptions, assumption, calculations, and results shall be available for the AHJ.

Statement of Problem and Substantiation for Public Input

In recognition of the potential risk during venting operations, many designers use existing prescriptive electrical area classification distances referenced in NFPA-2, NFPA-55, and NFPA-497. The prescriptive distances for defining the extent of hazardous areas are based on leaks and do not account for normal venting and safety release and its variability of atmospheric dispersion. An atmospheric dispersion model for identifying the extent of hazardous areas accompanying normal venting and safety device release should also be included in the determination of area classification based on the specified definition in Article 500 of NFPA 70.

IEC 60079-10-1 is also limited in determining area classification. When large venting release occurs, IEC 60079-10-1 the method of appendix D does not allow for extrapolation of the curves. Therefore, a plume dispersion model is necessary to determine the area classification.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 176-NFPA 2-2023 [Section No. 8.3.1.2.2.3]	
Public Input No. 253-NFPA 2-2024 [Section No. 8.3.1.2.6.1]	

Submitter Information Verification

Submitter Full Name: Allen Adriani
Organization: Plug Power
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 12 19:24:47 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The proposed revision is not written as mandatory text and it is unclear on whether or not it is intended for the annex of 6.17.2. Additionally, the information is redundant to the current annex of 6.17.2 and is not needed.

Public Input No. 254-NFPA 2-2024 [Section No. 6.17.4]

6.17.4*

The horizontal separation distance from the vent pipe termination to Exposures Group 1 and Exposures Group 2 in Table 7.3.2.3.1.2(B)(a), 8.2.2.3.4, 8.3.2.3.1.6(a) and 8.3.2.3.1.6(b) shall be the greatest of the following:

(1) The horizontal component of the thermal radiation and impingement distance determined in Section 6.17

(2) The horizontal component of the extent of the hazardous (classified) area determined in 6.17.2

Statement of Problem and Substantiation for Public Input

We should include the relevant LH2 sections.

Submitter Information Verification

Submitter Full Name: Allen Adriani
Organization: Plug Power
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 16:59:38 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-153-NFPA 2-2024
Statement: Cross-references to the relevant LH2 requirements have been added to the this requirement on horizontal separation distances to account for the continuous venting of hydrogen gas from LH2 tanks.

Public Input No. 201-NFPA 2-2023 [Section No. 6.18]

6.18* Exhaust Ventilation.

Indoor storage and use areas and storage buildings for GH_2 and LH_2 shall be provided with mechanical exhaust ventilation ~~or fixed natural ventilation, where natural ventilation is shown to be acceptable for the GH 2 or LH 2 as stored~~ .

6.18.1 Exhaust Ventilation Rate.

Mechanical exhaust ~~or fixed natural~~ ventilation shall be provided at a rate of not less than 1 scf/min/ft^2 (0.0051 m^3/sec/m^2) of floor area over the area of storage or use.

6.18.2

~~– Mechanical Exhaust Ventilation.~~

~~6.18.2.1~~ ~~– Ventilation Systems.~~

~~In addition to the requirements of Section~~ ~~6.18~~ ~~,~~

~~-~~

I Exhaust ventilation systems shall be designed and

~~installed~~

installed in accordance with the requirements of the adopted mechanical code.

6.18.

~~2.1.1~~ ~~Continuous Operation.~~

~~When operation of ventilation systems is required, systems shall operate continuously unless an alternative design is approved by the AHJ~~

~~**3**~~ ~~-~~

~~Exhaust ventilation systems shall operate continuously .~~

~~**6.18.**~~

~~2.1.2~~ ~~Shutoff Controls.~~

~~Where powered ventilation is provided, a~~

~~**4**~~ ~~- .~~

~~A manual shutoff switch shall be provided outside the room in a position adjacent to the principal access door to the room or in an approved location.~~

~~**6.18.**~~

~~2~~

~~**4 .1**~~

~~.3~~

~~– Manual Shutoff Switch.~~

~~The switch shall be the breakglass or equivalent type and shall be labeled as follows:~~

~~WARNING:~~

~~VENTILATION SYSTEM EMERGENCY SHUTOFF~~

6.18.

2.1.4 Exhaust System.

6.18.2.1.4.1 –

5 -

The exhaust ventilation system design shall take into account the density of the potential gases released.

6.18.

2.1.4.2

For gases that are lighter than air

6 -

For hydrogen , exhaust shall be taken from a point within 12 in. (305 mm) of the ceiling. The use of supplemental inlets shall be allowed to be installed at points below the 12 in. (305 mm) threshold level.

6.18.

2.1.4.3

7 * –

The inlets

Inlets to the exhaust systems shall be either designed to prevent blockage due to debris, foliage, ice, snow, and so on, or the exhaust system shall detect and react to the blockage.

6.18.

2.1.5

8 -

The location of both the exhaust and inlet air openings shall be designed to provide air movement across all portions of the room or area to prevent the accumulation of hydrogen within the ventilated space.

6.18.

2.1.6

9 -

Exhaust ventilation shall not be recirculated.

6.18.

2.1.7

~~**10** * – Ventilation Discharge.~~

~~Ventilation discharge systems conveying hydrogen mixtures exceeding 25 percent LFL in any normal or emergency operating mode shall terminate at a point outdoors not less than 30 ft (9.1 m) from property lines, 10 ft (3 m) from operable openings into buildings and public access, 6 ft (1.8 m) from exterior walls and roofs, 30 ft (9.1 m) from combustible walls and operable openings into buildings that are in the direction of the exhaust discharge, and 10 ft (3 m) above adjoining grade.~~

~~**6.18.2.1.8** – Ventilation Failure.~~

~~**6.18.2.1.8.1** * –~~

~~Where a mechanical ventilation system is used to reduce the area classification, it shall include a means to detect the loss of air flow.~~

~~**6.18.2.1.8.2** –~~

~~Upon detection of loss of air flow or other ventilation failure, the system shall accomplish the following:~~

(1) ~~Stop all hydrogen generation processes~~

(2) ~~Close all supply valves that feed hydrogen or other flammable materials to the ventilated area~~

(3) ~~De-energize all ignition sources in the ventilated area that are not suitable for the area classification that would apply without ventilation.~~

~~**6.18.2.1.8.3** * –~~

~~The components of the ventilation system, detection system, and the circuit or system that accomplishes 6.18.2.1.8.2 shall be suitable for the area classification that would apply without ventilation.~~

Statement of Problem and Substantiation for Public Input

Consistent use of the term “Mechanical Exhaust Ventilation” clarifies intent of the section and reduces possible confusion with building ventilation systems which are not addressed by section 16.8. Renumbering simplifies the entire section 16.8

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 15:40:39 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-183-NFPA 2-2024

Statement: Natural exhaust ventilation lacks the needed reliability to maintain constant upwards airflow required for hydrogen storage. Wind, outside temperature inversions, or other expected natural occurrences can defeat natural exhaust ventilation. Hydrogen requires an always on exhaust ventilation system and natural ventilation cannot guarantee this.

Consistent use of the term “Mechanical Exhaust Ventilation” clarifies intent of the section and reduces possible confusion with building ventilation systems which are not addressed by section 16.8.

Public Input No. 200-NFPA 2-2023 [Section No. 6.18 [Excluding any Sub-Sections]]

Indoor storage and use areas and storage buildings for GH_2 and LH_2 shall be provided with ~~mechanical~~ exhaust ventilation~~ or fixed natural ventilation, where natural ventilation is shown to be acceptable for the GH~~ $_2$ ~~or LH~~ $_2$ ~~as stored~~ .

Statement of Problem and Substantiation for Public Input

Substantiation: Natural exhaust ventilation lacks the needed reliability to maintain constant upwards airflow required for hydrogen storage. Wind, outside temperature inversions, or other expected natural occurrences can defeat natural exhaust ventilation. Hydrogen requires an always on exhaust ventilation system and natural ventilation cannot guarantee this.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 15:36:48 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-183-NFPA 2-2024

Statement: Natural exhaust ventilation lacks the needed reliability to maintain constant upwards airflow required for hydrogen storage. Wind, outside temperature inversions, or other expected natural occurrences can defeat natural exhaust ventilation. Hydrogen requires an always on exhaust ventilation system and natural ventilation cannot guarantee this.

Consistent use of the term “Mechanical Exhaust Ventilation” clarifies intent of the section and reduces possible confusion with building ventilation systems which are not addressed by section 16.8.

Public Input No. 80-NFPA 2-2023 [Section No. 6.18.1]

6.18.1 Ventilation Rate.

Mechanical exhaust or fixed natural ventilation shall be provided at a rate of not less than 1 scf/min/ft^2 (0.0051 m^3/sec/m^2) of floor area over the area of storage or use. ~~[**55:** 6.17.3.2]~~ , but no less than 1 ft 3 /min/12 ft 3 . (0.03 m 3 / min/ 0.34 m 3 . of room volume.

Additional Proposed Changes

File Name	Description	Approved
PC_No._50_Rejected_but_Held.pdf	NFPA 2 PC No. 50 Rejected but held	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as "Rejected but Held" in Public Comment No. 50 of A2022 Second Draft Report for NFPA 2 and per Regs. at 4.4.8.3.1 and needs to be reconsidered by the TC for the next edition of the document.

This public comment was developed by the NFPA2/55 Venting and Ventilation Task Group.

As part of the effort to reorganize and consolidate the ventilation requirements for NFPA 2020, part of this requirement was deleted from 7.3.2.2.2, 8.3.2.2.2, 10.6.3.2.2 but was not added to Section 6.17.2.1.8. This requirement provides a minimum ventilation requirement based upon room volume. requirement is important because room volume may have an impact on the ability to remove hazardous gases.

A similar Public Comment was submitted to NFPA 55 and if accepted, then this Public Comment should be withdrawn to retain the extract from NFPA 55.

Submitter Information Verification

Submitter Full Name: Yiu Lee
Organization: holds@nfpa.org
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 07:52:41 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: This would discourage taller building from lowering the ceiling. Taller rooms will have more volume and allow for more dispersion and reduce the requirement for exhaust ventilation. The substantiation provided assumes a hazard increase with room height.

Public Comment No. 50-NFPA 2-2021 [Section No. 6.18.1]

6.18.1 Ventilation Rate.

Mechanical exhaust or fixed natural ventilation shall be provided at a rate of not less than 1 scf/min/ft^2 (0.0051 m^3/sec/m^2) of floor area over the area of storage or use~~. [**55:** 6.17.3.2]~~ , but no less than 1 ft^3/min/12 ft^3 . (0.03 m^3 / min/ 0.34 m^3 . of room volume. .

Statement of Problem and Substantiation for Public Comment

This public comment was developed by the NFPA2/55 Venting and Ventilation Task Group.

As part of the effort to reorganize and consolidate the ventilation requirements for NFPA 2020, part of this requirement was deleted from 7.3.2.2.2, 8.3.2.2.2, 10.6.3.2.2 but was not added to Section 6.17.2.1.8. This requirement provides a minimum ventilation requirement based upon room volume. requirement is important because room volume may have an impact on the ability to remove hazardous gases.

A similar Public Comment was submitted to NFPA 55 and if accepted, then this Public Comment should be withdrawn to retain the extract from NFPA 55.

Related Item

• PI 14

Submitter Information Verification

Submitter Full Name: Spencer Quong
Organization: Quong & Associates Inc.
Affiliation: Toyota, NFPA 2/55 Ventilation and Venting Task Group
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jun 02 13:11:37 EDT 2021
Committee: HYD-AAA

Committee Statement

Committee Action: Rejected but held
Resolution: The committee needs further time to refine this requirement and will consider moving the requirement to the HEE section at the next cycle.

Public Input No. 92-NFPA 2-2023 [Section No. 6.18.2.1.3]

6.18.2.1.3 Manual Shutoff Switch.

The switch shall be the ~~breakglass or equivalent type and~~ accessible, non resttable and shall be labeled as follows:

WARNING:

VENTILATION SYSTEM EMERGENCY SHUTOFF

Additional Proposed Changes

File Name	Description	Approved
PC_No._109_Rejected_but_Held.pdf	NFPA 2 PC No. 109 Rejected but held	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as "Rejected but Held" in Public Comment No. 109 of A2022 Second Draft Report for NFPA 2 and per Regs. at 4.4.8.3.1 and needs to be reconsidered by the TC for the next edition of the document.

The main purpose of clause 6.18.2.3.1 is to provide means to manually shut off the ventilation switch either for service or in case of emergency. For the case of emergency, an ESD button can be provided which either removes power for the vent fan ONLY or removes power from the entire HEE.

Based on this, the requirement that a break glass device be used instead of a normal ESD or service switch is unnecessary and places undo requirements on HEE manufacturers that provide no additional safety.

Submitter Information Verification

Submitter Full Name:
Organization: Holds
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 10:00:28 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-182-NFPA 2-2024

Statement: Breakglass devices have been replaced with other manually resettable devices. Break glass can affect product quality and there are other types of switches available that are manually resettable. Based on this, the requirement for a break glass device be used instead of a normal ESD or service switch is unnecessary and places undo requirements on HEE manufacturers that provide no additional safety. By requiring the switch to be latching, the switch cannot be reset automatically.

Public Comment No. 109-NFPA 2-2021 [Section No. 6.18.2.1.3]

6.18.2.1.3 Manual Shutoff Switch.

The switch shall be the ~~breakglass or equivalent type~~ accessibe, non resettable and shall be labeled as follows:

WARNING:

VENTILATION SYSTEM EMERGENCY SHUTOFF

Statement of Problem and Substantiation for Public Comment

The main purpose of clause 6.18.2.3.1 is to provide means to manually shut off the ventilation switch either for service or in case of emergency. For the case of emergency, an ESD button can be provided which either removes power for the vent fan ONLY or removes power from the entire HEE.

Based on this, the requirement that a break glass device be used instead of a normal ESD or service switch is unnecessary and places undo requirements on HEE manufacturers that provide no additional safety.

Related Item

• PI-2

Submitter Information Verification

Submitter Full Name: Bryan Gordon
Organization: Ivys Energy Solutions, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Sun Jul 11 20:15:14 EDT 2021
Committee: HYD-AAA

Committee Statement

Committee Action: Rejected but held

Resolution: The proposed revision is not on a topic discussed at the First Draft meeting and is considered new material and cannot be acted upon at the Second Draft meeting.

Public Input No. 90-NFPA 2-2023 [New Section after 6.18.2.1.4.1]

TITLE OF NEW CONTENT

New section 6.18.2.1.4.1

Liquid hydrogen systems require exhaust ventilation systems be designed to take inlet air from both high and low points in accordance with 6.18.2.1.4.2.

Additional Proposed Changes

File Name	Description	Approved
PC_No._93_Rejected_but_Held.pdf	NFPA 2 PC No. 93 Rejected but held	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as "Rejected but Held" in Public Comment No. 93 of A2022 Second Draft Report for NFPA 2 and per Regs. at 4.4.8.3.1 and needs to be reconsidered by the TC for the next edition of the document.

When liquid hydrogen is released it is heavier than air and when it warms up is lighter than air. Exhaust systems should be designed to take gases from high and low points.

Submitter Information Verification

Submitter Full Name:
Organization: Holds
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 09:54:09 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: Whether a liquid or gaseous release, there needs to be assurance that the ventilation is able to properly exhaust the room (i.e., in from the bottom and out from the top).

Public Comment No. 93-NFPA 2-2021 [New Section after 6.18.2.1.4.1]

New section 6.18.2.1.4.1

Liquid hydrogen systems require exhaust ventilation systems be designed to take inlet air from both high and low points in accordance with 6.18.2.1.4.2.

Statement of Problem and Substantiation for Public Comment

When liquid hydrogen is released it is heavier than air and when it warms up is lighter than air. Exhaust systems should be designed to take gases from high and low points.

Related Item

- PI-258

Submitter Information Verification

Submitter Full Name: Thomas Deary
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jun 03 10:49:35 EDT 2021
Committee: HYD-AAA

Committee Statement

Committee Action: Rejected but held
Resolution: The proposed revision is not on a topic discussed at the First Draft meeting and is considered new material and cannot be acted upon at the Second Draft meeting.

Public Input No. 89-NFPA 2-2023 [New Section after 6.18.2.1.7]

TITLE OF NEW CONTENT

Accept language proposed in Public Input 12.

Add to section 6.18.2.1.8.4 a new line item (4) The mechanical ventilation systems and gas detection system shall be provided with standby power in accordance with NFPA 110 and 111.

Additional Proposed Changes

File Name	Description	Approved
PC_No._91_Rejected_but_Held.pdf	NFPA 2 PC No. 91 Rejected but held	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as "Rejected but Held" in Public Comment No. 91 of A2022 Second Draft Report for NFPA 2 and per Regs. at 4.4.8.3.1 and needs to be reconsidered by the TC for the next edition of the document.

If they lose power the detection and ventilation system can't operate and the reason for the power loss may be fire or explosion.

Submitter Information Verification

Submitter Full Name:
Organization: Holds
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 09:50:13 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: Standby power is already addressed in 6.8.1. This proposed language has not been adopted since it is redundant.

Public Input No. 91-NFPA 2-2023 [New Section after 6.18.2.1.7]

TITLE OF NEW CONTENT

Add new section 6.18.2.1.7.1

When operation of ventilation systems is required, systems shall operate continuously unless an alternative design is approved by the AHJ.

Additional Proposed Changes

File Name	Description	Approved
PC_No._95_Rejected_but_Held.pdf	NFPA 2 PC No. 95 Rejected but held	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as "Rejected but Held" in Public Comment No. 95 of A2022 Second Draft Report for NFPA 2 and per Regs. at 4.4.8.3.1 and needs to be reconsidered by the TC for the next edition of the document.

Continuous ventilation is required in accordance with NFPA 55.

Submitter Information Verification

Submitter Full Name:
Organization: Holds
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 09:56:59 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: Continuous operation is addressed in 6.18.2.1.1. This proposed language is redundant and not needed.

Public Comment No. 95-NFPA 2-2021 [New Section after 6.18.2.1.7]

Add new section 6.18.2.1.7.1

When operation of ventilation systems is required, systems shall operate continuously unless an alternative design is approved by the AHJ. [55:6.17.3.1].

Statement of Problem and Substantiation for Public Comment

Continuous ventilation is required in accordance with NFPA 55.

Related Item

• PI-255

Submitter Information Verification

Submitter Full Name: Thomas Deary
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jun 03 13:31:13 EDT 2021
Committee: HYD-AAA

Committee Statement

Committee Action: Rejected but held

Resolution: The proposed revision is not on a topic discussed at the First Draft meeting and is considered new material and cannot be acted upon at the Second Draft meeting.

Public Input No. 199-NFPA 2-2023 [Section No. 6.18.2.1.8]

~~**6.18.2.1.8** – Ventilation Failure.~~

~~**6.18.2.1.8.1** * –~~

~~Where a mechanical ventilation system is used to reduce the area classification, it shall include a means to detect the loss of air flow.~~

~~**6.18.2.1.8.2** –~~

~~Upon detection of loss of air flow or other ventilation failure, the system shall accomplish the following:~~

(1) ~~Stop all hydrogen generation processes~~

(2) ~~Close all supply valves that feed hydrogen or other flammable materials to the ventilated area~~

(3) ~~De-energize all ignition sources in the ventilated area that are not suitable for the area classification that would apply without ventilation.~~

~~**6.18.2.1.8.3** * –~~

~~The components of the ventilation system, detection system, and the circuit or system that accomplishes 6.18.2.1.8.2 shall be suitable for the area classification that would apply without ventilation.~~

Statement of Problem and Substantiation for Public Input

Substantiation:
This requirement was added last cycle. This is excessive, unprecedented and unwarranted. This level of safety system is not required for any other flammable gas by any other codes – only for hydrogen in NFPA 2. Very little basis was presented when this requirement was added last cycle other than it seems like a good idea for safety. Which it does, but we must be reasonable and balance risk with cost. The cost of complying with this is substantial. Compliance likely requires a means of monitoring fan status. These commonly include sail switches and/or current monitoring. Both have reliability issues. Sail switches require frequent maintenance to assure they are not fouled or out of adjustment. Current switches may not detect some failure modes such as partial plugging. Creating a system to monitor exhaust ventilation likely requires a safety system not required prior. The control system is a significant initial and recurring cost that is not justified by the remote possibility that ventilation failure will occur concurrently with a leak. Control systems often become the archilles heel of an otherwise clean and simple installation and require commissioning testing. All added cost. Accepted hazard analysis processes commonly deem failure modes that require two independent failures as incredible (not reasonable). This entire requirement assumes that a ventilation system fails and then a leak occurs. These are independent event that lack a common cause. Typical hazard analyses processes would not pursue such a scenario due to a lack of credibility. This requirement is built in to device for which it is important (like hydrogen generators) and should not be included for all hydrogen areas >MAQ by inserting it here. Please delete it.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:

City:
State:
Zip:
Submittal Date: Tue Dec 26 15:27:15 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The several requirements in NFPA 2 direct the user to section 6.18 for ventilation. The deletion of this language would remove needed requirements for action due to ventilation failure. This requirement only applies to ventilation systems used to reduce the hazardous area classification and does not apply to all ventilation systems.

Public Input No. 68-NFPA 2-2023 [Section No. 6.22.1.2]

6.22.1.2

Cleaning and purging of the internal surfaces of hydrogen systems shall be conducted by qualified individuals trained in cleaning and purging operations and procedures, including the recognition of potential hazards associated with cleaning and purging.

6.22.1.2.1 Cleaning and purging of piping systems and equipment shall be in accordance with NFPA 56.

a. Planning for the cleaning and purging operations shall be in accordance with NFPA 56 chapter 4.

b. Purging into service shall be in accordance with NFPA 56 chapter 7.

c. Purging out of service shall be in accordance with NFPA 56 chapter 8.

Statement of Problem and Substantiation for Public Input

In recognition of potential risk that can exist during cleaning and purging operation if flammable gases are unintentional mixed in a system, a reference to the cleaning and purging processes in NFPA 56 is appropriate.

Submitter Information Verification

Submitter Full Name: Allen Adriani
Organization: Plug Power
Street Address:
City:
State:
Zip:
Submittal Date: Fri Nov 03 13:13:48 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: The proposed language has not been adopted since NFPA 56 in chapter 1.1.2 identifies that NFPA 56 is not applicable to NFPA 2. If this language were adopted, the user would be directed to a non-applicable document. Before such language can be adopted into NFPA 2, the scope chapter of NFPA 56 will need to be revised.

Public Input No. 14-NFPA 2-2023 [Section No. 7.1.4.1.3]

7.1.4.1.3 Classification.

The hazard classification of the metal hydride storage system ~~, as required by 5.1.1 and 5.1.3 of NFPA 55,~~ shall be based on the GH_2 stored without regard to the metal hydride content.

Statement of Problem and Substantiation for Public Input

NFPA 55 no longer covers hydrogen, so the reference to NFPA 55 should be removed.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Affiliation: NFPA 2/55 hydrogen alignment task group
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 24 14:26:15 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-1-NFPA 2-2024

Statement: The scope of NFPA 2 has been revised to contain all requirements for hydrogen storage, use, and handling. The scope of NFPA 55 has been revised so that it no longer contains requirements for hydrogen storage, use, and handling. This first revision removes the references to NFPA 55, sections 5.1.1 and 5.1.3, because those sections no longer exist in NFPA 55 and because NFPA 2's scope does not include referencing NFPA 55 content.

Public Input No. 184-NFPA 2-2023 [New Section after 7.1.5.5.6]

7.1.5.5.7 Pressure relief devices or stationary or portable containers shall be vented directly outdoors or to an exhaust hood. ...

Statement of Problem and Substantiation for Public Input

Substantiation: This new (to this section) requirement has been relocated from 6.4.1.1.2, where it was misplaced, and placed here in the GH2 PRD section. Containers are separate from cylinders and tanks. The submitter thinks this requirement is not needed and this PI is intended to solicit TC input for a rejection basis. This is related to PI-183. LH2 is addressed separately.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 183-NFPA 2-2023 [Section No. 6.4.1.1.2]	

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 13:16:08 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-136-NFPA 2-2024

Statement: This revision relocates 6.4.1.1.2, where it was to this new location in the GH2 PRD section.

Containers are separate from cylinders and tanks. A related change has been made separately to address LH2 in a similar manner. An editorial change was also made to correct a typo.

Public Input No. 40-NFPA 2-2023 [Section No. 7.1.16 [Excluding any Sub-Sections]]

Hydrogen-venting systems serving pressure relief devices ~~discharging~~ , pressure regulators, vent valves, and other devices discharging GH_2 to the atmosphere shall be in accordance with CGA G-5.5, *Hydrogen Vent Systems*.

Statement of Problem and Substantiation for Public Input

The vent system vents more than just release from pressure relief devices.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 13:54:41 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-155-NFPA 2-2024
Statement: CGA 5.5 applies to all releases of hydrogen from multiple device such as vent valves, back press regulators, and pressure relief devices. This revision expands the already common practice within the industry.

Public Input No. 93-NFPA 2-2023 [Section No. 7.1.21 [Excluding any Sub-Sections]]

Inflatable equipment, devices, or balloons shall not be pressurized or filled with GH_2 unless they comply with 7.1.21.1 or 7.1.22.

Additional Proposed Changes

File Name	Description	Approved
TIA_2_23_1.pdf	NFPA 2 TIA Log No. 23-1 Log No. 1700	

Statement of Problem and Substantiation for Public Input

NOTE: This public input originates from Tentative Interim Amendment No. 2 Log No.1700 issued by the Standards Council on August 25, 2023, and per the NFPA Regs., needs to be reconsidered by the Technical Committee for the next edition of the Document.

Substantiation: As written, the text of 7.1.21 allows the use of hydrogen in any balloon for any purpose as long as the balloon is designed for hydrogen. Many balloons meet that requirement however only the uses described in 7.1.21.1 (meteorological) or 7.1.22 (piloted) are allowed when in compliance with the requirements of those sections. The charging language in 7.1.21 allows any use in a balloon approved for hydrogen. This is not safe. The intent of 7.1.21 and 7.1.22 is to allow two specific uses of hydrogen inflated balloons, namely meteorological and piloted, when in compliance with the requirements of those section, while still prohibiting all other uses. However, unless changed, the text of 7.1.21 allows any use (party balloons, etc.) as long as the balloon is designed for hydrogen. This subverts the intent of these two new sections to allow two specific uses of hydrogen balloon rather than prohibiting all of them as previous editions have.

Emergency Nature: The standard contains an error or an omission that was overlooked during the regular revision process.

The current text allows any use of hydrogen in a balloon that is approved for hydrogen. This is not safe and the use of hydrogen in balloons must be limited to those approved by the committee as described in 7.1.21.1 and 7.1.22.

Submitter Information Verification

Submitter Full Name:
Organization: TIA
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 10:48:19 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: No additional changes to 7.1.21 need to be made from those already incorporated by the

TIA.

Tentative Interim Amendment

NFPA® 2

Hydrogen Technologies Code

2023 Edition

Reference: 7.1.21
TIA 23-1
(SC 23-8-43 / TIA Log #1700)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 2, *Hydrogen Technologies Code*, 2023 edition. The TIA was processed by the Technical Committee on Hydrogen Technology and was issued by the Standards Council on August 25, 2023, with an effective date of September 14, 2023.

1. Revise paragraph 7.1.21 to read as follows:

7.1.21 Use of GH_2 for Inflation. Inflatable equipment, devices, or balloons shall not be pressurized or filled with GH_2 unless they comply with 7.1.21.1 or 7.1.22.~~the balloon is designed specifically for hydrogen as a lift gas.~~

Issue Date: August 25, 2023

Effective Date: September 14, 2023

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**
Copyright © 2023 All Rights Reserved
NATIONAL FIRE PROTECTION ASSOCIATION

Public Input No. 66-NFPA 2-2023 [Section No. 7.1.23.1 [Excluding any Sub-Sections]]

Hydrogen equipment enclosures (HEEs) shall be in accordance with one of the following:

(1) the approved building code ~~or~~ ;

(2) 7.1.23 when the total quantity of hydrogen stored in or piped into the enclosure exceeds 1000 scf (28.3 Nm^3) or where the enclosure contains hydrogen processing or generating equipment;

(3) listed or approved to CSA B107 .

Statement of Problem and Substantiation for Public Input

Rationale: The first edition of CSA B107, Enclosed Hydrogen Equipment - Safety, is expected to publish early 2024 and is a suitable additional listing reference as the it contains requirements for assemblies of hydrogen equipment integrated into an enclosure such as a freight container or custom enclosure, i.e. enclosed hydrogen equipment. CSA B107 applies to enclosed hydrogen equipment intended for stationary outdoor installation. CSA B107 primarily addresses the safety requirements related to hydrogen and its use inside an enclosure, i.e. hydrogen equipment enclosures (HEEs).

Submitter Information Verification

Submitter Full Name: Mark Duda
Organization: CSA Group
Street Address:
City:
State:
Zip:
Submittal Date: Wed Oct 25 07:26:51 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: CSA B107, Enclosed Hydrogen Equipment - Safety has not yet been issued by CSA and can therefore not be adopted at this time.

Public Input No. 67-NFPA 2-2023 [Section No. 7.1.23.1.1]

7.1.23.1.1

Subsection 7.1.23 shall not apply to any of the following:

(1) Gas cabinets in accordance with Section 6.19

(2) Exhausted enclosures in accordance with Section 6.20

(3) Ventilated enclosures with sufficient dilution to maintain an unclassified area in the interior in accordance with Section 4.12

(4) Enclosures integral to fuel cell systems that are listed or approved in accordance with Chapter 12

(5) Enclosures integral to hydrogen generators that are listed or approved in accordance with Chapter 13

(6) Hydrogen equipment enclosures that are listed or approved in accordance with CSA B107.

Statement of Problem and Substantiation for Public Input

Rationale: The first edition of CSA B107, Enclosed Hydrogen Equipment - Safety, is expected to publish early 2024 and is a suitable additional listing reference as the it contains requirements for assemblies of hydrogen equipment integrated into an enclosure such as a freight container or custom enclosure, i.e. enclosed hydrogen equipment. CSA B107 applies to enclosed hydrogen equipment intended for stationary outdoor installation. CSA B107 primarily addresses the safety requirements related to hydrogen and its use inside an enclosure, i.e. hydrogen equipment enclosures (HEEs).

Submitter Information Verification

Submitter Full Name: Mark Duda
Organization: CSA Group
Street Address:
City:
State:
Zip:
Submittal Date: Wed Oct 25 07:28:55 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: CSA B107, Enclosed Hydrogen Equipment - Safety has not yet been issued by CSA and can therefore not be adopted at this time.

Public Input No. 34-NFPA 2-2023 [New Section after 7.1.23.1.2]

7.1.23.1.3 (new)

HEEs located indoors shall be regulated as indoor gas storage and use in accordance with chapters 1 through 7.

Statement of Problem and Substantiation for Public Input

Ensure that indoor requirements are met in such a circumstance.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 13:15:08 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: HEEs are already required to be regulated for indoor storage and use, when installed indoors. There are specific requirements for HEEs in Chapter 7 and and a HEE may or may not have integral storage, and if not should not have to align with the proposed requirement. Therefore there is not an over site within the code that exits, which the proposal resolves.

Public Input No. 37-NFPA 2-2023 [Section No. 7.1.23.3.2]

7.1.23.3.2

~~Vent pipes shall~~ GH2 venting systems and vent terminations shall be in accordance with Section 6.17 and 7.1.16.

Statement of Problem and Substantiation for Public Input

To have consistent use of venting applications and to add reference to section 7.1.16 for more complete requirement s

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 13:35:55 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-157-NFPA 2-2024
Statement: The new terminology is more accurate than the current language and provides clarity to the user when trying to align with the intent of the requirement. The adopted language better aligns this section with the with 6.17.

Public Input No. 35-NFPA 2-2023 [New Section after 7.1.23.11.2]

7.1.23.11.3 (new)

HEEs shall be located accordingly as applicable:

(1) HHEs containing hydrogen bulk system quantities exceeding 15,000 scf shall be located in accordance with the Building Code for detached buildings.

(2) HEEs containing hydrogen bulk quantities less than 15,000 scf shall be located in accordance with Table 7.3.2.3.1.2(B)(a).

(3) HEEs containing hydrogen non-bulk quantities shall be located in accordance with Table 7.2.2.3.2.

Statement of Problem and Substantiation for Public Input

If the shelter is a detached noncombustible building the same siting provisions would apply. In the case of an HEE noncombustible shelter the same hazards apply. The bulk table and non-bulk tables should apply accordingly.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 13:16:49 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: The proposed language is redundant since there are already separation distances located in 7.1.23.1. Detached storage is also already required in Table 7.3.2.2.1.

Public Input No. 5-NFPA 2-2023 [Sections 7.1.23.14.2, 7.1.23.14.3, 7.1.23.14.4]

Sections 7.1.23.14.2, 7.1.23.14.3, 7.1.23.14.4

7.1.23.14.~~2~~ 1.1 GH_2 Detection.

7.1.23.14.~~2~~ 1 .1.1

GH_2 detection shall be provided in accordance with Section 6.13.

7.1.23.14.~~2~~ 1 .1. 2

Detection of hydrogen above 25 percent of the LFL shall result in activation of the ESS.

7.1.23.14.~~3~~ 1.2 Fire Detection.

7.1.23.14.~~3.~~ 1–

~~Fire detection shall be provided.~~

~~7.1.23.14.3.2~~ .2.1

The type of detection shall be as determined by a risk assessment.

7.1.23.14.~~3~~ 1 .~~3~~ 2.2

Fire detection shall comply with both of the following:.

(1) Be in accordance with *NFPA 72*

(2) Activate the ESS

7.1.23.14.4 1.3 Ventilation Detection.

7.1.23.14.4 1 .3. 1

A device shall be provided to detect failure of the ventilation system.

7.1.23.14.4 1 .3. 2

The device shall activate the ESS when airflow drops below 75 percent of the required flow.

Statement of Problem and Substantiation for Public Input

Current Sections 7.1.23.14.2 GH2 Detection, 7.1.23.14.3 Fire Detection, and 7.1.23.14.4 Ventilation Detection should be subsections of Section 7.1.23.14.1, which clarifies these systems are required per Table 7.1.23.9.1 criteria.

An example of the issue is as follows: Currently Section 7.1.23.14.3.1 could be construed as requiring fire detection for all HEE regardless of Table 7.1.23.9.1 criteria.

Submitter Information Verification

Submitter Full Name: Eric Dein
Organization: Black & Veatch
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jun 20 15:10:53 EDT 2023

Committee: HYD-AAA

Committee Statement

Resolution: Charging language for gaseous hydrogen detection (see 7.1.23.14.1) already addresses the concerns raised by the proposed revision.

Public Input No. 108-NFPA 2-2023 [Section No. 7.1.23.15.1 [Excluding any Sub-Sections]]

Where required by Table 7.1.23.9.1, explosion control shall be provided in accordance with ~~Section~~ ~~6.10~~ . Chapter 9

Statement of Problem and Substantiation for Public Input

this is one of the many referenced to explosion control that are being redirected to Chapter 9

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 175-NFPA 2-2023 [Chapter 9]	
Public Input No. 109-NFPA 2-2023 [Section No. 7.3.2.2.2.3]	
Public Input No. 111-NFPA 2-2023 [Section No. 7.3.2.5]	
Public Input No. 112-NFPA 2-2023 [Section No. 8.3.2.2.2.1(B)]	
Public Input No. 113-NFPA 2-2023 [Section No. 8.3.2.2.3.2]	
Public Input No. 114-NFPA 2-2023 [Section No. 10.5.3.4.1.4]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control Task Group
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 14 09:59:06 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-30-NFPA 2-2024
Statement: The cross reference to section 6.10 is being changed to chapter 9 which now contains the explosion protection requirements.

Public Input No. 33-NFPA 2-2023 [New Section after 7.1.23.16.1.5]

7.1.21.17 Standby power (new)

HEEs containing a total quantity of hydrogen stored in or piped into the enclosure exceeds 1000 scf (28.3 Nm3) or where the enclosure contains hydrogen processing or generating equipment shall be in accordance with 6.8.1.1

Statement of Problem and Substantiation for Public Input

This is in harmony with chapter 6 provisions for standby power. Additionally, gas detection is used to control the on and off operation of ventilation, alarms and the ESS.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 13:12:37 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-184-NFPA 2-2024

Statement: This revision clarifies that standby power is need for HEEs that do not have a fail safe system. By requiring standby power the risk of fire and explosion accidents will not be made worse by a loss of power to the HEE.

This revision changed the proposed language of 1000 scf to MAQ, so that the requirement would allow for flexibility that is built into the MAQ requirements (e.g., such as for suppression or exhaust ventilation).

Public Input No. 36-NFPA 2-2023 [Section No. 7.1.25.2]

7.1.25.2

Approved means of meeting the requirements for emergency isolation shall include any of the following:

(1) Automatic shutoff valves, located as close to the bulk source as practical, tied to leak detection systems

(2) Attended control stations ~~where~~ , either local or remote, where trained personnel can monitor alarms or supervisory signals and can trigger emergency responses

(3) ~~A constantly monitored control station with an alarm and remote shutoff of the gas supply system~~

(4)

(5) Excess flow valves at the bulk source

Statement of Problem and Substantiation for Public Input

Overlap between options (2) and (3) are cleared up by defining requirements in option (2) and deleting option (3).

Formatting may look strange because of Terra. There should be three options left after the deletion of previous option (3).

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 13:29:03 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-159-NFPA 2-2024
Statement: Overlap between options (2) and (3) are cleared up by defining requirements in option (2) and deleting the current option (3). The current (4) has become (3) with this change.

Public Input No. 19-NFPA 2-2023 [Section No. 7.2.1.1 [Excluding any Sub-Sections]]

GH_2 cylinders, containers, and tanks shall be separated in accordance with Table 7.2.1.1.

Table 7.2.1.1 Separation of Gas Cylinders, Containers, and Tanks by Hazard Class from Non-Bulk GH_2 Cylinders, Containers, Tanks, and Systems

	-	GH_2*
Gas Category	**ft**	**m**
Toxic or highly toxic	20	6.1
Pyrophoric	20	6.1
Flammable	—	—
Oxidizing	20	6.1
Corrosive	20	6.1
Unstable reactive Class 2, Class 3, or Class 4	20	6.1
Other gas	NR	NR

NR: No separation required.

~~*See flammable gas column from Table 7.1.10.2 of NFPA 55.~~

Statement of Problem and Substantiation for Public Input

Hydrogen is no longer covered by NFPA 55 and so the reference to NFPA 55 should be removed.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Affiliation: NFPA 2/55 hydrogen alignment task group
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 24 14:47:14 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-2-NFPA 2-2024
Statement: The scope of NFPA 2 has been revised to contain all requirements for hydrogen storage, use, and handling. The scope of NFPA 55 has been revised so that it no longer contains requirements for hydrogen storage, use, and handling. Separation distances for non-bulk hydrogen storage systems were originally extracted into NFPA 2 from NFPA 55's separation distances for all non-bulk flammable gases. NFPA 2 has removed the extract tags and so now maintains the non-bulk hydrogen storage system distances in table

7.2.1.1. The note pointing to NFPA 55 table 7.1.10.2 is no longer valid because NFPA 55 table 7.1.10.2 no longer applies to hydrogen

Public Input No. 38-NFPA 2-2023 [Section No. 7.2.2.2.2.1]

7.2.2.2.2.1

Hydrogen systems of less than 5000 scf (141.6 Nm^3) and greater than the MAQ, where located inside buildings, shall be in accordance with the following:

(1) In a ventilated area in accordance with the provisions of Section 6.18

(2) Separated from incompatible materials in accordance with the provisions of 7.2.1.1

(3) A distance of 25 ft (7.6 m) from open flames and other sources of ignition

(4) A distance of 50 ft (15 m) from intakes of ventilation, air-conditioning equipment, and air compressors located in the same room or area as the hydrogen system

(5) The distance shall be permitted to be reduced to 10 ft (3.1 m) where the room or area in which the hydrogen system is installed is protected by a listed detection system per Article 500.7(K) of *NFPA 70* and the detection system shuts down the fuel supply in the event of a leak that results in a concentration that exceeds 25 percent of the LFL.

(6) Emergency shutoff valves shall be provided in accordance with 7.1.24 .

(7) A distance of 50 ft (15 m) from other flammable gas storage

(8) Protected against damage in accordance with the provisions of 7.1.7.3

(9) Compliance with the provisions required for the occupancy classification in accordance with the Building Code.

Statement of Problem and Substantiation for Public Input

To ensure a link to required protection level 2 provisions of which some are required by OSHA in 29 CFR 1910/103 (b)(3)(iii).

Terra has shown lines (4)(a) and (4)(b) with underlining as if for new text, but this public input does not address those sections. Please ignore the incorrect underlining.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 13:44:46 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-105-NFPA 2-2024

Statement: By referencing the building code it ensures a link to required protection level 2 provisions of which some are required by OSHA in 29 CFR 1910/103 (b)(3)(iii).

Public Input No. 39-NFPA 2-2023 [Section No. 7.2.2.2.2.2(A)]

(A)

More than one system of 5000 scf (141.6 Nm^3) or less shall comply with 7.2.2.2.2.1 and shall be permitted to be installed in the same room or area, provided the systems are separated by at least 50 ft (15 m) or a full-height fire-resistive partition having a minimum fire resistance rating of 2 hours is located between the systems.

Statement of Problem and Substantiation for Public Input

Provisions of 7.2.2.2.2.1 are applicable and shouldn't be missed.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 13:50:59 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-160-NFPA 2-2024
Statement: This ensure that the user will understand that 7.2.2.2.2.1, for indoor hydrogen system location, needs to be followed when properly aligning with this section.

Public Input No. 109-NFPA 2-2023 [Section No. 7.3.2.2.2.3]

7.3.2.2.2.3*

Explosion control shall be provided in accordance with the requirements of ~~Section~~ ~~6.10~~ . Chapter 9

Statement of Problem and Substantiation for Public Input

this redirects explosion control to chapter 9

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 108-NFPA 2-2023 [Section No. 7.1.23.15.1 [Excluding any Sub-Sections]]	
Public Input No. 175-NFPA 2-2023 [Chapter 9]	
Public Input No. 111-NFPA 2-2023 [Section No. 7.3.2.5]	
Public Input No. 112-NFPA 2-2023 [Section No. 8.3.2.2.2.1(B)]	
Public Input No. 113-NFPA 2-2023 [Section No. 8.3.2.2.3.2]	
Public Input No. 114-NFPA 2-2023 [Section No. 10.5.3.4.1.4]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control Task Group
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 14 10:04:06 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-31-NFPA 2-2024
Statement: The cross reference to section 6.10 is being changed to chapter 9 which now contains the explosion protection requirements.

Public Input No. 32-NFPA 2-2023 [New Section after 7.3.2.2.2.5]

7.3.2.2.2.6 (new)

An automatic fire protection system shall be provided in accordance with section 6.11.

Statement of Problem and Substantiation for Public Input

The building by default exceeds the MAQ and therefore requires a sprinkler system.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 13:08:54 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-162-NFPA 2-2024

Statement: This revision has been made since by default detached buildings exceed the MAQ. When over the MAQ there is a requirement of installing a sprinkler system. This revision makes that it clear that detached building include this requirement and that the user does not mistakenly think sprinklers are not required because not directly stated.

Public Input No. 110-NFPA 2-2023 [Section No. 7.3.2.2.3.3]

7.3.2.2.3.3

Explosion control shall be provided in accordance with the requirements of ~~Section~~ ~~6.10~~ . Chapter 9

Statement of Problem and Substantiation for Public Input

this redirects explosion control to chapter 9

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 175-NFPA 2-2023 [Chapter 9]	
Public Input No. 111-NFPA 2-2023 [Section No. 7.3.2.5]	
Public Input No. 112-NFPA 2-2023 [Section No. 8.3.2.2.2.1(B)]	
Public Input No. 113-NFPA 2-2023 [Section No. 8.3.2.2.3.2]	
Public Input No. 114-NFPA 2-2023 [Section No. 10.5.3.4.1.4]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control Task Group
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 14 10:16:29 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-32-NFPA 2-2024
Statement: The cross reference to section 6.10 is being changed to chapter 9 which now contains the explosion protection requirements.

Public Input No. 178-NFPA 2-2023 [Section No. 7.3.2.3.1.2(A)]

(A)

The ~~vent stack shall~~ Vent System shall not be considered part of the bulk hydrogen compressed gas system for determining separation distances in 7.3.2.3.1.1. S eparation distances to Group I exposures shall be determined by a dispersion analysis and separation distance for Group II and III shall be determined by a heat flux analysis.

Statement of Problem and Substantiation for Public Input

We should be consistent with the definition of Vent System, 3.3.225. The designer also needs to consider the plume dispersion in relation to group I exposures. The designer also must consider the radiation effects of a vent stack fire for group II and III exposures.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 253-NFPA 2-2024 [Section No. 8.3.1.2.6.1]	

Submitter Information Verification

Submitter Full Name: Allen Adriani
Organization: Plug Power
Street Address:
City:
State:
Zip:
Submittal Date: Sun Dec 24 11:57:06 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-118-NFPA 2-2024

Statement: The terminology has changed to align with the definition of Vent System, 3.3.225. The designer needs to consider the plume dispersion in relation to group I exposures. The designer also must consider the radiation effects of a vent stack fire for group II and III exposures.CGA PS-48 has been revised and renamed to apply to the hydrogen distances that are in NFPA 2 and are no longer in NFPA 55. The term storage has been added to several sections to specify what the separation distance is applying to.

Public Input No. 115-NFPA 2-2023 [Section No. 7.3.2.3.1.2(B)]

~~shall be permitted with tabular~~

(B)

~~– Maximum Internal Diameter of Interconnecting Piping.~~

~~The maximum internal diameter of the piping system used for interconnecting piping between the shutoff valve on any single storage container to the point of connection to the system source valve shall not be required to be in accordance with the values shown in Table 7.3.2.3.1.2(B)(a) when in accordance with Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c) . The separation distance for piping systems with internal diameters other than those specified in Table 7.3.2.3.1.2(B)(a) for the pressure range selected~~

Separation distances determined based on the use of Table 7.3.2.3.1.2(B)(b)

~~or~~

, Table 7.3.2.3.1.2(B)(c)

~~.Separation distances determined based on the use of~~

, and Table 7.3.2.3.1.2(B)(

~~b) or Table 7.3.2.3.1.2(B)(~~

c) shall be subject to review and approval by the AHJ.

(C) The separation distance shall be measured from the part of the bulk hydrogen compressed gas system closest to the exposure.

(D) * **Determination of Internal Diameter.** The internal diameter of the piping system shall be determined by the diameter of the piping serving that portion of a storage array with content greater than 5000 scf (141.6 Nm^3). The piping system size used in the application of Table 7.3.2.3.1.2(B)(a) , Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c) shall be determined based on that portion of the system with the greatest maximum internal diameter.

(E) * **Determination of System Pressure.** The system pressure shall be determined by the maximum operating pressure of the storage array with content greater than 5000 scf (141.6N m^3), irrespective of those portions of the system elevated to a higher pressure.

Table 7.3.2.3.1.2(B)(a)

~~Minimum Distance (D) from Outdoor Bulk Hydrogen Compressed Gas Systems to Exposures — Typical Maximum Pipe Size Pressure >15 to ≤250 psig >250 to ≤3000 psig >3000 to ≤7500 psig >7500 to ≤15000 psig Internal Pipe Diameter (ID) >103.4 to ≤1724 kPa >1724 to ≤20,684 kPa >20,684 to ≤51,711 kPa >51,711 to ≤103,421 kPa d **mm** d = 52.5 **mm** d = 18.97 **mm** d = 7.31 **mm** d = 7.16 **mm** **Exposures Group 1** **m** **ft** **m** **ft** **m** **ft** **m** **ft** Lot lines 5 16 6 20 4 13 5 16~~

~~Listing of exposures for each group~~

Exposures Group 1
Lot lines
Air intakes (HVAC, compressors, other)

Operable openings in buildings and structures

Ignition sources such as open flames and welding

Exposures Group 2

m ft m ft m ft m ft

Exposed persons other than those servicing the system

5 16 6 20 3 10 4 13 **Exposures Group 3** **m ft m ft m ft m ft**

Parked cars

Buildings of

non-

combustible

non-fire-rated construction 4 13 5 16 3 10 4 13 Buildings of combustible construction -------- Flammable gas

construction

Hazardous materials storage systems above ground or

below ground -------- Hazardous materials storage systems above or below ground -------- Heavy timber, coal, or other slow-burning combustible solids --------

fill/vent openings for below-ground storage systems

Ordinary combustibles, including fast-burning solids such as ordinary lumber, excelsior, paper, or combustible waste and vegetation other than that found in maintained landscaped areas

---

Exposures Group 3

Buildings of non-combustible non-fire-rated construction

Flammable gas storage systems above or below ground

Heavy timber, coal, or other slow-burning combustible solids

Unopenable openings in building and structures

Encroachment by overhead utilities (horizontal distance from the vertical plane Below the nearest overhead electrical wire of building service)

Piping containing other hazardous materials

Flammable gas metering and regulating stations such as natural gas or propane.

Table 7.3.2.3.1.2(B)(b) Minimum Distance (D ft) from Outdoor Bulk Hydrogen Compressed Gas Systems to Group 1 Exposures by Maximum Pipe Size with Pressures >15 to ≤3000 psig Pressure >15 to ≤250 psig >103.4 to ≤1724 kPa >250 to ≤3000 psig >1724 to ≤20,684 kPa Exposures* ‡ Exposures* ‡

Maximum Pressure and Inner Pipe Diameter

	Max					
	250	500	750	1,000	2,000	3,000
Internal Pipe Diameter (ID in)						
Group 1						
Group						
Group						
	2					
Group 1						
Group 2						
Group 3						

- 0.2 5.1 0.5 2 0.2 1 0.4 1 1.6 5 1.3 4 1.3 4 0.3 7.6 0.7 2 0.4 1 0.6 2 2.4 8 2.2 7 2.0 7 0.4 10.2 1.0 3 0.7 2

- D = 0.0952d D = 0.1019d - 0.3485 D = 0.0762 D = 0.3168d D = 0.3384d - 0.4188 D = 0.2636d ID (in.) d (mm) m ft m ft m ft m ft m ft m ft

8	9	11	12	13					
0.3	3	4	5	5	8	9	11	12	14
0.4	4	5	6	7	10	13	15	16	20
0.5	5	6	8	9	13	16	18	21	25
0.6	6	8	10	11	16	19	23	25	30
0.7	7	9	11	13	19	23	27	30	36
0.8	8	11	13	15	22	27	31	34	42
0.9	9	12	15	17	25	30	35	39	47
1	10	14	17	19	27	34	39	44	53
1.1	11	15	18	21	30	37	43	48	59
1.2	12	16	20	23	33	41	48	53	64
1.3	13	18	22	26	36	45	52	58	70
1.4	14	19	24	28	40	49	56	63	76
1.5	15	21	26	30	43	52	61	68	91
1.6	16	22	28	32	46	56	65	72	97
1.7	17	24	29	34	49	60	69	77	103
1.8	18	25	31	36	52	64	74	91	110
1.9	19	27	33	38	55	68	78	96	116
2	20	28	35	41	58	72	92	102	122
2.1	21	30	37	43	61	75	96	107	128

Notes: Linear interpolation of internal pipe diameters and distances between table entries by diameter is allowed.

Alternative calculations within the maximum pressures and diameters in the table may be made using the formula $D = 1.3653 \cdot d \cdot P^{0.4250}$ where D is the group 1 distance in ft, d is the internal pipe diameter in in and P is the maximum pressure in psi.

For a list of exposures in each exposure group, see Table 7.3.2.3.1.2(B)(a).

Table 7.3.2.3.1.2(B)(c) Minimum Distance (ft) from Outdoor Bulk Hydrogen Compressed Gas Systems to Group 2 Exposures by Maximum Pipe Size with Maximum Pressure and Inner Pipe Diameter

		250	500	750	1,000	2,000
Internal Pipe Diameter (in)	0.2	2	2	3	3	5
	0.3	3	4	4	5	7
	0.4	3	5	6	7	9

0.5	4	6	7	8	12
0.6	5	7	9	10	14
0.7	6	8	10	12	17
0.8	7	10	12	14	20
0.9	8	11	13	16	22
1	9	12	15	17	25
1.1	10	14	17	19	27
1.2	11	15	18	21	30
1.3	12	16	20	23	33
1.4	13	18	21	25	35
1.5	13	19	23	27	38
1.6	14	20	25	29	41
1.7	15	22	26	30	43
1.8	16	23	28	32	46
1.9	17	24	30	34	49
2	18	26	31	36	51
2.1	19	27	33	38	54

Notes : Linear interpolation of internal pipe diameters and distances between table entries by diameter is allowed.

*

-

Alternative calculations within the maximum pressures and diameters in the table may be made using the formula $D = 0.6813 \cdot d \cdot P^{0.4752}$ where D is the group 2 distance in ft, d is the internal pipe diameter in in and P is the maximum pressure in psi.

For a list of exposures in each exposure group, see

Column 1 of

Table 7.3.2.3.1.2(B)(a).

†When calculating the minimum separation distance (D) using the formulas indicated, based on the exposure group and pressure indicated, the internal pipe diameter (d) is entered in millimeters (mm). The calculated distance (D) is expressed in units of measure in meters (m). To convert distance (D) to units of measure in feet, multiply the value of (D) in meters by 3.2808 and round to the nearest whole foot.

-

Table 7.3.2.3.1.2(B)(

c

d) Minimum Distance (

D

ft) from Outdoor Bulk Hydrogen Compressed Gas Systems to Group 3 Exposures by Maximum Pipe Size with

Pressures >3000 to ≤15,000 psig Pressure >3000 to ≤7500 psig

>20,684 to ≤51,711 kPa >7500 to ≤15,000 psig

>51,711 to ≤103,421 kPa Exposures* ‡ Exposures* ‡ Internal Pipe Diameter (ID) Group 1 Group 2 Group 3 Group 1 Group 2 Group 3 - - D = 1.105d - 4.078 D = 0.6831d - 1.99 D = 0.459d - 0.355 D = 1.448d - 5.368 D = 0.9291d - 2.65 D = 0.602d - 0.3103 ID (in.) d (mm) m ft m ft m ft m ft m ft m ft 0.2 5.1 1.6 5 1.5 5 2 7 2 7 2 7 3 9 0.3 7.6 4.3 14 3.2 11 3 10 6 18 4 14 4

Maximum Pressure and Inner Pipe Diameter

		250	**500**	**750**	**1,000**	**2,000**
Internal Pipe Diameter (in)	**0.2**	2	2	3	3	4
	0.3	2	3	4	5	7
	0.4	3	5	6	6	9
	0.5	4	6	7	8	11
	0.6	5	7	8	10	13
	0.7	6	8	10	11	16
	0.8	7	9	11	13	18
	0.9	7	10	13	14	20
	1	8	12	14	16	23
	1.1	9	13	15	18	25
	1.2	10	14	17	19	27
	1.3	11	15	18	21	30
	1.4	12	16	20	23	32
	1.5	13	17	21	24	34
	1.6	13	19	23	26	37
	1.7	14	20	24	28	39
	1.8	15	21	26	29	41
	1.9	16	22	27	31	44
	2	17	23	28	33	46
	2.1	18	25	30	34	48

Notes : Linear interpolation of internal pipe diameters and distances between table entries by diameter is allowed.

*

-

~~Alternative calculations within the maximum pressures and diameters in the table may be made using the formula~~ ~~- $D = 0.6862 \cdot d \cdot P^{0.4608}$~~ $D = 0.6862 \cdot d \cdot P^{0.4608}$ ~~where~~ ~~- D~~ D ~~is the group 2 distance in ft,~~ ~~- d~~ d ~~is the internal pipe diameter in in and~~ ~~- P~~ P ~~is the maximum pressure in psi.~~

~~For a list of exposures in each exposure group, see~~

~~Column 1 of~~

~~Table 7.3.2.3.1.2(B)(a).~~

~~†When calculating the minimum separation distance (D) using the formulas indicated, based on the exposure group and pressure indicated, the internal pipe diameter (d) is entered in millimeters (mm). The calculated distance (D) is expressed in units of measure in meters (m). To convert distance (D) to units of measure in feet, multiply the value of (D) in meters by 3.2808 and round to the nearest whole foot.~~

Additional Proposed Changes

File Name	Description	Approved
NFPA_2_Code_Revision_option_2_12-7-23.docx	Word document with better formatting of tables.	

Statement of Problem and Substantiation for Public Input

The bulk gaseous separation distance calculation method has diverged from the bulk liquid separation distance. This adds consistency to the calculation method of the setback distances. Distances are still consequence-based, but calculations are now linked to a specific version of a software (HyRAM+, version 5.0) such that the calculations can be repeated and updated. Calculations have consistent criteria with the bulk liquid setback distances for each of the groups and also include unconfined overpressure as a criteria. These calculations are for a 3% by area leak with no safety factor. Group 1 criteria is the furthest distance to the 8% mole fraction, a heat flux of 4.7 kW/m^2 or an overpressure of 1 psi. Group 2 criteria is the furthest distance to a heat flux of 9 kW/m^2 or an overpressure of 2 psi. Group 3 criteria is the furthest distance to a heat flux of 20 kW/m^2, the visible flame length, or an overpressure of 3 psi. In addition, some exposures have been moved from group 3 to group 2 to remain consistent with the exposure groupings for bulk liquid.

In addition to making the calculations consistent, this public input also adds more resolution to different pressure operating systems. In this way, a system with a MAWP of 500 psi would not have to use the setback distance for a system with a MAWP of 3000 psi, as would need to be done currently.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 96-NFPA 2-2023 [Section No. 7.3.2.3.1.2(B)]	Revises the same section with the same calculations but does not include additional resolution for pressure.

Submitter Information Verification

Submitter Full Name: Ethan Hecht
Organization: Sandia National Laboratories
Street Address:
City:

State:
Zip:
Submittal Date: Thu Dec 14 20:26:16 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: A basis is needed around changing from 1% to 3% is needed. More information is needed on if the 1% is an incorrect number or a technical parameter. The technical committee is unsure if this should apply retroactively and until that is clarified it cannot be added to the document. Justification for deletion of the safety factor is also needed. The technical committee is interested in seeing further work on this topic. The technical committee supports the concept of the reorganized tables.

Public Input No. 96-NFPA 2-2023 [Section No. 7.3.2.3.1.2(B)]

(B)

~~Maximum~~

Maximum Internal Diameter of Interconnecting Piping.

The maximum internal diameter of the piping system used for interconnecting piping between the shutoff valve on any single storage container to the point of connection to the system source valve shall not be required to be in accordance with the values shown in Table 7.3.2.3.1.2(B)(a) when in accordance with Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c) .

(1) The separation distance for piping systems with internal diameters other than those specified in Table 7.3.2.3.1.2(B)(a) for the pressure range selected shall be permitted with tabular distances determined based on the use of Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c) .

(2) Separation distances determined based on the use of Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c) shall be subject to review and approval by the AHJ.

(3) The separation distance shall be measured from the part of the bulk hydrogen compressed gas system closest to the exposure.

(4) * **Determination of Internal Diameter.** The internal diameter of the piping system shall be determined by the diameter of the piping serving that portion of a storage array with content greater than 5000 scf (141.6 Nm^3). The piping system size used in the application of Table 7.3.2.3.1.2(B)(a) , Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c) shall be determined based on that portion of the system with the greatest maximum internal diameter.

(5) * **Determination of System Pressure.** The system pressure shall be determined by the maximum operating pressure of the storage array with content greater than 5000 scf (141.6N m^3), irrespective of those portions of the system elevated to a higher pressure.

Table 7.3.2.3.1.2(B)(a) Minimum Distance (D) from Outdoor Bulk Hydrogen Compressed Gas Systems to Exposures — Typical Maximum Pipe Size

Pressure	**>15 to ≤250 psig**		**>250 to ≤3000 psig**		**>3000 to ≤7500 psig**		**>7500 to ≤15000 psig**	
Internal Pipe Diameter (ID)	**>103.4 to ≤1724 kPa**		**>1724 to ≤20,684 kPa**		**>20,684 to ≤51,711 kPa**		**>51,711 to ≤103,421 kPa**	
d mm	**d = 52.5 mm**		**d = 18.97 mm**		**d = 7.31 mm**		**d = 7.16 mm**	
Exposures Group 1	**m**	**ft**	**m**	**ft**	**m**	**ft**	**m**	**ft**
Lot lines								
~~5~~								
				6				
~~16~~								
				21				
~~6~~								
				8				
~~20~~								

	25				4		
~~13~~							
			14				
~~5~~							
			6				
~~16~~							
			18				
Air intakes (HVAC, compressors, other)							

Operable openings in buildings and structures							

Ignition sources such as open flames and welding							

Exposures Group 2	**m**	**ft**	**m**	**ft**	**m**	**ft**	**m**	**ft**
Exposed persons other than those servicing the system								
~~5~~ ~~16~~								
			6					
~~20~~								
			19					
~~3~~								
			7					
~~10~~								
	22		4	13		5	16	
Parked cars								

Buildings of combustible construction								
Hazardous materials storage systems above ground or fill/vent openings for below ground storage systems								
Ordinary combustibles, including fast-burning solids such as ordinary lumber, excelsior, paper, or combustible waste and vegetation other than that found in maintained landscaped areas								
Exposures Group 3	**m**	**ft**	**m**	**ft**	**m**	**ft**	**m**	**ft**
Buildings of non-combustible non-fire-rated construction								

~~4~~ ~~13~~

5

~~16~~

17

~~3~~

6

~~10 Buildings of combustible construction~~ - - - - - - - -

20 4

~~13 Hazardous materials storage systems above or below ground~~ - - - - - - - -

12 5 15

Flammable gas storage systems above or below ground

- - - - - - - -

~~Ordinary combustibles, including fast-burning solids such as ordinary lumber, excelsior, paper, or combustible waste and vegetation other than that found in maintained landscaped areas~~ - - - - - - - -

Heavy timber, coal, or other slow-burning combustible solids

- - - - - - - -

Unopenable openings in building and structures

- - - - - - - -

Encroachment by overhead utilities (horizontal distance from the vertical plane Below the nearest overhead electrical wire of building service)

- - - - - - - -

Piping containing other hazardous materials

- - - - - - - -

Flammable gas metering and regulating stations such as natural gas or propane.

- - - - - - - -

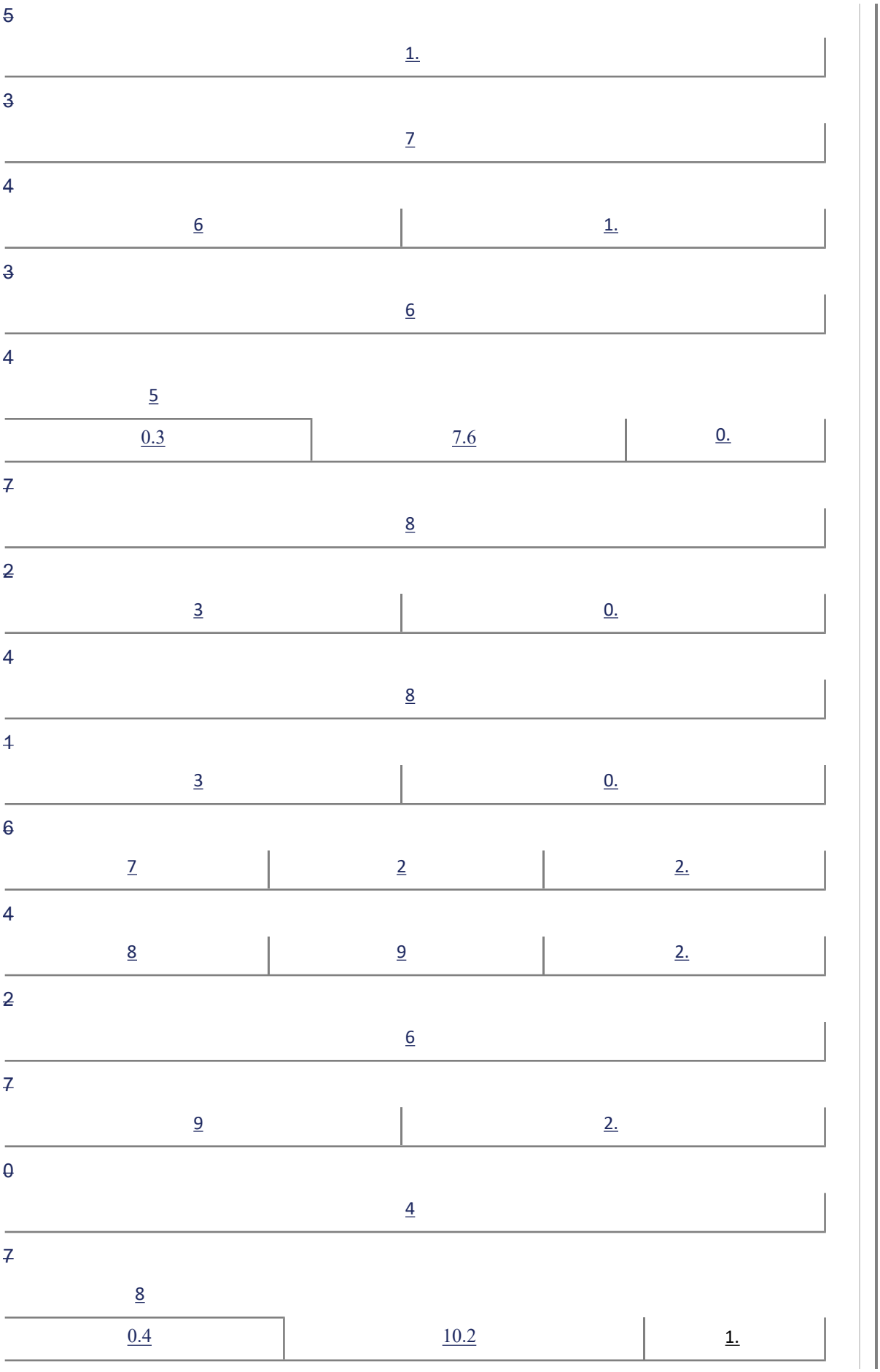
Table 7.3.2.3.1.2(B)(b) Minimum Distance (D) from Outdoor Bulk Hydrogen Compressed Gas Systems to Exposures by Maximum Pipe Size with Pressures >15 to ≤3000 psig

Pressure	**>15 to ≤250 psig** **.**
>103.4 to ≤1724 kPa	**>250 to ≤3000 psig** **.**

>1724 to ≤20,684 kPa						
Exposures* †.			Exposures* †.			
Internal Pipe Diameter (ID)	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
D=0.						
0952d						
1232d-0.1690			D=0.			
1019d						
1105d -0.						
3485						
0948			D=0.			
0762						
1015d-0.0324			D=0.			
3168d						
4400d-0.7192			D=0.			
3384d						
3847d -0.						
4188						
4629			D=0.			
2636d						

3397d-0.1978

ID (in.)	d (mm)	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft
0.2	5.1	0.5	2	0. 5	2								
1													
0.													
4													
5													
1													
2		1. 8								6			


5
1.
3
7
4
6
1.
3
6
4
5
0.3
7.6
0.
7
8
2
3
0.
4
8
1
3
0.
6
7
2
2.
4
8
9
2.
2
6
7
9
2.
0
4
7
8
0.4
10.2
1.

0

1

3

4

0

1 .

7 2

0

.8

3

3.2 11 3.0 10 2.7 9 0.5 12.7

1.

2 4

0

.9

3

1.0

3

4

.

0

8 13 3.

9

5

13

12 3.3 11

0.

6

5

15

12 .

2

7	1.4	5	1.

2

3	4	1.

2

3	4	4.

8

9	16	4.

7

4

16

15	4.

0

1

13

14
0.

7

6

17

15 .

8

2	1.7	6	1.

5

6	5	1.

4

5

4

5	5.

6

9	19	5.

6

4 18

4

5 .

7

0

15

16

0. 7 17. 8

20

2 .

3

0 7 1.9 6 1.

7

8 6

1

7 .

5

0

5

23 6.

4

3 21

6.

5

21 5

.

4

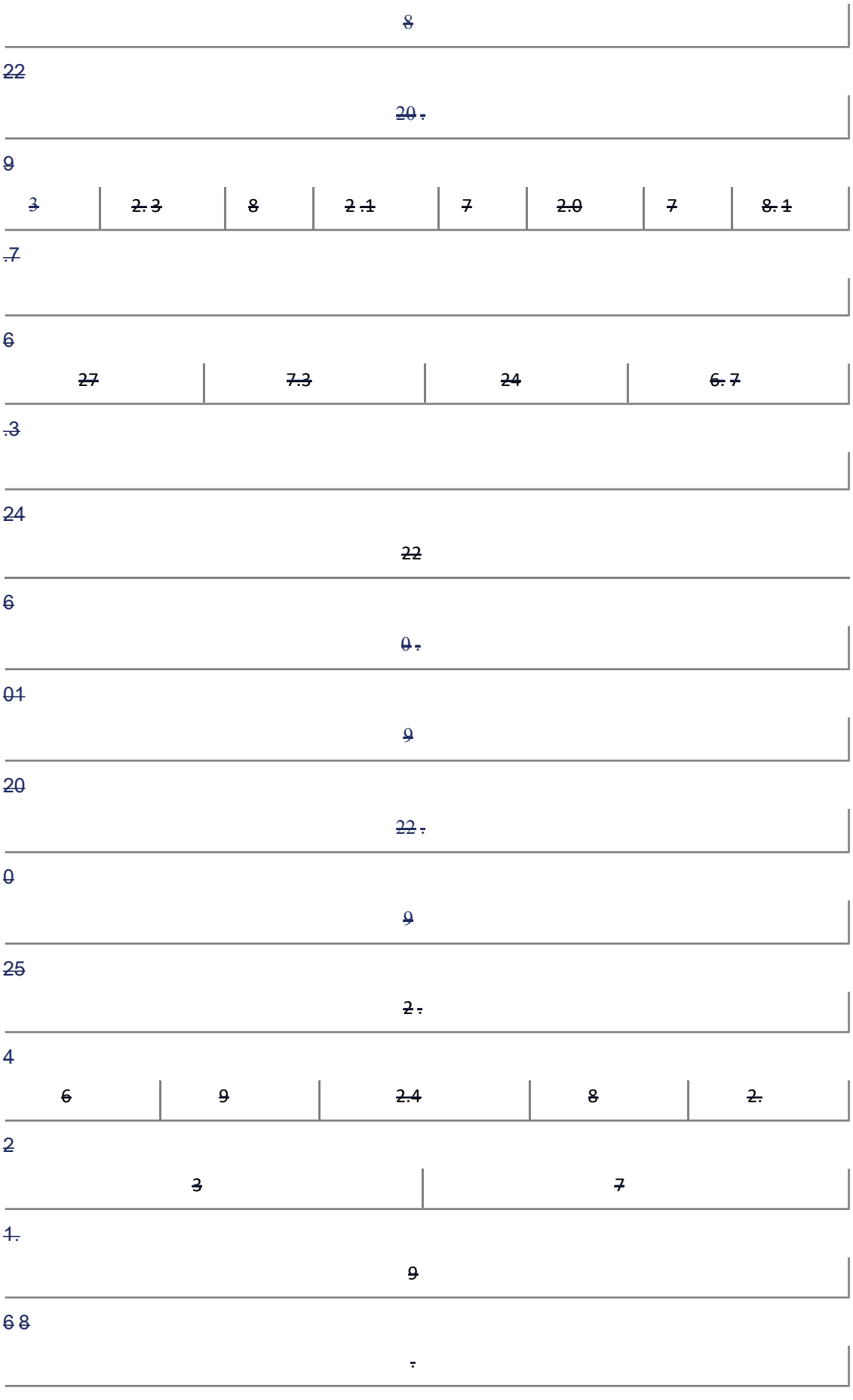
8

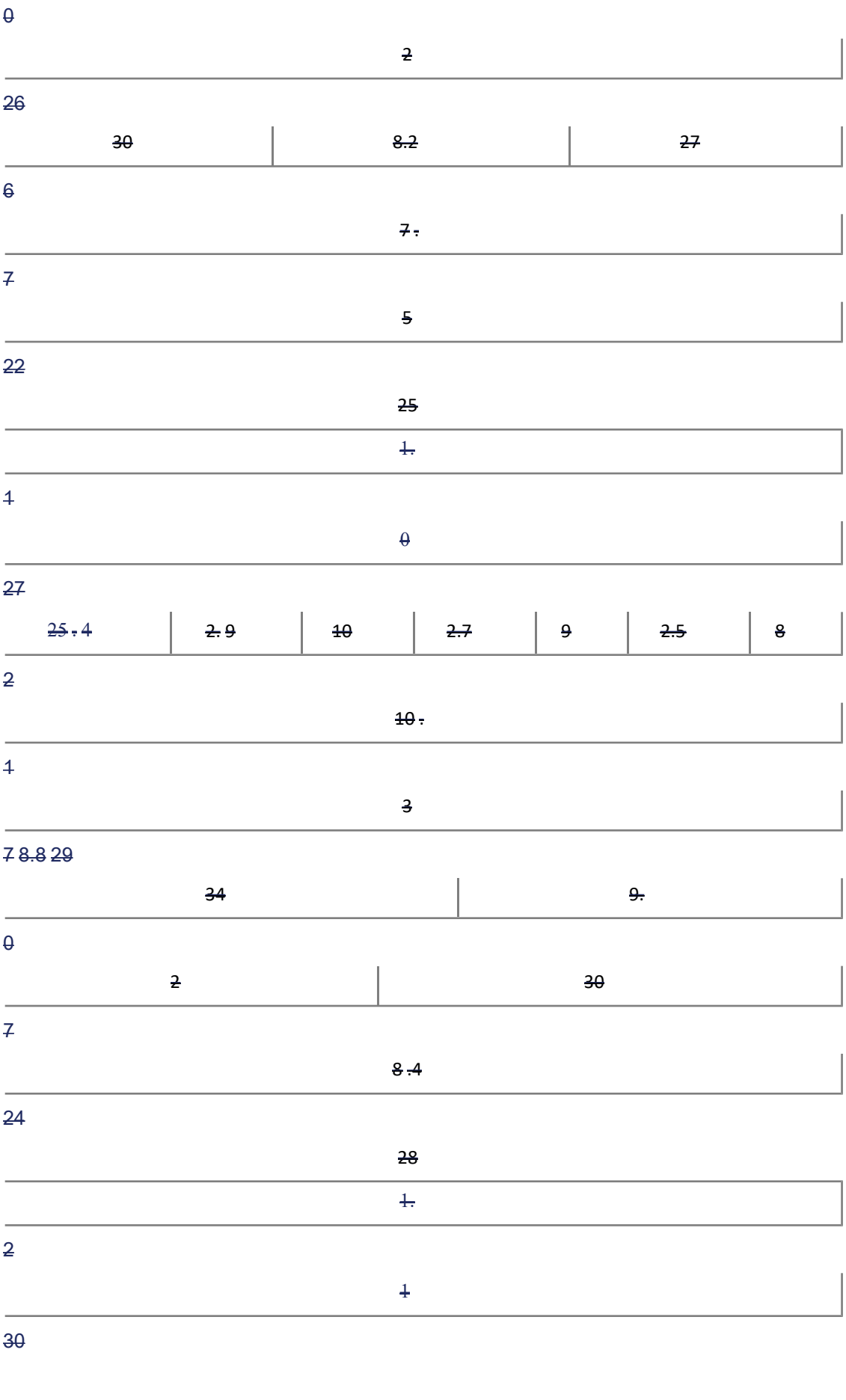
18

19

0.

9





27.

5

9	3.2	11	3.

9

0	10	2.8	9

2

11.

3

4

8

37

9

10.

7

2

32

33	9.

9

2

32

30

8

1.

0

2

26

30.5

1.

3

33

.

0

5	12	3.

1

2

10

11	3.0	10

2

12 .5

8

41

10

11 .

5

2

34

37	10.

7

1

35

33

8

1 .

71

3

29

33 .

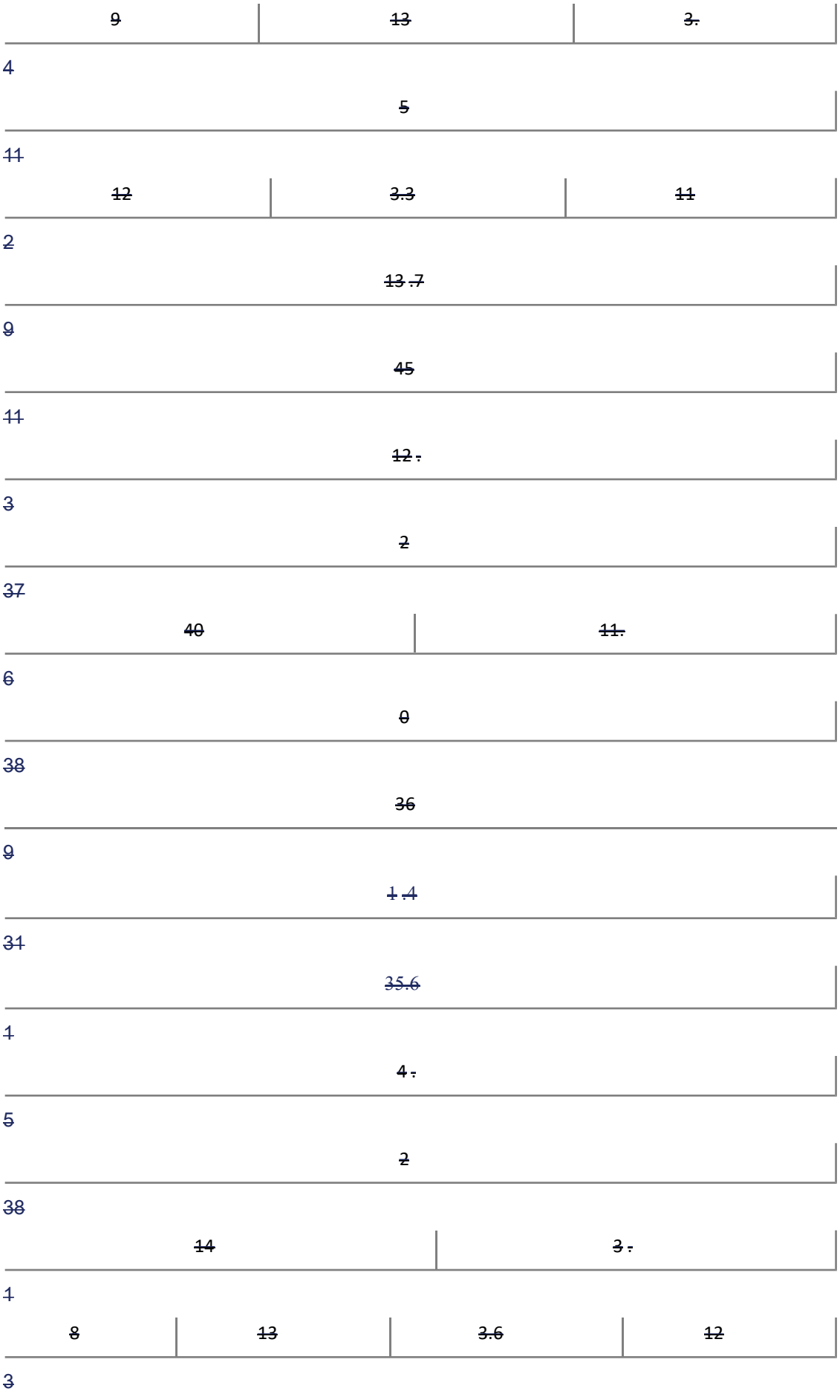
4

0

35

3 .

6


9
13
3.
4
5
11
12
3.3
11
2
13 .7
9
45
11
12 .
3
2
37
40
11.
6
0
38
36
9
1 .4
31
35.6
1
4 .
5
2
38
14
3 .
1
8
13
3.6
12
3

14.

5

8

12

49

2.

13.1	43	11.9

10

39

1212

1.5	38.1

40

4.5

41

15

10.

4.1	13	3.8	13	16.0

33

52	14.1	46	12.7	42
1.6	40.6			

3

4.

9

8

13

16

3

4.

8

4

12

~~14~~

~~3~~

~~4.1~~

~~10~~

~~13~~

~~12~~

~~17.~~

~~9~~

~~1~~

~~42~~

~~56~~

~~13~~

~~15.~~

~~3~~

~~1~~

~~44~~

~~50~~

~~10~~

~~13.~~

~~7~~

~~6~~

~~35~~

~~45~~

~~1.7~~	~~43.2~~

~~4~~

~~5.~~

~~1~~

~~2~~

~~13~~

~~17~~	~~4.~~

~~1~~

~~7~~

~~13~~

~~15~~

~~3~~

~~4.3~~

~~11~~

~~14~~

~~13~~

~~18.~~

~~7~~

~~3~~

~~45~~

~~60~~

~~14~~

~~16.2~~

~~47~~

~~53~~

~~11~~

~~14.~~

~~4~~

~~5~~

~~37~~

~~47~~

~~1.8~~ ~~45.7~~

~~4~~

~~5.~~

~~4~~

~~5~~

~~14~~

~~18~~

~~4~~

5.

3

0

14

16

3

4.

5

6

11

15

14

19.5

47

64

15

17.

0

2

49

56

12

15.

0

3

40

50

1.9

48.3

4

5.

6

~~8~~

~~15~~

~~19~~

~~4~~

~~5.~~

~~6~~

~~3~~

~~15~~

~~17~~

~~3~~

~~4.~~

~~7~~

~~9~~

~~12~~

~~16~~

~~15~~

~~20.~~

~~3~~

~~6~~

~~50~~

~~68~~

~~15~~

~~18.~~

~~9~~

~~2~~

~~52~~

~~60~~

~~12~~

~~16.~~

~~7~~

~~2~~

~~42~~

~~53~~

~~2.0~~	~~50.8~~

~~4~~

~~6.~~

~~8~~

~~1~~

~~16~~

~~20~~

~~4~~

~~5.~~

~~8~~

~~5~~

~~16~~

~~18~~

~~3~~

~~5.~~

~~9~~

~~1~~

~~13~~

~~17~~

~~16~~

~~21.~~

~~1~~

~~8~~

~~53~~

~~72~~

~~16~~

~~19.~~

~~8~~

~~2~~

~~55~~

63

13

17 .

4

1

44

56

2.1	53.3	6. 5

.1

17

21	5.

1

8

17

19	5. 4

.1

13

18

16

23 .

9

0

55

75

17

20 .

6

2

58

66

14

18 .0

46

59

Note: Linear interpolation of internal pipe diameters and distances between table entries is allowed.

*For a list of exposures in each exposure group, see Column 1 of Table 7.3.2.3.1.2(B)(a).

†When calculating the minimum separation distance (D) using the formulas indicated, based on the exposure group and pressure indicated, the internal pipe diameter (d) is entered in millimeters (mm). The calculated distance (D) is expressed in units of measure in meters (m). To convert distance (D) to units of measure in feet, multiply the value of (D) in meters by 3.2808 and round to the nearest whole foot.

Table 7.3.2.3.1.2(B)(e) Minimum Distance (D) from Outdoor Bulk Hydrogen Compressed Gas Systems to Exposures by Maximum Pipe Size with Pressures >3000 to ≤15,000 psig

Pressure	>3000 to ≤7500 psig =
>20,684 to ≤51,711 kPa	>7500 to ≤15,000 psig =

>51,711 to ≤103,421 kPa

Exposures* ‡			Exposures* ‡			
Internal Pipe Diameter (ID)	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
--						
	D=					
1						
0 .						
105d						
7684d -						
4						
2 .						
078						

4405 D=0.

6831d

5972d -

1

0 .

99

7550 D=0.

459d

5201d -0.

355

3371 D=1.

448d

0263d -

5

2 .

368

5496 D=0.

9291d

8061d -

2

1 .

65

0658 D=0.

602d

6953d -0.

3103

4971

ID (in.)	d (mm)	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft
0.2	5.1												

1

	2.	
6		
	8	
5		
	9	
1		
	2.	
5		
	6	
5		
9	2.5	
7		
	8	
2		
	3.8	
7		
	13	
2		
	3.5	
7		
11	3.2	
9		
11		
0.3	7.6	4.
3		
4	14	
3		
	4.	
2		
	0	
11		

13	3 .7

10

12

6

5.9

18

19

4

5.3

14

18	4 .9

14

16

0.4	10.2

7

6 .

2

0

24

20	5. 4	18	5. 0	16

4

8.1

14

27

9 31

7 .3

22

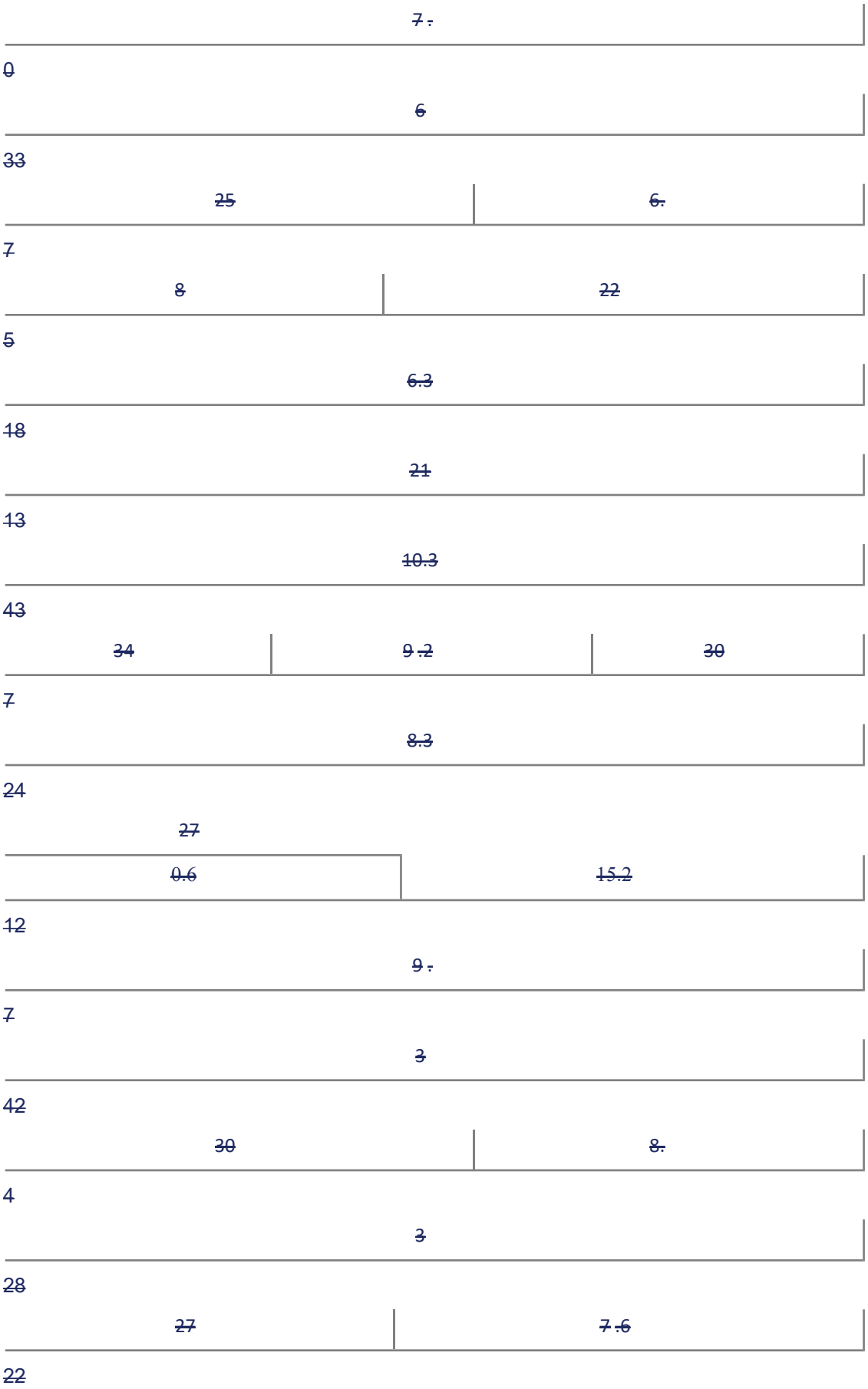
24	6 .6

19

22

0.5	12.7

10


7 .
0
6
33
25
6.
7
8
22
5
6.3
18
21
13
10.3
43
34
9 .2
30
7
8.3
24
27
0.6
15.2
12
9 .
7
3
42
30
8.
4
3
28
27
7 .6
22

~~25~~

~~17~~

~~12.6~~

~~55~~

~~41~~ ~~11.1~~

~~38~~

~~37~~

~~9~~

~~10.1~~

~~29~~

~~33~~

~~0.7~~ ~~17.8~~

~~15~~

~~11.~~

~~6~~

~~0~~

~~51~~

~~36~~

~~10~~

~~9.~~

~~2~~

~~8~~

~~33~~

~~32~~ ~~8.9~~

~~26~~

~~29~~

~~20~~

~~14.9~~

~~67~~

~~49~~

~~14~~

~~13.1~~

~~46~~

~~43~~

~~10~~

~~11.8~~

~~34~~

~~39~~

~~0.8~~ ~~20.3~~

~~18~~

~~12 .~~

~~4~~

~~7~~

~~60~~

~~42~~ ~~11.~~

~~9~~

~~3~~

~~39~~

~~37~~

~~9~~

~~10.2~~

~~29~~

~~33~~

~~24~~

~~17.2~~

~~79~~

~~56~~

~~16~~

~~15.1~~

~~53~~

~~50~~

~~12~~

~~13.5~~

~~39~~

~~44~~

~~0.9~~ ~~22.9~~

~~21~~

~~14~~ .

~~2~~

~~4~~

~~70~~

~~47~~

~~13~~

~~12~~ .

~~7~~

~~8~~

~~45~~

~~42~~

~~10~~

~~11.5~~

~~33~~

~~38~~

~~28~~

~~19.5~~

~~91~~

~~64~~

~~19~~

~~17.2~~

~~61~~

~~56~~

~~13~~

~~15.3~~

~~44~~

~~50~~

1.0	25.4
24	
16 .	
0	
1	
79	
53	
15	
14 .	
4	
3	
50	
47	
11	
12.8	
37	
42	
31	
21.9	
103	
72	
21	
19.2	
69	
63	
15	
17.1	
49	
56	
1.1	27.9
26.	

17.9	59	15. 8

88

52

17

14 .1

56

46

12

27.1

41

89

35

21.2

115

70

23

18.8

76

62

16 54

1.2	30.5

29

19 .6

97

64

18

17 .

8

3

62

57

14

~~15.5~~

~~45~~

~~51~~

~~39~~

~~29.6~~

~~127~~

~~97~~

~~26~~

~~23.3~~

~~84~~

~~76~~

~~18~~

~~20.6~~

~~59~~

~~68~~

~~1.3~~ ~~33~~

~~32~~

~~21 .4~~

~~106~~

~~70~~

~~20~~

~~18 .~~

~~6~~

~~8~~

~~67~~

~~62~~

~~15~~

~~16.8~~

~~49~~

~~55~~

~~42~~

~~32.1~~

~~139~~

~~105~~

~~28~~

~~25.4~~

~~92~~

~~83~~

~~20~~

~~22.4~~

~~64~~

~~73~~

~~1.4~~ ~~35.6~~

~~35~~

~~23 .~~

~~3~~

~~2~~

~~116~~

~~76~~

~~22~~

~~20 .~~

~~3~~

~~4~~

~~73~~

~~67~~

~~16~~

~~18.1~~

~~52~~

~~59~~

~~46~~

~~34.6~~

~~152~~

~~113~~

~~30~~

~~27.5~~

~~100~~

~~90~~

~~21~~

~~24.2~~

~~69~~

~~79~~

~~1.5~~ ~~38.1~~

~~38~~

~~27.~~

~~0~~

~~8~~

~~125~~

~~91~~

~~24~~

~~21.~~

~~0~~

~~9~~

~~79~~

~~72~~

~~17~~

~~19.5~~

~~56~~

~~64~~

~~50~~

~~37.0~~

~~163~~

~~121~~

~~33~~

~~29.6~~

~~107~~

~~97~~

~~23~~

~~26.0~~

~~74~~

~~85~~

~~1.6~~ ~~40.6~~

~~40~~

~~29.~~

~~8~~

~~7~~

~~134~~

~~97~~

~~25~~

~~23.~~

~~7~~

~~5~~

~~84~~

~~77~~

~~18~~

~~20.8~~

~~60~~

~~68~~

~~53~~

~~39.5~~

~~175~~

~~130~~

~~35~~

~~31.6~~

~~115~~

~~104~~

~~24~~

~~27.7~~

~~79~~

~~91~~

~~1.7~~ ~~43.2~~

~~43~~

~~31 .~~

~~7~~

~~5~~

~~143~~

~~103~~

~~27~~

~~25 .~~

~~5~~

~~0~~

~~90~~

~~82~~

~~19~~

~~22.1~~

~~64~~

~~73~~

~~57~~

~~42.0~~

~~188~~

~~138~~

~~37~~

~~33.8~~

~~123~~

~~111~~

~~26~~

~~29.5~~

~~84~~

~~97~~

~~1.8~~ ~~45.7~~

~~46~~

~~33 .4~~

~~152~~

~~110~~

~~29~~

~~26 .~~

~~2~~

~~6~~

~~96~~

~~87~~

~~21~~

~~23.5~~

~~68~~

~~77~~

~~61~~

~~44.4~~

~~199~~

~~146~~

~~40~~

~~35.9~~

~~131~~

~~118~~

~~27~~

~~31.3~~

~~89~~

~~103~~

~~1.9~~ ~~48.3~~

~~49~~

~~35 .~~

~~3~~

~~2~~

~~162~~

~~116~~

~~31~~

~~28 .~~

~~0~~

~~2~~

~~102~~

~~92~~

~~22~~

~~24.8~~

~~72~~

~~81~~

~~65~~

~~46.9~~

~~212~~

~~154~~

~~42~~

~~38.0~~

~~139~~

~~125~~

~~29~~

~~33.1~~

~~94~~

~~109~~

~~2.0~~	~~50.8~~

~~52~~

~~37 .1~~

~~171~~

~~122~~

~~32~~

~~29 .7~~

~~107~~

~~98~~

~~23~~

~~26.2~~

~~75~~

~~86~~

~~68~~

~~49.4~~

~~224~~

~~162~~

~~45~~

~~40.1~~

~~146~~

~~132~~

~~30~~

~~34.9~~

~~99~~

~~115~~

~~Note: Linear interpolation of internal pipe diameters and distances between table entries is allowed.~~

~~*For a list of exposures in each exposure group, see Column 1 of Table 7.3.2.3.1.2(B)(a).~~

~~†When calculating the minimum separation distance (D) using the formulas indicated, based on the exposure group and pressure indicated, the internal pipe diameter (d) is entered in millimeters (mm). The calculated distance (D) is expressed in units of measure in meters (m). To convert distance (D) to units of measure in feet, multiply the value of (D) in meters by 3.2808 and round to the nearest whole foot.~~

Additional Proposed Changes

File Name	Description	Approved
NFPA_2_Code_Revisions_Suggestions_12-6-23.docx	Word document with better formatting of tables.	

Statement of Problem and Substantiation for Public Input

The bulk gaseous separation distance calculation method has diverged from the bulk liquid separation distance. This adds consistency to the calculation method of the setback distances. Distances are still consequence-based, but calculations are now linked to a specific version of a software (HyRAM+, version 5.0) such that the calculations can be repeated and updated. Calculations have consistent criteria with the bulk liquid setback distances for each of the groups and also include unconfined overpressure as a criteria. These calculations are for a 3% by area leak with no safety factor. Group 1 criteria is the furthest distance to the 8% mole fraction, a heat flux of 4.7 kW/m^2 or an overpressure of 1 psi. Group 2 criteria is the furthest distance to a heat flux of 9 kW/m^2 or an overpressure of 2 psi. Group 3 criteria is the furthest distance to a heat flux of 20 kW/m^2, the visible flame length, or an overpressure of 3 psi. In addition, some exposures have been moved from group 3 to group 2 to remain consistent with the exposure groupings for bulk liquid.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 115-NFPA 2-2023 [Section No. 7.3.2.3.1.2(B)]	

Submitter Information Verification

Submitter Full Name: Ethan Hecht
Organization: Sandia National Laboratories
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 12:40:12 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: A basis is needed around changing from 1% to 3% is needed. More information is needed on if the 1% is an incorrect number or a technical parameter. The technical committee is unsure if this should apply retroactively and until that is clarified it cannot be added to the document. Justification for deletion of the safety factor is also needed. The technical committee is interested in seeing further work on this topic.

7.3.2.3.1.2* Minimum Distance for Aboveground Locations

(B) Maximum Internal Diameter of Interconnecting Piping.

The maximum internal diameter of the piping system used for interconnecting piping between the shutoff valve on any single storage container to the point of connection to the system source valve shall not be required to be in accordance with the values shown in Table 7.3.2.3.1.2(B)(a) when in accordance with Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c).

1. The separation distance for piping systems with internal diameters other than those specified in Table 7.3.2.3.1.2(B)(a) for the pressure range selected shall be permitted with tabular distances determined based on the use of Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c).
2. Separation distances determined based on the use of Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c) shall be subject to review and approval by the AHJ.
3. The separation distance shall be measured from the part of the bulk hydrogen compressed gas system closest to the exposure.
4. ***Determination of Internal Diameter.** The internal diameter of the piping system shall be determined by the diameter of the piping serving that portion of a storage array with content greater than 5000 scf (141.6 Nm^3). The piping system size used in the application of Table 7.3.2.3.1.2(B)(a), Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c) shall be determined based on that portion of the system with the greatest maximum internal diameter.
5. ***Determination of System Pressure.** The system pressure shall be determined by the maximum operating pressure of the storage array with content greater than 5000 scf (141.6N m^3), irrespective of those portions of the system elevated to a higher pressure.

Table 7.3.2.3.1.2(B)(a) Minimum Distance (D) from Outdoor Bulk Hydrogen Compressed Gas Systems to Exposures — Typical Maximum Pipe Size

Pressure	**>15 to ≤250 psig**		**>250 to ≤3000 psig**		**>3000 to ≤7500 psig**		**>7500 to ≤15000 psig**	
Internal Pipe Diameter (ID)	**>103.4 to ≤1724 kPa**		**>1724 to ≤20,684 kPa**		**>20,684 to ≤51,711 kPa**		**>51,711 to ≤103,421 kPa**	
d_{mm}	**d = 52.5mm**		**d = 18.97mm**		**d = 7.31mm**		**d = 7.16mm**	
Exposures Group 1	**m**	**ft**	**m**	**ft**	**m**	**ft**	**m**	**ft**
Lot lines	6	21	8	25	4	14	6	18
Air intakes (HVAC, compressors, other)								
Operable openings in buildings and structures								
Ignition sources such as open flames and welding								
Exposures Group 2	**m**	**ft**	**m**	**ft**	**m**	**ft**	**m**	**ft**
Exposed persons other than those servicing the system	6	19	7	22	4	13	5	16
Parked cars								
Buildings of combustible construction								

Pressure	>15 to ≤250 psig		>250 to ≤3000 psig		>3000 to ≤7500 psig		>7500 to ≤15000 psig	
Internal Pipe Diameter (ID)	>103.4 to ≤1724 kPa		>1724 to ≤20,684 kPa		>20,684 to ≤51,711 kPa		>51,711 to ≤103,421 kPa	
d_{mm}	$d = 52.5_{mm}$		$d = 18.97_{mm}$		$d = 7.31_{mm}$		$d = 7.16_{mm}$	
Hazardous materials storage systems above ground or fill/vent openings for below ground storage systems Ordinary combustibles, including fast-burning solids such as ordinary lumber, excelsior, paper, or combustible waste and vegetation other than that found in maintained landscaped areas								
Exposures Group 3	**m**	**ft**	**m**	**ft**	**m**	**ft**	**m**	**ft**
Buildings of non-combustible non-fire-rated construction Flammable gas storage systems above or below ground Heavy timber, coal, or other slow-burning combustible solids Unopenable openings in building and structures Encroachment by overhead utilities (horizontal distance from the vertical plane Below the nearest overhead electrical wire of building service) Piping containing other hazardous materials Flammable gas metering and regulating stations such as natural gas or propane.	5	17	6	20	4	12	5	15

Table 7.3.2.3.1.2(B)(b) Minimum Distance (D) from Outdoor Bulk Hydrogen Compressed Gas Systems to Exposures by Maximum Pipe Size with Pressures >15 to ≤3000 psig

Pressure		>15 to ≤250 psig >103.4 to ≤1724 kPa						>250 to ≤3000 psig >1724 to ≤20,684 kPa					
		Exposures*†						Exposures*†					
Internal Pipe Diameter (ID)		Group 1		Group 2		Group 3		Group 1		Group 2		Group 3	
		D=0.1232d-0.1690		D=0.1105d-0.0948		D=0.1015d-0.0324		D=0.4400d-0.7192		D=0.3847d-0.4629		D=0.3397d-0.1978	
ID (in.)	d (mm)	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft
0.2	5.1	0.5	2	0.5	2	0.5	2	1.8	6	1.7	6	1.6	5
0.3	7.6	0.8	3	0.8	3	0.7	2	2.8	9	2.6	9	2.4	8
0.4	10.2	1.1	4	1.0	3	1.0	3	3.8	13	3.5	12	3.3	11
0.5	12.7	1.4	5	1.3	4	1.3	4	4.9	16	4.4	15	4.1	14
0.6	15.2	1.7	6	1.6	5	1.5	5	5.9	19	5.4	18	5.0	16
0.7	17.8	2.0	7	1.9	6	1.8	6	7.0	23	6.3	21	5.8	19
0.8	20.3	2.3	8	2.1	7	2.0	7	8.1	27	7.3	24	6.7	22
0.9	22.9	2.6	9	2.4	8	2.3	7	9.2	30	8.2	27	7.5	25
1.0	25.4	2.9	10	2.7	9	2.5	8	10.3	34	9.2	30	8.4	28
1.1	27.9	3.2	11	3.0	10	2.8	9	11.4	37	10.2	33	9.2	30
1.2	30.5	3.5	12	3.2	11	3.0	10	12.5	41	11.2	37	10.1	33
1.3	33.0	3.9	13	3.5	12	3.3	11	13.7	45	12.2	40	11.0	36
1.4	35.6	4.2	14	3.8	13	3.6	12	14.8	49	13.1	43	11.9	39
1.5	38.1	4.5	15	4.1	13	3.8	13	16.0	52	14.1	46	12.7	42
1.6	40.6	4.8	16	4.4	14	4.1	13	17.1	56	15.1	50	13.6	45
1.7	43.2	5.2	17	4.7	15	4.3	14	18.3	60	16.2	53	14.5	47
1.8	45.7	5.5	18	5.0	16	4.6	15	19.5	64	17.2	56	15.3	50
1.9	48.3	5.8	19	5.3	17	4.9	16	20.6	68	18.2	60	16.2	53
2.0	50.8	6.1	20	5.5	18	5.1	17	21.8	72	19.2	63	17.1	56
2.1	53.3	6.5	21	5.8	19	5.4	18	23.0	75	20.2	66	18.0	59

Note: Linear interpolation of internal pipe diameters and distances between table entries is allowed.

*For a list of exposures in each exposure group, see Column 1 of Table 7.3.2.3.1.2(B)(a).

†When calculating the minimum separation distance (D) using the formulas indicated, based on the exposure group and pressure indicated, the internal pipe diameter (d) is entered in millimeters (mm). The calculated distance (D) is expressed in units of measure in meters (m). To convert distance (D) to units of measure in feet, multiply the value of (D) in meters by 3.2808 and round to the nearest whole foot.

Table 7.3.2.3.1.2(B)(c) Minimum Distance (D) from Outdoor Bulk Hydrogen Compressed Gas Systems to Exposures by Maximum Pipe Size with Pressures >3000 to ≤15,000 psig

Pressure		>3000 to ≤7500 psig >20,684 to ≤51,711 kPa						>7500 to ≤15,000 psig >51,711 to ≤103,421 kPa					
		Exposures*†						Exposures*†					
Internal Pipe Diameter (ID)		Group 1		Group 2		Group 3		Group 1		Group 2		Group 3	
		D=0.7684d-2.4405		D=0.5972d-0.7550		D=0.5201d-0.3371		D=1.0263d-2.5496		D=0.8061d-1.0658		D=0.6953d-0.4971	
ID (in.)	d (mm)	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft
0.2	5.1	2.8	9	2.6	9	2.5	8	3.8	13	3.5	11	3.2	11
0.3	7.6	4.4	14	4.0	13	3.7	12	5.9	19	5.3	18	4.9	16
0.4	10.2	6.0	20	5.4	18	5.0	16	8.1	27	7.3	24	6.6	22
0.5	12.7	7.6	25	6.8	22	6.3	21	10.3	34	9.2	30	8.3	27
0.6	15.2	9.3	30	8.3	27	7.6	25	12.6	41	11.1	37	10.1	33
0.7	17.8	11.0	36	9.8	32	8.9	29	14.9	49	13.1	43	11.8	39
0.8	20.3	12.7	42	11.3	37	10.2	33	17.2	56	15.1	50	13.5	44
0.9	22.9	14.4	47	12.8	42	11.5	38	19.5	64	17.2	56	15.3	50
1.0	25.4	16.1	53	14.3	47	12.8	42	21.9	72	19.2	63	17.1	56
1.1	27.9	17.9	59	15.8	52	14.1	46	27.1	89	21.2	70	18.8	62
1.2	30.5	19.6	64	17.3	57	15.5	51	29.6	97	23.3	76	20.6	68
1.3	33	21.4	70	18.8	62	16.8	55	32.1	105	25.4	83	22.4	73
1.4	35.6	23.2	76	20.4	67	18.1	59	34.6	113	27.5	90	24.2	79
1.5	38.1	27.8	91	21.9	72	19.5	64	37.0	121	29.6	97	26.0	85
1.6	40.6	29.7	97	23.5	77	20.8	68	39.5	130	31.6	104	27.7	91
1.7	43.2	31.5	103	25.0	82	22.1	73	42.0	138	33.8	111	29.5	97
1.8	45.7	33.4	110	26.6	87	23.5	77	44.4	146	35.9	118	31.3	103
1.9	48.3	35.2	116	28.2	92	24.8	81	46.9	154	38.0	125	33.1	109
2.0	50.8	37.1	122	29.7	98	26.2	86	49.4	162	40.1	132	34.9	115

Note: Linear interpolation of internal pipe diameters and distances between table entries is allowed.

*For a list of exposures in each exposure group, see Column 1 of Table 7.3.2.3.1.2(B)(a).

†When calculating the minimum separation distance (D) using the formulas indicated, based on the exposure group and pressure indicated, the internal pipe diameter (d) is entered in millimeters (mm). The calculated distance (D) is expressed in units of measure in meters (m). To convert distance (D) to units of measure in feet, multiply the value of (D) in meters by 3.2808 and round to the nearest whole foot.

7.3.2.3.1.2* Minimum Distance for Aboveground Locations
(B) Separation distances determined based on the use of Table 7.3.2.3.1.2(B)(b), Table 7.3.2.3.1.2(B)(c), and Table 7.3.2.3.1.2(B)(c) shall be subject to review and approval by the AHJ.
(C) The separation distance shall be measured from the part of the bulk hydrogen compressed gas system closest to the exposure.
(D) ***Determination of Internal Diameter.** The internal diameter of the piping system shall be determined by the diameter of the piping serving that portion of a storage array with content greater than 5000 scf (141.6 Nm^3). The piping system size used in the application of Table 7.3.2.3.1.2(B)(a), Table 7.3.2.3.1.2(B)(b) or Table 7.3.2.3.1.2(B)(c) shall be determined based on that portion of the system with the greatest maximum internal diameter.
(E) ***Determination of System Pressure.** The system pressure shall be determined by the maximum operating pressure of the storage array with content greater than 5000 scf (141.6N m^3), irrespective of those portions of the system elevated to a higher pressure.

Table 7.3.2.3.1.2(B)(a) Listing of exposures for each group

Exposures Group 1
Lot lines
Air intakes (HVAC, compressors, other)
Operable openings in buildings and structures
Ignition sources such as open flames and welding
Exposures Group 2
Exposed persons other than those servicing the system
Parked cars
Buildings of combustible construction
Hazardous materials storage systems above ground or fill/vent openings for below ground storage systems
Ordinary combustibles, including fast-burning solids such as ordinary lumber, excelsior, paper, or combustible waste and vegetation other than that found in maintained landscaped areas
Exposures Group 3
Buildings of non-combustible non-fire-rated construction
Flammable gas storage systems above or below ground
Heavy timber, coal, or other slow-burning combustible solids
Unopenable openings in building and structures
Encroachment by overhead utilities (horizontal distance from the vertical plane Below the nearest overhead electrical wire of building service)
Piping containing other hazardous materials
Flammable gas metering and regulating stations such as natural gas or propane.

Table 7.3.2.3.1.2(B)(b) Minimum Distance (ft) from Outdoor Bulk Hydrogen Compressed Gas Systems to Group 1 Exposures by Maximum Pipe Size with Maximum Pressure and Inner Pipe Diameter

Internal Pipe Diameter (in)	Maximum Pressure (psig)											
	250	**500**	**750**	**1,000**	**2,000**	**3,000**	**4,000**	**5,000**	**7,500**	**10,000**	**12,500**	**15,000**
0.2	2	2	3	3	5	6	7	8	9	11	12	13
0.3	3	4	5	5	8	9	11	12	14	16	18	19
0.4	4	5	6	7	10	13	15	16	20	22	25	27
0.5	5	6	8	9	13	16	18	21	25	28	31	34
0.6	6	8	10	11	16	19	23	25	30	35	38	41
0.7	7	9	11	13	19	23	27	30	36	41	45	49
0.8	8	11	13	15	22	27	31	34	42	47	52	56
0.9	9	12	15	17	25	30	35	39	47	54	59	64
1	10	14	17	19	27	34	39	44	53	60	66	72
1.1	11	15	18	21	30	37	43	48	59	67	74	89
1.2	12	16	20	23	33	41	48	53	64	73	90	97
1.3	13	18	22	26	36	45	52	58	70	89	98	105
1.4	14	19	24	28	40	49	56	63	76	96	106	113
1.5	15	21	26	30	43	52	61	68	91	103	113	121
1.6	16	22	28	32	46	56	65	72	97	110	121	130
1.7	17	24	29	34	49	60	69	77	103	117	128	138
1.8	18	25	31	36	52	64	74	91	110	124	136	146
1.9	19	27	33	38	55	68	78	96	116	131	143	154
2	20	28	35	41	58	72	92	102	122	138	151	162
2.1	21	30	37	43	61	75	96	107	128	144	158	170

Notes: Linear interpolation of internal pipe diameters and distances between table entries by diameter is allowed.

Alternative calculations within the maximum pressures and diameters in the table may be made using the formula $D = 1.3653 \cdot d \cdot P^{0.4250}$ where D is the group 1 distance in ft, d is the internal pipe diameter in in and P is the maximum pressure in psi.

For a list of exposures in each exposure group, see Table 7.3.2.3.1.2(B)(a).

Table 7.3.2.3.1.2(B)(c) Minimum Distance (ft) from Outdoor Bulk Hydrogen Compressed Gas Systems to Group 2 Exposures by Maximum Pipe Size with Maximum Pressure and Inner Pipe Diameter

		Maximum Pressure (psig)											
		250	**500**	**750**	**1,000**	**2,000**	**3,000**	**4,000**	**5,000**	**7,500**	**10,000**	**12,500**	**15,000**
Internal Pipe Diameter (in)	**0.2**	2	2	3	3	5	6	6	7	9	10	11	11
	0.3	3	4	4	5	7	9	10	11	13	15	16	18
	0.4	3	5	6	7	9	12	13	15	18	20	22	24
	0.5	4	6	7	8	12	15	17	19	22	25	28	30
	0.6	5	7	9	10	14	18	20	23	27	31	34	37
	0.7	6	8	10	12	17	21	24	27	32	36	40	43
	0.8	7	10	12	14	20	24	27	31	37	42	46	50
	0.9	8	11	13	16	22	27	31	35	42	48	52	56
	1	9	12	15	17	25	30	35	39	47	53	58	63
	1.1	10	14	17	19	27	33	38	43	52	59	65	70
	1.2	11	15	18	21	30	37	42	47	57	65	71	76
	1.3	12	16	20	23	33	40	46	51	62	70	77	83
	1.4	13	18	21	25	35	43	50	55	67	76	84	90
	1.5	13	19	23	27	38	46	53	60	72	82	90	97
	1.6	14	20	25	29	41	50	57	64	77	88	96	104
	1.7	15	22	26	30	43	53	61	68	82	93	103	111
	1.8	16	23	28	32	46	56	65	72	87	99	109	118
	1.9	17	24	30	34	49	60	69	76	92	105	116	125
	2	18	26	31	36	51	63	73	81	98	111	122	132
	2.1	19	27	33	38	54	66	76	85	103	117	129	139

Notes: Linear interpolation of internal pipe diameters and distances between table entries by diameter is allowed.

Alternative calculations within the maximum pressures and diameters in the table may be made using the formula $D = 0.6813 \cdot d \cdot P^{0.4752}$ where D is the group 2 distance in ft, d is the internal pipe diameter in in and P is the maximum pressure in psi.

For a list of exposures in each exposure group, see Table 7.3.2.3.1.2(B)(a).

Table 7.3.2.3.1.2(B)(d) Minimum Distance (ft) from Outdoor Bulk Hydrogen Compressed Gas Systems to Group 3 Exposures by Maximum Pipe Size with Maximum Pressure and Inner Pipe Diameter

		Maximum Pressure (psig)											
		250	**500**	**750**	**1,000**	**2,000**	**3,000**	**4,000**	**5,000**	**7,500**	**10,000**	**12,500**	**15,000**
Internal Pipe Diameter (in)	**0.2**	2	2	3	3	4	5	6	7	8	9	10	11
	0.3	2	3	4	5	7	8	9	10	12	14	15	16
	0.4	3	5	6	6	9	11	12	14	16	18	20	22
	0.5	4	6	7	8	11	14	15	17	21	23	25	27
	0.6	5	7	8	10	13	16	19	21	25	28	31	33
	0.7	6	8	10	11	16	19	22	24	29	33	36	39
	0.8	7	9	11	13	18	22	25	28	33	38	41	44
	0.9	7	10	13	14	20	25	28	31	38	43	47	50
	1	8	12	14	16	23	28	32	35	42	48	52	56
	1.1	9	13	15	18	25	30	35	39	46	52	58	62
	1.2	10	14	17	19	27	33	38	42	51	57	63	68
	1.3	11	15	18	21	30	36	41	46	55	62	68	73
	1.4	12	16	20	23	32	39	45	49	59	67	74	79
	1.5	13	17	21	24	34	42	48	53	64	72	79	85
	1.6	13	19	23	26	37	45	51	57	68	77	85	91
	1.7	14	20	24	28	39	47	54	60	73	82	90	97
	1.8	15	21	26	29	41	50	58	64	77	87	96	103
	1.9	16	22	27	31	44	53	61	68	81	92	101	109
	2	17	23	28	33	46	56	64	71	86	97	107	115
	2.1	18	25	30	34	48	59	68	75	90	102	112	120

Notes: Linear interpolation of internal pipe diameters and distances between table entries by diameter is allowed.

Alternative calculations within the maximum pressures and diameters in the table may be made using the formula $D = 0.6862 \cdot d \cdot P^{0.4608}$ where D is the group 2 distance in ft, d is the internal pipe diameter in in and P is the maximum pressure in psi.

For a list of exposures in each exposure group, see Table 7.3.2.3.1.2(B)(a).

Public Input No. 111-NFPA 2-2023 [Section No. 7.3.2.5]

7.3.2.5 Courts.

Where a bulk gas system is located in a court or enclosed court, the installation shall meet all of the following requirements:

(1) Courts shall have natural or mechanical ventilation in accordance with Section 6.18.

(2) Explosion control shall be provided in accordance with the requirements of ~~Section 6.10~~ . Chapter 9

(3) The distance from any part of the system to exterior building walls and related exposures shall meet the requirements of Table 7.3.2.3.1.2(B)(a), Table 7.3.2.3.1.2(B)(b), or Table 7.3.2.3.1.2(B)(c).

(4) Fire barrier walls shall meet the requirements of 7.3.2.3.1.4(A)(1) through 7.3.2.3.1.4(A)(4) and 7.3.2.3.1.4(A)(7) through 7.3.2.3.1.4(A)(9).

(5) Vents and ventilation exhausts shall terminate above the walls or outside of the court.

Statement of Problem and Substantiation for Public Input

this redirects explosion control to chapter 9

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 108-NFPA 2-2023 [Section No. 7.1.23.15.1 [Excluding any Sub-Sections]]	
Public Input No. 109-NFPA 2-2023 [Section No. 7.3.2.2.2.3]	
Public Input No. 110-NFPA 2-2023 [Section No. 7.3.2.2.3.3]	
Public Input No. 175-NFPA 2-2023 [Chapter 9]	Chapter 9
Public Input No. 112-NFPA 2-2023 [Section No. 8.3.2.2.2.1(B)]	
Public Input No. 113-NFPA 2-2023 [Section No. 8.3.2.2.3.2]	
Public Input No. 114-NFPA 2-2023 [Section No. 10.5.3.4.1.4]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control Task Group
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 14 10:27:28 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-33-NFPA 2-2024

Statement: The cross reference to section 6.10 is being changed to chapter 9 which now contains the explosion protection requirements.

Public Input No. 202-NFPA 2-2023 [New Section after 8.1.2]

8.1.2.1 Overfilling.

Controls shall be provided to prevent overfilling of stationary containers. ...

Statement of Problem and Substantiation for Public Input

Relocated from 8.1.5.5
Substantiation: This requirement addresses overfill prevention but is currently under 8.1.5 which addresses pressure relief vent piping. Relocating to create a new section 8.1.2.1, which addresses container design, makes sense.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 15:51:50 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-165-NFPA 2-2024
Statement: This requirement addresses overfill prevention but is currently under 8.1.5 which addresses pressure relief vent piping. Relocating to create a new section 8.1.2.1, which addresses container design.

Public Input No. 185-NFPA 2-2023 [New Section after 8.1.5.5]

8.1.5.6 Pressure relief devices or stationary or portable containers shall be vented directly outdoors or to an exhaust hood.

Statement of Problem and Substantiation for Public Input

Substantiation: This new (to this section) requirement has been relocated from 6.4.1.1.2, where it was misplaced, and placed here in the GH2 PRD section. Containers are separate from cylinders and tanks. The proponent thinks this requirement is not needed and this PI is intended to solicit TC input for a rejection basis. This is related to PI-183. LH2 is addressed separately.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 183-NFPA 2-2023 [Section No. 6.4.1.1.2]	

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 13:21:30 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-137-NFPA 2-2024

Statement: This revision mimics the language of 6.4.1.1.2 (which has been moved to Chapter 7 through a separate action).

Containers are separate from cylinders and tanks. A related change has been made separately to address LH2 in a similar manner. An editorial change was also made to correct a typo.

Also see FR-116.

Public Input No. 44-NFPA 2-2023 [Section No. 8.2.2.3.4.1(D)]

~~(D)~~ –

~~The fire barrier wall shall be located not less than 5 ft (1.5 m) from any exposure.~~

Statement of Problem and Substantiation for Public Input

Location of fire barriers relative to exposures is not always under the control of the hydrogen system owner, such as offsite exposures.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 14:14:46 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-166-NFPA 2-2024
Statement: For non-bulk systems this overly constricting as certain exposures can be anchored to the fire barrier wall such as can be the case for hydrogen cylinders. Additionally, this requirement requires a 5ft separation from the exposure and not the system which is overly limiting and does not enhance safety

Public Input No. 46-NFPA 2-2023 [Section No. 8.3.1.2.1]

8.3.1.2.1 Fire ~~Protection~~ Resistance of Structural Supports.

8.3.1.2.1.1*

Steel supports in excess of 18 in. (457 mm) in height shall have a minimum 2-hour fire resistance rating in accordance with ASTM E1529, *Determining the Effects of Large Hydrocarbon Pool Fires on Structural Members and Assemblies*.

Statement of Problem and Substantiation for Public Input

Fire protection is a sprinkler system. Fire resistance is coating and materials that meets ASTM standards referenced.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 14:25:47 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-167-NFPA 2-2024
Statement: The title has been updated to the appropriate term since fire protection is a broad based term while fire resistance is specific for coating and materials. This change aligns with the referenced ASTM standard along with NFPA 252 and NFPA 257.

Public Input No. 176-NFPA 2-2023 [Section No. 8.3.1.2.2.3]

8.3.1.2.2.3

Hydrogen venting systems discharging to the atmosphere shall be in accordance with CGA G-5.5, *Hydrogen Vent Systems and 6 . 17 .*

Statement of Problem and Substantiation for Public Input

In the 2023 edition, 8.3.1.2.2.3 does not require the designer to follow 6.17 and only requires the designer to follow CGA G-5.5. CGA- G-5.5 has no requirement for area classifications around a vent stack. CGA G-5.5 only requires the designer to be responsible for the extent of the LFL vapor cloud. The standard distances for area classification bubbles listed in NPFA-2 and NFPA-497 are prescriptive and appear only for leaks. They currently do not consider normal operational venting or non-catastrophic releases. Following section 6.17, IEC 60079-10-1 requires defining an area class bubble based on the normal or non-catastrophic release rate.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 105-NFPA 2-2023 [Section No. 6.17.2]	Area Classification
Public Input No. 177-NFPA 2-2023 [Section No. 6.17 [Excluding any Sub-Sections]]	
Public Input No. 253-NFPA 2-2024 [Section No. 8.3.1.2.6.1]	

Submitter Information Verification

Submitter Full Name: Allen Adriani
Organization: Plug Power
Street Address:
City:
State:
Zip:
Submittal Date: Sun Dec 24 11:32:50 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-169-NFPA 2-2024

Statement: CGA- G-5.5 has no requirement for area classifications around a vent stack. Additionally, 6.17 already requires CGA G-5.5 with additional requirements and has been removed since it is redundant.

The standard distances for area classification bubbles listed in NPFA-2 and NFPA-497 are prescriptive and appear only for leaks. They currently do not consider normal operational venting or noncatastrophic releases. Following section 6.17, IEC 60079-10-1 requires defining an area class bubble based on the normal or non-catastrophic release rate.

Public Input No. 253-NFPA 2-2024 [Section No. 8.3.1.2.6.1]

~~8.3.1.2.6.1~~ –

~~Specific locations for the Class 1, Division 1, Group B (hydrogen) and Class 1, Division 2, Group B (hydrogen) areas shall be classified in accordance with Table 8.3.1.2.6.1 .~~

~~Table 8.3.1.2.6.1 Electrical Area Classification~~

~~Location Division Extent of Classified Area The bulk liquefied hydrogen system fill connection, pressure relief vent outlets, or other points on the system where hydrogen is vented to the atmosphere under the designed operating conditions 1 Within 3 ft (1 m) measured spherically from system fill connection, system pressure relief vent outlets, other points of release when the system is operating as designed - 2 Between 3 ft (1 m) and 25 ft (7.6 m) measured spherically from the system fill connection, any vent outlet, and within 25 ft (7.6 m) of any portion of the bulk supply system that contains liquefied hydrogen~~

Statement of Problem and Substantiation for Public Input

In recognition that 8.3.1.2.6.1 and Table 8.3.1.2.6.1 are in direct conflict with section 6.17.2. It is also not in the spirit of the code with NFPA 497 5.6.1(see Annex A.5.6.1), which NFPA 497 was derived from API RP 500. API RP 500 8.2.3.1.1 that process vents in the non-enclosed areas are too "diverse to specify distances." This section needs to be delated.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 178-NFPA 2-2023 [Section No. 7.3.2.3.1.2(A)]	
Public Input No. 177-NFPA 2-2023 [Section No. 6.17 [Excluding any Sub-Sections]]	
Public Input No. 176-NFPA 2-2023 [Section No. 8.3.1.2.2.3]	
Public Input No. 105-NFPA 2-2023 [Section No. 6.17.2]	

Submitter Information Verification

Submitter Full Name: Allen Adriani
Organization: Plug Power
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 16:39:27 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: The proposed revision does not resolve the issue with area classification during a normal venting. Deletion of the table does not address the stated issue but recommendations to make specific revisions to the table could be proposed for consideration.

Public Input No. 95-NFPA 2-2023 [Section No. 8.3.1.2.6.1]

8.3.1.2.6.1

Specific locations for the Class 1, Division 1, Group B (hydrogen) and Class 1, Division 2, Group B (hydrogen) areas shall be classified in accordance with Table 8.3.1.2.6.1.

Table 8.3.1.2.6.1 Electrical Area Classification

Location	Division	Extent of Classified Area
The bulk liquefied hydrogen system fill connection, pressure relief vent outlets, or other points on the system where hydrogen is vented to the atmosphere under the designed operating conditions	1	Within 3 ft (1 m) measured spherically from system fill connection, system pressure relief vent outlets, other points of release when the system is operating as designed
	2	Between 3 ft (1 m) and 25 ft (7.6 m) measured spherically from the system fill connection, any vent outlet, and within 25 ft (7.6 m) of any portion of the bulk supply system that contains liquefied hydrogen

Additional Proposed Changes

File Name	Description	Approved
TIA_2_23_3.pdf	NFPA 2 TIA Log No. 23-3 Log No. 1725	

Statement of Problem and Substantiation for Public Input

NOTE: This public input originates from Tentative Interim Amendment No. 2 Log No.1725 issued by the Standards Council on August 25, 2023, and per the NFPA Regs., needs to be reconsidered by the Technical Committee for the next edition of the Document.

Substantiation: The incorrect division is being referenced. The division should match table 8.3.1.2.6.1.

Emergency Nature: The standard contains an error or an omission that was overlooked during the regular revision process.

Submitter Information Verification

Submitter Full Name:
Organization: TIA
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 11:03:00 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: No further changes need to be made in addition with the TIA.

Tentative Interim Amendment

NFPA® 2

Hydrogen Technologies Code

2023 Edition

Reference: 8.3.1.2.6.1
TIA 23-3
(SC 23-8-45 / TIA Log #1725)

Pursuant to Section 5 of the NFPA *Regulations Governing the Development of NFPA Standards*, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 2, *Hydrogen Technologies Code*, 2023 edition. The TIA was processed by the Technical Committee on Hydrogen Technology and was issued by the Standards Council on August 25, 2023, with an effective date of September 14, 2023.

1. Revise paragraph 8.3.1.2.6.1 to read as follows:

8.3.1.2.6.1 Specific locations for the Class 1, Division 1, Group B (hydrogen) and Class 1, Division ~~1,~~2, Group B (hydrogen) areas shall be classified in accordance with Table 8.3.1.2.6.1.

Issue Date: August 25, 2023

Effective Date: September 14, 2023

(Note: For further information on NFPA Codes and Standards, please see www.nfpa.org/docinfo**)**
Copyright © 2023 All Rights Reserved
NATIONAL FIRE PROTECTION ASSOCIATION

Public Input No. 62-NFPA 2-2023 [Section No. 8.3.1.2.8.3]

8.3.1.2.8.3 Emergency Shutdown System Operation.

When an emergency shutdown (ESD) is required, activation of the ~~ESD system~~ Emergency Shutdown System (ESS) shall shut down operation of all pumps and compressors.

Statement of Problem and Substantiation for Public Input

The confusing use of the terms ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV. The harmonized definitions are show below:
Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.
Emergency Shutoff Valve (ESV)* -- A designated valve designed to shut off the flow of fluid in the event of an emergency

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 57-NFPA 2-2023 [Section No. 3.3.69]	
Public Input No. 58-NFPA 2-2023 [Sections 3.3.69, 3.3.70]	
Public Input No. 59-NFPA 2-2023 [New Section after 3.3.69]	
Public Input No. 60-NFPA 2-2023 [Section No. 3.3.63.1]	
Public Input No. 61-NFPA 2-2023 [Section No. 3.3.252]	
Public Input No. 63-NFPA 2-2023 [Section No. 8.3.1.2.9]	
Public Input No. 64-NFPA 2-2023 [New Section after A.3.3.64]	

Submitter Information Verification

Submitter Full Name:	Robert Boyd
Organization:	Boyd Hydrogen LLC
Affiliation:	This is one of a series of leftover PCs that came out of the previous cycle HEE TG that were too late for the first draft
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Oct 23 14:12:55 EDT 2023
Committee:	HYD-AAA

Committee Statement

Resolution: FR-124-NFPA 2-2024

Statement: The confusing use of the terms ESD and ESD System [Emergency Shutdown System (ESS)] has been clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together (e.g., ESS, ESD, and ESV).

Public Input No. 88-NFPA 2-2023 [Section No. 8.3.1.2.8.3]

8.3.1.2.8.3 Emergency Shutdown System Operation.

When an emergency shutdown (ESD) is required, activation of the ~~ESD system shall~~ emergency shutdown system (ESS) shall shut down operation of all pumps and compressors.

Additional Proposed Changes

File Name	Description	Approved
PC_No._90_Rejected_but_Held.pdf	NFPA 2 PC No. 90 Rejected but held	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as "Rejected but Held" in Public Comment No. 90 of A2022 Second Draft Report for NFPA 2 and per Regs. at 4.4.8.3.1 and needs to be reconsidered by the TC for the next edition of the document.

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comment will provide consistency in the definitions and use of the terms ESS an ESD trough out the document.
This proposal also harmonizes the use of these term in CSA-HGV-4.1 and CSA-HGV-4.6.

Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

This Public Comment 90 supplements the changes proposed in PC-79 , PC-80, PC-81, PC-82, PC-83, PC-84 and PC-87

Submitter Information Verification

Submitter Full Name:
Organization: Holds
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 09:45:20 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-124-NFPA 2-2024

Statement: The confusing use of the terms ESD and ESD System [Emergency Shutdown System (ESS)] has been clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together (e.g., ESS, ESD, and ESV).

Public Comment No. 90-NFPA 2-2021 [Section No. 8.3.1.2.8.3]

8.3.1.2.8.3 Emergency Shutdown System Operation.

When an emergency shutdown (ESD) is required, activation of the ~~ESD system~~ emergency shutdown system (ESS) shall shut down operation of all pumps and compressors.
[~~**55:** 11.2.8.3~~]

Additional Proposed Changes

File Name	Description	Approved
ESD-ESS_-_Rev5.pdf	Clarification of ESS and ESD and definition of ESS in NFPA-2	

Statement of Problem and Substantiation for Public Comment

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comment will provide consistency in the definitions and use of the terms ESS an ESD trough out the document.
This proposal also harmonizes the use of these term in CSA-HGV-4.1 and CSA-HGV-4.6.

Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:
Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

This Public Comment 90 supplements the changes proposed in PC-79 , PC-80, PC-81, PC-82, PC-83, PC-84 and PC-87

Related Item

• PI-230

Submitter Information Verification

Submitter Full Name:	Robert Boyd
Organization:	Boyd Hydrogen LLC
Affiliation:	This change was developed after a further review of NFPA-2 first draft and submittal of PC-79 , PC-80, PC-81, PC-82, PC-83, PC-84 and PC-87
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Thu Jun 03 00:20:33 EDT 2021
Committee:	HYD-AAA

Committee Statement

Committee Action:	Rejected but held
Resolution:	The proposed revisions were not discussed during the First Draft meeting and are considered to be new material which cannot be acted upon at the Second Draft meeting.

Clarification of ESS and ESD and definition of ESS in NFPA-2

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comments will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This series of Public Comments also harmonizes the use of these terms with what is defined in CSA-HGV-4.1 *Hydrogen Dispensers,* and CSA-HGV-4.9 *Hydrogen Fueling Stations*

This document supports public comments: PC-79 , PC-80, PC-81, PC-82, PC-83, PC-84, PC-87 and PC-90

Problem Statement

The confusing use of the term ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Annex notes (new)

A.3.3.69. Emergency Shutdown Device (ESD).

Emergency Shutdown Devices (ESDs) may be any of the following devices that will "trip" the Emergency Shutdown System (ESS) to shut down the system into a safe mode:

1. A manually operated red pushbutton switch with a yellow background in compliance with NFPA-79,
2. A low pressure switch measuring hydrogen compressor suction pressure,
3. An UV/IR or hydrogen detector,
4. Or any other safety related input device that has a switch for electrical conductivity of signal or other means of connection to the ESS.

Most hydrogen Fueling station modules will include a separate ESS to stop the process of the module (production, compression, dispensing) in the event of an ESS activation.

Each hydrogen fueling station site will typically have all operating modules connected to a site-wide Emergency Shutdown System.

Emergency Shutdown System (ESS): The ESS responds to any activation of an ESD and shuts down the system safely.

Actions to take in NFPA-2

- Delete 3.3.63.1 (ESD definition, extract from NFPA 52)
- Modify 3.3.69 (ESD- use definition from ANSI/CSA HGV 4.1)

- Add new section after 3.3.69 (ESS-use definition from ANSI/CSA HGV 4.1) – this will go between ESD and Emergency Shutoff Valve
- Modify 3.3.70 Emergency Shutoff Valve drop link to see 3.3.250.1 and adopt current language: A designated valve designed to shut off the flow of liquids or gases

The following shows how the use of ESD and ESS need to be cleaned up and how important it is to define ESS

- 8.3.1.2.8.3 – propose to change "ESD" to "ESS" and "ESD system" change to "ESS"
  - Proposed language: "When an emergency shutdown is required, activation of the ESS shall shut down operation of all pumps and compressors. 55:11.2.8.3
- 8.3.1.2.9- propose to add acronym (ESS)
- 8.3.1.2.9.2- propose to change "system" to "device:
  - Proposed language: "An emergency shutdown device (ESD) shall be provided at the bulk source to stop the flow of liquid and gas into the use line when actuated."
- 8.3.2.1.9.4- Proposed language: "Reactivation of the ESS after activation shall require that the ESS be manually reset."
-
- 8.3.1.2.9.5- Proposed language: "The ESD manual activation shall be identified by means of a sign."
- 11.3.1.8: change "(ESD)" to "(ESS)". Revise language

This proposal was developed during parallel discussions by members of the NFPA-2-HEE Task Group

The following change was developed after a further review of NFPA-2 first draft are shown below:

8.3.1.2.8.3 Emergency Shutdown System Operation.
When an emergency shutdown (ESD) is required, activation of the **Emergency Shutdown System (ESS)** ~~**ESD** system~~ shall shut down operation of all pumps and compressors. [~~**55:**11.2.8.3~~]

Public Input No. 63-NFPA 2-2023 [Section No. 8.3.1.2.9]

8.3.1.2.9 Emergency Shutdown System.

8.3.1.2.9.1

Emergency isolation shall comply with 7.1.25.1, 8.3.1.2.4.2, and 8.3.1.2.9.

8.3.1.2.9.2

An emergency shutdown device (ESD) ~~system shall~~ shall be provided at the bulk source to stop the flow of liquid and gas into the use line when actuated.

8.3.1.2.9.3

The ~~ESD system~~ Emergency Shutdown System shall be operated by a remotely located, manually activated shutdown ~~control located~~ device (switch or push button) located not less than 15 ft (4.5 m) from the source of supply.

8.3.1.2.9.4

Reactivation of the ~~ESD system after ESD~~ ESS after an ESD event shall require that the ~~ESD system be~~ ESS be manually reset.

8.3.1.2.9.5

The ~~ESD system shall~~ manually activated ESD (s) shall be identified by means of a sign.

Statement of Problem and Substantiation for Public Input

The confusing use of the terms ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

this PC is one of a series of leftover PCs that came out of the previous cycle HEE TG that were too late for the first draft

The harmonized definitions are show below:
Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.
Emergency Shutoff Valve (ESV)* -- A designated valve designed to shut off the flow of fluid in the event of an emergency

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 57-NFPA 2-2023 [Section No. 3.3.69]	
Public Input No. 58-NFPA 2-2023 [Sections 3.3.69, 3.3.70]	
Public Input No. 59-NFPA 2-2023 [New Section after 3.3.69]	
Public Input No. 60-NFPA 2-2023 [Section No. 3.3.63.1]	
Public Input No. 61-NFPA 2-2023 [Section No. 3.3.252]	
Public Input No. 62-NFPA 2-2023 [Section No. 8.3.1.2.8.3]	
Public Input No. 64-NFPA 2-2023 [New Section after A.3.3.64]	

Submitter Information Verification

Submitter Full Name:	Robert Boyd
Organization:	Boyd Hydrogen LLC
Affiliation:	This is one of a series of leftover PCs that came out of the previous cycle HEE TG that were too late for the first draft
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Oct 23 14:16:35 EDT 2023
Committee:	HYD-AAA

Committee Statement

Resolution: FR-125-NFPA 2-2024

Statement: The confusing use of the terms ESD and ESD System [Emergency Shutdown System (ESS)] has been clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together (e.g., ESS, ESD, and ESV).

Public Input No. 85-NFPA 2-2023 [Section No. 8.3.1.2.9]

8.3.1.2.9 Emergency Shutdown System (ESS) .

8.3.1.2.9.1

Emergency isolation shall comply with 7.1.25.1, 8.3.1.2.4.2, and 8.3.1.2.9.

8.3.1.2.9.2

An emergency shutdown (ESD) ~~system~~ _ shall be provided at the bulk source to stop the flow of liquid and gas into the use line when actuated. [**55:** 11.2.9.2]

8.3.1.2.9.3

The ~~ESD~~ emergency shutdown system (ESS) shall be ~~operated by a~~ initiated by a remotely located, manually activated shutdown ~~control~~ device (ESD) located not less than 15 ft (4.5 m) from the source of supply. [**55:** 11.2.9.3]

8.3.1.2.9.4

Reactivation of the ~~ESD system~~ ESS after ~~ESD~~ and ESD activation shall require that ~~the ESD system~~ the ESS be manually reset.. [**55:** 11.2.9.4]

8.3.1.2.9.5

The ~~ESD system shall be identified by~~ ESD (Emergency Stop Button) shall be red in color and identified by means of a sign. [**55:** 11.2.9.5]

Additional Proposed Changes

File Name	Description	Approved
PC_No._83_Rejected_but_Held.pdf	NFPA 2 PC No. 83 Rejected but held	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as "Rejected but Held" in Public Comment No. 83 of A2022 Second Draft Report for NFPA 2 and per Regs. at 4.4.8.3.1 and needs to be reconsidered by the TC for the next edition of the document.

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comment will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This proposal also harmonizes the use of these term in CSA-HGV-4.1 and CSA-HGV-4.6.
Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:
Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation

Submitter Information Verification

Submitter Full Name:
Organization: Holds

Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 09:20:12 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-125-NFPA 2-2024

Statement: The confusing use of the terms ESD and ESD System [Emergency Shutdown System (ESS)] has been clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together (e.g., ESS, ESD, and ESV).

Public Comment No. 83-NFPA 2-2021 [Section No. 8.3.1.2.9]

8.3.1.2.9 Emergency Shutdown System (ESS) .

8.3.1.2.9.1

Emergency isolation shall comply with 7.1.24.1, 8.3.1.2.4.2, and 8.3.1.2.9.

8.3.1.2.9.2

An emergency shutdown [device (ESD)] ~~system~~ shall be provided at the bulk source to stop the flow of liquid and gas into the use line when actuated. [**55:**11.2.9.2]

8.3.1.2.9.3

The ~~ESD system shall be operated by~~ emergency shutdown system (ESS) shall be initiated by a remotely located, manually activated shutdown ~~control~~ device (ESD) located not less than 15 ft (4.5 m) from the source of supply. [**55:**11.2.9.3]

8.3.1.2.9.4

Reactivation of the ~~ESD system~~ ESS after and ESD ~~shall~~ activation shall require that the ~~ESD system be~~ ESS be manually reset. [**55:**11.2.9.4]

8.3.1.2.9.5

The ESD ~~system shall be identified~~ (Emergency Stop Button) shall be red in color and identified by means of a sign. [**55:**11.2.9.5]

Additional Proposed Changes

File Name	Description	Approved
ESD-ESS_Rev_1.pdf	Clarification of ESS and ESD and definition of ESS in NFPA-2	

Statement of Problem and Substantiation for Public Comment

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comment will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This proposal also harmonizes the use of these term in CSA-HGV-4.1 and CSA-HGV-4.6.
Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:
Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Related Item

• PI-230

Submitter Information Verification

Submitter Full Robert Boyd

Name:	
Organization:	Boyd Hydrogen LLC
Affiliation:	This proposal was developed during parallel discussions by members of the NFPA-HEE Task Group
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Jun 02 18:31:20 EDT 2021
Committee:	HYD-AAA

Committee Statement

Committee Action:	Rejected but held
Resolution:	The proposed revisions were not discussed during the First Draft meeting and are considered to be new material which cannot be acted upon at the Second Draft meeting.

Clarification of ESS and ESD and definition of ESS in NFPA-2

Problem Statement

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comment will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This proposal also harmonizes the use of these term in CSA-HGV-4.1 and CSA-HGV-4.6.

Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

This word file will be used for multiple public comments

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Annex notes

Emergency Shutdown Devices (ESDs) may be: manually operated (Red) pushbuttons with a yellow background in compliance with NFPA-79, a low pressure switch measuring compressor suction pressure or any other input device that will "trip" an the Emergency Shutdown System (ESS) to shut down the system into a safe mode.

The Emergency Shutdown System (ESS) responds to any activation of an ESD and shut down the system safely

Actions to take in NFPA-2

- Delete 3.3.63.1 (ESD definition, extract from NFPA 52)
- Modify 3.3.69 (ESD- use definition from ANSI/CSA HGV 4.1)
- Add new section after 3.3.69 (ESS-use definition from ANSI/CSA HGV 4.1) – this will go between ESD and Emergency Shutoff Valve
- Modify 3.3.70 Emergency Shutoff Valve drop link to see 3.3.250.1 and adopt current language: A designated valve designed to shut off the flow of liquids or gases
- Modify 3.3.250.1 and refer to 3.3.70

The following shows how the use of ESD and ESS need to be cleaned up and how important it is to define ESS

- 8.3.1.2.8.3 – propose to change "ESD" to "ESS" and "ESD system" change to "ESS"
  - Proposed language: "When an emergency shutdown is required, activation of the ESS shall shut down operation of all pumps and compressors. 55:11.2.8.3
- 8.3.1.2.9- propose to add acronym (ESS)

- 8.3.1.2.9.2- propose to change "system" to "device:
  - Proposed language: "An emergency shutdown device (ESD) shall be provided at the bulk source to stop the flow of liquid and gas into the use line when actuated."

- 8.3.2.1.9.4- Proposed language: "Reactivation of the ESS after activation shall require that the ESS be manually reset."
-
- 8.3.1.2.9.5- Proposed language: "The ESD manual activation shall be identified by means of a sign."

- 11.3.1.8: change "(ESD)" to "(ESS)". Revise language

This proposal was developed during parallel discussions by members of the NFPA-HEE Task Group

Public Input No. 43-NFPA 2-2023 [Section No. 8.3.1.2.9.1]

8.3.1.2.9.1

Emergency isolation shall comply with ~~7.1.25.1~~ , 8.3.1.2.4.2 , and 8.3.1.2.9 , and any of the approved means of meeting the requirements for emergency isolation, which shall include any of the following:

(1) Automatic shutoff valves, located as close to the bulk source as practical, tied to leak detection systems

(2) Attended control stations, local or remote, where trained personnel can monitor alarms or supervisory signals and can trigger emergency responses

(3) Excess flow valves at the bulk source

Statement of Problem and Substantiation for Public Input

To make the requirements consistent with those for gaseous hydrogen in chapter 7.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 14:09:17 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-170-NFPA 2-2024
Statement: This revision has been made since emergency isolation is necessary for both liquid and gas storage. This language is consistent with 7.1.25.2 for gaseous storage.

Public Input No. 47-NFPA 2-2023 [Section No. 8.3.2.2.2]

8.3.2.2.2 Detached Buildings.

~~**8.3.2.2.2.1** – Explosion Control.~~

(A) _

Detached buildings

~~containing more than 300 gal (1136 L) of LH~~ 2

shall be constructed of noncombustible or limited-combustible materials in accordance with the requirements of the adopted building code.

(B)

A building containing more than 300 gallons of LH2 shall be a detached building.

8.3.2.2.2.1 Explosion Control.

-

Explosion control shall be provided in accordance with the requirements of Section 6.10.

8.3.2.2.2.2 Ventilation.

Ventilation shall be provided in accordance with the requirements of Section 6.18 and 8.3.2.2.2.2(A) through 8.3.2.2.2.2(D).

(A)

Inlet openings shall be located within 18 in. (0.46 m) of the floor in exterior walls only.

(B)

Outlet openings shall be located at the high point of the room in exterior walls or the roof.

(C)

Both the inlet and outlet vent openings shall have a minimum total area of 1 ft^2/1000 scf (1 m^2/300 Nm^3) of room volume.

(D)

Discharge from outlet openings shall be directed or conducted to a location that allows for dissipation of the exhaust air in the ambient surroundings away from air intakes and occupied spaces.

8.3.2.2.2.3* Ignition Sources.

There shall be no sources of ignition within the room or area where the hydrogen system is installed.

8.3.2.2.2.4 Heating.

(A)

Heating, if provided, shall be by indirect means such as steam or hot water.

(B)

Electrical heating in accordance with 8.1.9 shall be allowed.

Statement of Problem and Substantiation for Public Input

The MAQ is an important point that triggers special provisions like explosion control and fire protection.

Exceeding 300 gallons is what triggers a detached building, which is a supplemental special provision on top of being an H-occupancy triggered at the MAQ.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 14:30:28 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-178-NFPA 2-2024
Statement: The MAQ is an important point that triggers special provisions like explosion control and fire protection. Exceeding 300 gallons is what triggers a detached building, which is a supplemental special provision on top of being an H-occupancy triggered at the MAQ.

Public Input No. 112-NFPA 2-2023 [Section No. 8.3.2.2.2.1(B)]

(B)

Explosion control shall be provided in accordance with the requirements of ~~Section~~ ~~6.10~~ . Chapter 9

Statement of Problem and Substantiation for Public Input

this redirects explosion control to chapter 9

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 108-NFPA 2-2023 [Section No. 7.1.23.15.1 [Excluding any Sub-Sections]]	
Public Input No. 109-NFPA 2-2023 [Section No. 7.3.2.2.2.3]	
Public Input No. 110-NFPA 2-2023 [Section No. 7.3.2.2.3.3]	
Public Input No. 111-NFPA 2-2023 [Section No. 7.3.2.5]	
Public Input No. 175-NFPA 2-2023 [Chapter 9]	Chapter 9
Public Input No. 113-NFPA 2-2023 [Section No. 8.3.2.2.3.2]	
Public Input No. 114-NFPA 2-2023 [Section No. 10.5.3.4.1.4]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control Task Group
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 14 10:41:21 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-179-NFPA 2-2024
Statement: The cross reference to section 6.10 is being changed to Chapter 9 which now contains the explosion protection requirements.

Public Input No. 48-NFPA 2-2023 [Section No. 8.3.2.2.3]

8.3.2.2.3 Gas Rooms.

Gas rooms containing LH2 quantities greater than the MAQ shall comply with the provisions of 8.3.2.2.

8. 3.2.2.3. 1

Heating, if provided, shall be by steam, hot water, or other indirect means.

8.3.2.2.3.2

Explosion control shall be provided in accordance with the requirements of Section 6.10.

8.3.2.2.3.3

Electrical heating in accordance with 8.1.9 shall be allowed.

Statement of Problem and Substantiation for Public Input

To ensure the provision is linked to the building code for indoor storage to prevent an oversight.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 14:35:32 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-37-NFPA 2-2024
Statement: The addition of the cross reference to 8.3.2.2 clarify that all the provisions of 8.3.2.2 apply for gas rooms and not just the 3 requirements of 8.3.2.2.3. The 6.10 cross reference is being corrected to chapter 9 which covers explosion protection requirements.

Public Input No. 113-NFPA 2-2023 [Section No. 8.3.2.2.3.2]

8.3.2.2.3.2

Explosion control shall be provided in accordance with the requirements of ~~Section~~ ~~6.10~~ . Chapter 9

Statement of Problem and Substantiation for Public Input

this redirects explosion control to chapter 9

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 108-NFPA 2-2023 [Section No. 7.1.23.15.1 [Excluding any Sub-Sections]]	
Public Input No. 109-NFPA 2-2023 [Section No. 7.3.2.2.2.3]	
Public Input No. 110-NFPA 2-2023 [Section No. 7.3.2.2.3.3]	
Public Input No. 111-NFPA 2-2023 [Section No. 7.3.2.5]	
Public Input No. 112-NFPA 2-2023 [Section No. 8.3.2.2.2.1(B)]	
Public Input No. 175-NFPA 2-2023 [Chapter 9]	Chapter 9
Public Input No. 114-NFPA 2-2023 [Section No. 10.5.3.4.1.4]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control Task Group
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 14 10:45:35 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-37-NFPA 2-2024

Statement: The addition of the cross reference to 8.3.2.2 clarify that all the provisions of 8.3.2.2 apply for gas rooms and not just the 3 requirements of 8.3.2.2.3. The 6.10 cross reference is being corrected to chapter 9 which covers explosion protection requirements.

Public Input No. 16-NFPA 2-2023 [Section No. 8.3.2.3.1.5(D)]

(D)* Open Courts

Stationary containers shall be sited so that they are open to the surrounding environment except that encroachment by building walls of unlimited height shall be permitted when in accordance with the distances specified by Table 8.3.2.3.1.6(a) ~~or the material-specific tables in Chapters 9, 11, 13, and 16 of NFPA 55~~ .

(1)* Where exterior building walls encroach on the system to form a court, the system shall be located at a distance not less than the height of the wall from at least two court walls.

(2) The required distance between the exterior walls of the building forming the court and the container shall be determined independently without regard to fire barrier walls used to allow encroachment by fire exposure hazards.

Statement of Problem and Substantiation for Public Input

NFPA 55 no longer covers hydrogen, so the references to sections of NFPA 55 should be removed.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Affiliation: NFPA 2/55 hydrogen alignment task group
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 24 14:33:37 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-5-NFPA 2-2024

Statement: The scope of NFPA 2 has been revised to contain all requirements for hydrogen storage, use, and handling. The scope of NFPA 55 has been revised so that it no longer contains requirements for hydrogen storage, use, and handling. These sections of NFPA 2 were originally extracted from NFPA 55's general language that applies to all cryogenic fluids and compressed gases, including oxygen, nitrogen, and other gases along with hydrogen. NFPA 2 has removed the extract tags and now maintains the requirements for hydrogen in these sections.

Public Input No. 45-NFPA 2-2023 [New Section after 8.3.2.3.1.6(A)]

8.3.2.3.1.6(A)(1) (new)

Vent stack termination shall be sited in accordance with 6.17.

Statement of Problem and Substantiation for Public Input

A link to 6.17 is needed.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 14:18:55 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-172-NFPA 2-2024
Statement: This revision provides a cross-reference to Section 6.17 which provides more specific detail for vent stack terminations.

Public Input No. 175-NFPA 2-2023 [Chapter 9]

Chapter 9 Explosion ~~Protection (Reserved)~~ **~~Control~~**

9.1* General

Explosion control shall be provided for buildings and hydrogen equipment enclosures where the amount of GH2 or LH2 exceeds the maximum allowable quantities per control area or where required by the hazard analysis in accordance with 9.2

A.9.1

Explosion control is provided to prevent formation of flammable mixtures, prevent ignition, protect against deflagration, and prevent detonation conditions from developing when there is the potential to exceed 1 percent hydrogen concentration in enclosures.

NFPA 69 provides guidance on the use of suppression, ventilation systems, and the limiting of oxidants as a means to prevent the occurrence of an explosion.

NFPA 68 provides guidance on the use of deflagration venting systems in buildings and other enclosures. The primary purpose of a venting system is to relieve the overpressure produced in an explosion to limit the potential damage to the building where the explosion occurs. Although some structural damage can be anticipated, the use of relief venting is expected to prevent massive building failure and collapse. In cases where detonation is probable, venting is often used in conjunction with barricade construction where the pressure-resistant portions of the building have been constructed to resist the pressures anticipated should an explosive event occur.

When relief vents are to be used as a means to provide deflagration relief, the fundamental requirements of the adopted building code for structural elements, including snow, wind, and seismic events, should be considered. In some instances, the requirements for wind resistance can impose more rigorous requirements on the relief vents than required by the engineering analysis used to determine the relief pressure. Users must demonstrate that the relief vents will not become airborne or release in such a manner as to create secondary hazards within or external to the building in which they are installed. Specific designs might require approval by the AHJ.

9.1.2 Explosion prevention shall be in accordance with one or more of the methods specified in this chapter or NFPA 69 .

9.1.2 Deflagration venting shall not be an allowed method to mitigate detonations.

9.1.3. Where provided, explosion protection by the use of deflagration venting shall be in accordance with this chapter or NFPA 68 .

9.1.4 Deflagration prevention and control for occupied enclosures shall prevent the structural failure of the enclosure and minimize injury to personnel in adjacent areas outside of the enclosure. [**69:** 4.2.1.1]

9.1.5 Deflagration prevention and control for unoccupied enclosures shall prevent the rupture of the enclosure. [**69:** 4.2.1.2]

9.1.6 Deflagration prevention and control shall be arranged to avoid injury to personnel. [**69:** 4.2.1.3]

9.1.7 Deflagration prevention and control systems shall be designed to limit damage of the protected enclosure. [**69:** 4.2.2.1]

9.1.8 Deflagration prevention and control systems shall be arranged to avoid ignition of

adjacent property. [**69:** 4.2.2.2]

9.1.9 Deflagration prevention and control systems shall be designed to avoid damage to adjacent property. [**69:** 4.2.2.3]

9.1.10 Deflagration prevention and control shall be designed to avoid projectile damage to adjacent property. [**69:** 4.2.2.4]

9 . 2 Hazard Analysis.

9.2.1 A documented hazard analysis acceptable to the authority having jurisdiction shall be permitted to be conducted to determine the level of protection to be provided.

9.2.2 The documented hazard analysis shall consider the expected leak rates and ventilation system employed and

9.2.2.1 The documented hazard analysis shall specify the explosion prevention and control requirements in accordance with this chapter and NFPA 69

9.2.2.2 When required, the documented hazard analysis shall specify the deflagration venting requirements in accordance with this chapter and NFPA 68.

9.2.3 The risk of detonations shall not be mitigated by deflagration venting.

9.2.4 The documented hazard analysis shall identify the considered explosion hazard scenarios.

9.2.4.1 The design basis for the explosion prevention and control systems shall be based on the explosion hazard scenarios of 9.2.4.

9.2.4.2 The determined explosion prevention and control systems shall be documented in the hazard analysis.

9.3 Methods.

The methods recognized in this code shall be grouped based on the prevention or limitation of damage after combustion occurs. [**69:** 6.1]

9.3.1 Methods Based on the Prevention of Combustion.

The following shall be considered methods based on preventing combustion:

(1) Oxidant concentration reduction

(2) Combustible concentration reduction

[**69:** 6.1.1]

9.3.2* Methods Based on the Prevention or Limitation of Damage.

The following shall be considered methods based on preventing or limiting damage:

(1) * Predeflagration detection and ignition control systems

(2) Deflagration suppression

(3) Isolation methods

(4) Deflagration pressure containment

[**69:** 6.1.2]

A.9.3.2

The table below shows the detection limits for layers of protection used to minimize the

risk of ignition and deflagration of hydrogen / air mixtures

A screenshot of a document Description automatically generated

A.9.3.2(1)

Annex L contains guidance relative to the detection of hydrogen.

9.3.3* Limitations.

The limitations specific to each method shall be considered and are specified in the corresponding chapter for each method. [**69:** 6.2]

A.9.3.3.

Damage resulting from detonations cannot be prevented or limited by deflagration suppression or deflagration pressure containment.

9.3.4 Factors to Be Considered.

The following factors shall be considered in the selection of one of the methods and the design of the system:

(1) Effectiveness of each method

(2) Reliability of the system

(3) Personnel hazards inherent in each method

[**69:** 6.3]

9.3.5 System Reliability

The reliability of the system chosen shall be assessed using the following factors:

(1) System design basis

(2) Possibility of electrical and mechanical malfunction *(see 15.5.5.1 of NFPA 69 for safety system controls and instrumentation reliability requirements)*

(3) Dependence on sophisticated activating systems

(4) Need for special installation, training, operating, testing, and maintenance procedures

(5) Further limitations as presented in each chapter

[**69:** 6.3.1]

9.3.6 Installation, Inspection, and Maintenance of Explosion Protection Systems

The installation, inspection, and maintenance of explosion necessary for proper function of and operation of deflagration prevention and control systems shall be in accordance with this standard and Chapter 15 of NFPA 69.

9.4 Deflagration Venting

When required by 9.2 ,deflagration venting shall be provided in accordance with this chapter and NFPA 68.

9.4.1 Deflagration venting shall not be permitted for management of detonations.

9.4.2* . Where the hazard consists of a hydrogen in air mixture, the vent size shall be based on the fundamental burning velocity of the mixture.

A.9.4.2 _

See annex K.1 Burning Velocity of Hydrogen of NFPA 68.

9.4.3* _ _ Where the gas mixture composition is not certain, the vent size shall be based on the component having the highest fundamental burning velocity. [**68:** 6.2.1.2]

A.9.7.3

See annex X for more information on design deflagration venting for hydrogen enclosures.

9.4.3.1* _ Deflagration venting shall be designed for 18 percent hydrogen in air.

A.9.4.3.1

Hydrogen concentrations exceeding approximately 18 vol percent can readily undergo a deflagration to detonation transition in large enclosures, particularly those with congestion.

Additional Proposed Changes

File Name	Description	Approved
NFPA-2_Chapter_9_Staff_Review-v4_Clean.docx	Chapter 9 staff review Rev 4 with notes and comments and track changes	
Annex_X-reformat_-_for_new_Annex_K.docx	Chapter 9 staff review Rev 4 CLEAN copy	
Exposion_Control_TG_PCs.xlsx		

Statement of Problem and Substantiation for Public Input

this is the work product of the 2023 NFPA-2 Task Group on Explosion Control

in the big picture, this chapter replaces the 6.10 Explosion Control section, and guides the user to use the flame speed of 18% H2 in air when calculating deflagration vents.

this replaces the confusion of NFPA-68 calling for the use of the highest flame velocity (stoichiometric) when calculating deflagration vents, yet detonation can not be controlled with deflagration vents. this new language and the new language for annex K is a big step forward.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 174-NFPA 2-2023 [Chapter K]	new material for annex K
Public Input No. 169-NFPA 2-2023 [Section No. 3.3.81]	
Public Input No. 108-NFPA 2-2023 [Section No. 7.1.23.15.1 [Excluding any Sub-Sections]]	
Public Input No. 109-NFPA 2-2023 [Section No. 7.3.2.2.2.3]	
Public Input No. 110-NFPA 2-2023 [Section No. 7.3.2.2.3.3]	
Public Input No. 111-NFPA 2-2023 [Section No. 7.3.2.5]	
Public Input No. 112-NFPA 2-2023 [Section No. 8.3.2.2.2.1(B)]	
Public Input No. 113-NFPA 2-2023 [Section No. 8.3.2.2.3.2]	

Public Input No. 114-NFPA 2-2023 [Section No. 10.5.3.4.1.4]
Public Input No. 157-NFPA 2-2023 [Section No. 6.10]
Public Input No. 174-NFPA 2-2023 [Chapter K]

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: 2023 NFPA-2 Explosion Control Task Group
Street Address:
City:
State:
Zip:
Submittal Date: Sat Dec 23 11:06:23 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-77-NFPA 2-2024

Statement: Chapter 9 points enables the design and use of explosion vents and blow out panels for enclosures that contain hydrogen systems and captures (extracts) key requirements from NFPA-68 and NFPA-69 for explosion prevention and control, including deflagration venting. The explosion protection calculations of NFPA 68 require a deflagration vent that is larger than the available vent area.

The calculated deflagration vent area per NFPA 68 for a stoichiometric mixture of hydrogen is in many cases larger then the available vent area for the enclosure. The additional benefit from vent sized for more than 18% diminishes rapidly based on the increased likelihood of DDT. The numbers in table 9.3.2 come from the information in the Ventdef: A new engineering model for vented gas deflagration based on NFPA 68(2018) by Amy Shen and Derek Miller paper and Thomas Jordan Karlsruhe Institute of technology research. Key requirements are extracted from NFPA 69 to point the user to basic explosion prevention requirements.

This review is based off NFPA 2 Chapter 9 Explosion Protection Task Group, rev 10 work.

Extract Source Documents:

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, edition 2023.
NFPA 69, *Standard on Explosion Prevention Systems*, edition 2024.

New Definitions:

3.3.XX Deflagration.
Propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium. [**68,** 2023]

3.3.XX Detonation.
Propagation of a combustion zone at a velocity that is greater than the speed of sound in the unreacted medium. [**68,** 2023]

3.3.XX* Enclosure.
A confined or partially confined volume. [**68,** 2023]

> **A.3.3.XX Enclosure.**
> Examples of enclosures include a room, building, vessel, silo, bin, pipe, or duct. [**68,** 2023]

Revised Definitions:

3.3.51.2* Explosion Control.
A means of preventing an explosion **either** through the use of explosion suppression, fuel reduction, or oxidant reduction systems **or a** means to prevent the structural collapse of a building in the event of an explosion through the use of deflagration venting, barricades, or related construction methods.

A.3.3.51.2 Explosion Control
See Chapter 9

New Chapter Language:

Chapter 9 Explosion Control

9.1* General
Explosion control shall be provided for buildings and hydrogen equipment enclosures where the amount of GH2 or LH2 exceeds the maximum allowable quantities per control area or where required by the hazard analysis in accordance with 9.2

> A.9.1
> Explosion control is provided to prevent formation of flammable mixtures, prevent ignition, protect against deflagration, and prevent detonation conditions from developing when there is the potential to exceed 1 percent hydrogen concentration in enclosures.
>
> NFPA 69 provides guidance on the use of suppression, ventilation systems, and the limiting of oxidants as a means to prevent the occurrence of an explosion.

NFPA 68 provides guidance on the use of deflagration venting systems in buildings and other enclosures. The primary purpose of a venting system is to relieve the overpressure produced in an explosion to limit the potential damage to the building where the explosion occurs. Although some structural damage can be anticipated, the use of relief venting is expected to prevent massive building failure and collapse. In cases where detonation is probable, venting is often used in conjunction with barricade construction where the pressure-resistant portions of the building have been constructed to resist the pressures anticipated should an explosive event occur.

When relief vents are to be used as a means to provide deflagration relief, the fundamental requirements of the adopted building code for structural elements, including snow, wind, and seismic events, should be considered. In some instances, the requirements for wind resistance can impose more rigorous requirements on the relief vents than required by the engineering analysis used to determine the relief pressure. Users must demonstrate that the relief vents will not become airborne or release in such a manner as to create secondary hazards within or external to the building in which they are installed. Specific designs might require approval by the AHJ.

9.1.2
Explosion prevention shall be in accordance with one or more of the methods specified in this chapter or NFPA 69.

9.1.2 Deflagration venting shall not be an allowed method to mitigate detonations.

9.1.3*
Where provided, explosion protection by the use of deflagration venting shall be in accordance with this chapter or NFPA 68.

9.1.3
Deflagration prevention and control for occupied enclosures shall prevent the structural failure of the enclosure and minimize injury to personnel in adjacent areas outside of the enclosure. [**69:**4.2.1.1]

9.1.4
Deflagration prevention and control for unoccupied enclosures shall prevent the rupture of the enclosure. [**69:**4.2.1.2]

9.1.5
Deflagration prevention and control shall be arranged to avoid injury to personnel. [**69:**4.2.1.3]

9.1.6
Deflagration prevention and control systems shall be designed to limit damage of the protected enclosure. [**69:**4.2.2.1]

9.1.7
Deflagration prevention and control systems shall be arranged to avoid ignition of adjacent property. [**69:**4.2.2.2]

9.1.6
Deflagration prevention and control systems shall be designed to avoid damage to adjacent property. [**69:**4.2.2.3]

9.1.8
Deflagration prevention and control shall be designed to avoid projectile damage to adjacent property. [**69:**4.2.2.4]

9.2 Hazard Analysis.

9.2.1
A documented hazard analysis acceptable to the authority having jurisdiction shall be permitted to be conducted to determine the level of protection to be provided.

This review is based off NFPA 2 Chapter 9 Explosion Protection Task Group, rev 10 work.

9.2.2
The documented hazard analysis shall consider the expected leak rates and ventilation system employed and

9.2.2.1

The documented hazard analysis shall specify the explosion prevention and control requirements in accordance with this chapter and NFPA 69

9.2.2.2

When require, the documented hazard analysis shall specify the deflagration venting requirements in accordance with this chapter and NFPA 68.

9.2.3
The risk of detonations shall not be mitigated by deflagration venting.

9.2.4
The documented hazard analysis shall identify the considered explosion hazard scenarios.

9.2.4.1
The design basis for the explosion prevention and control systems shall be based on the explosion hazard scenarios of 9.2.4.

9.2.4.2
The determined explosion prevention and control systems shall be documented in the hazard analysis.

9.3 * Methods.
The methods recognized in this code shall be grouped based on the prevention or limitation of damage after combustion occurs. [**69:**6.1]

9.3.1 Methods Based on the Prevention of Combustion.
The following shall be considered methods based on preventing combustion:

(1) Oxidant concentration reduction
(2) Combustible concentration reduction
[**69:**6.1.1]

9.3.2* Methods Based on the Prevention or Limitation of Damage.
The following shall be considered methods based on preventing or limiting damage:
(1) * Predeflagration detection and ignition control systems
(2) Deflagration suppression
(3) Isolation methods

(4) Deflagration pressure containment
[**69:**6.1.2]

A.9.3.2
The table below shows the detection limits for layers of protection used to minimize the risk of ignition and deflagration of hydrogen / air mixtures

This review is based off NFPA 2 Chapter 9 Explosion Protection Task Group, rev 10 work.

					Emergency Shutdown System			Range of H2 in Air for deflagration venting										
					Alarm Action	Alarm Action	Alarm Action	Flammable		Explosive range of H2 in Air								
		Portable Personal Monitors (0 to 1000 ppm)			FLAMMABLE GAS DETECTION			still	turbulent	Deflagration			Detonation			Deflagration		Flammable	
					25% LFL	50% LFL	"LFL"											
hydrogen	%	0.001%	0.01%	0.10%	1%	2%	4%	5%	10%	10.5%	12%	17%	18.2%	29.53%	58.9%	60%	70%	71%	100%
hydrogen	**ppm**	**10**	**100**	**1000**	10,000	20,000	40,000	50,000	100,000	105,000	120,000	170,000	182,000	295,300	589,000	600,000	700,000	710,000	1,000,000
air	**%**	99.999%	99.99%	99.9%	99%	98%	96%	95%	90%	89.5%	88%	83%	82%	70%	41%	40%	30%	29%	0%
nitrogen	%	78%	78%	78%	77%	77%	75%	74%	70%	69.9%	69%	65%	64%	55%	32%	31%	23%	23%	0%
oxygen	%	21%	21%	21%	21%	21%	20%	20%	19%	18.8%	18%	17%	17%	15%	9%	8%	6%	6%	0%
Argon	%	1%	1%	1%	1%	1%	1%	1%	1%	0.8%	1%	1%	1%	1%	0.4%	0.4%	0.3%	0.3%	0%
CO2	%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	0.036%	0.04%	0.03%	0.03%	0.03%	0.02%	0.02%	0.01%	0.01%	0.00%
Hydrogen	ppm	10	100	1,000	10,000	20,000	40,000	50,000	100,000	105,000	120,000	170,000	182,000	295,300	589,000	600,000	700,000	710,000	1,000,000
oxygen	ppm	209,498	209,479	209,291	207,405	205,310	201,120	199,025	188,550	187,503	184,360	173,885	171,371	147,635	86,105	83,800	62,850	60,755	-
H2/O2									0.530363	0.559993	0.6509	0.977658	1.062023	2.000208	6.840525	7.159905	11.13763	11.68628	
hydrogen	gm/m3	0.0008	0.008	0.084	0.84	1.67	3.35	4.19	8.4	8.8	10.0	14.2	**15.2**	**24.7**	**49.3**	50.2	58.6	59.4	83.7
oxygen	gm/m3	275	275	275	273	270	264	262	248	246	242	228	225.2	194.0	113.1	110	83	80	0
TNT equiv	grams	0.02	0.24	2.40	24	48	96	120	240	252	288	408	436	708	1412	1439	1679	1703	2398

Lower Explosion limits : H2 in air @ 1 atm			10.50%	Thomas Jordan KITS	14-Sep-23	
	Explosion limits : H2 in air @ 1 atm		12%-70% (by Volume)			
	Detonable limits: H2 in air @ 1 atm		18.2%-70% (by Volume)			
	Flammable and Detonation limits from AP document 900-13-082-US (2014)					
	28.65	grams TNT/ gram H2				

A.9.3.2(1)
Annex L contains guidance relative to the detection of hydrogen.

9.3.3* Limitations.
The limitations specific to each method shall be considered and are specified in the corresponding chapter for each method. [**69:**6.2]

A.9.3.3.
Damage resulting from detonations cannot be prevented or limited by deflagration suppression or deflagration pressure containment.

9.3.4 Factors to Be Considered.
The following factors shall be considered in the selection of one of the methods and the design of the system:

(1) Effectiveness of each method
(2) Reliability of the system
(3) Personnel hazards inherent in each method

[**69:**6.3]

9.3.5 System Reliability
The reliability of the system chosen shall be assessed using the following factors:

(1) System design basis
(2) Possibility of electrical and mechanical malfunction *(see 15.5.5.1 of NFPA 69 for safety system controls and instrumentation reliability requirements)*
(3) Dependence on sophisticated activating systems
(4) Need for special installation, training, operating, testing, and maintenance procedures
(5) Further limitations as presented in each chapter
[**69:**6.3.1]

9.3.6 Installation, Inspection, and Maintenance of Explosion Protection Systems
The installation, inspection, and maintenance of explosion necessary for proper function of and operation of deflagration prevention and control systems shall be in accordance with this standard and Chapter 15 of NFPA 69.

This review is based off NFPA 2 Chapter 9 Explosion Protection Task Group, rev 10 work.

9.4 Deflagration Venting

When required by 9.2 ,deflagration venting shall be provided in accordance with this chapter and NFPA 68.

9.4.1

Deflagration venting shall not be permitted for management of detonations.

9.4.2*

Where the hazard consists of a hydrogen in air mixture, the vent size shall be based on the fundamental burning velocity of the mixture.

> **A.9.4.2**
> See annex K.1 Burning Velocity of Hydrogen of NFPA 68.

9.4.3*

Where the gas mixture composition is not certain, the vent size shall be based on the component having the highest fundamental burning velocity. [**68:**6.2.1.2]

> **A.9.7.3**
> See annex X for more information on design deflagration venting for hydrogen enclosures.

9.4.3.1*

Deflagration venting shall be designed for 18 percent hydrogen in air.

> **A.9.4.3.1**
> Hydrogen concentrations exceeding approximately 18 vol percent can readily undergo a deflagration to detonation transition in large enclosures, particularly those with congestion.

Annex X Determination of Internal Overpressure, External Overpressure and Fireball Size Resulting from Deflagration Venting of Hydrogen/Hydrogen Mixtures Based on NFPA 68 (2018)

This annex is a paper by Amy Shen and Derek Miller, "Ventdef: A new engineering model for vented gas deflagration based on NFPA 68 (2018)" [1]. Air Products and Chemicals, Inc.1940 Air Products Boulevard Allentown, PA 18106-5500.

X.1 Introduction. In the event of an accidental release of hydrogen inside an enclosure, a flammable gas cloud could form. Explosion of such a flammable cloud could have catastrophic consequences since confined deflagration can lead to much higher overpressures than would be the case for an equivalent explosion in the open atmosphere. Specific measures are usually required to reduce risk to a tolerable level. Forced or natural ventilation is commonly used to reduce flammable gas concentrations inside enclosures, and deflagration vents are commonly used to relieve deflagration over-pressure and mitigate potential equipment damage and risk to people close to the enclosure.

Various engineering models are available in the literature, including NFPA 68. After several significant developments and re-issues of NFPA 68 in recent years, NFPA 68 (2018) [2] is now proven to better address fast-burning fuels such as hydrogen. However, NFPA 68 (2018) recommends considering the worst-case stoichiometric mixture. This usually leads to over-conservative results and has limited applicability for hydrogen and hydrogen mixtures which has high reactivity.

Since NFPA 68 (2018) is based on fundamental combustion parameters, it can easily be modified to other hydrogen concentrations, more representative of expected conditions, resulting in less conservative conclusions. NFPA 68 (2018) modified in this way has been validated against published data across a range of hydrogen concentrations, from tests performed between 2016 and 2018 in Europe, under the project named HySEA[3,4].

X.2 Overview of HySEA Tests [3,4]. HySEA project aimed to conduct pre-normative research on vented hydrogen deflagrations to provide recommendations for European and international standards on hydrogen explosion venting mitigation systems. 66 vented deflagration tests were successfully performed using standard 20ft shipping containers, with various hydrogen concentrations, levels of internal congestion and deflagration panel size. 42 tests were with ignited homogeneous and quiescent mixtures (14 tests vented through open doors, one test with closed container, and 27 tests vented through openings on the roof). The remaining 24 tests were with ignited inhomogeneous mixtures (17 tests with stratified mixtures and 7 tests with initial turbulence generated by either a fan or a transient jet).

The tests include two venting orientations – roof venting with different vent areas and different opening pressures (blowout panels or plastic sheets), door venting with the door fully open, as shown in Figure X.2(a). Four levels of internal congestions were investigated to study the impact including no obstruction, pipe rack, bottle basket and high congestion. Figure X.2(b) shows the obstacles used in the tests. Internal and external pressure transducers, as well as external high-speed video recorded the tests.

Figure X.2(c) illustrates the positions of the pressure sensors. The internal pressure sensors were positioned at the U-beams along the side walls of the container, in the same distances from

the back wall as the eight bolts holding the frame. External overpressures were measured at 5 m, 10 m and 15 m from the door on the container, and about 1.65 m above ground. For experiments with venting through the roof, pressure sensor P10 was moved to a position above the container, about 2.7 m above the container roof and 1.25 m from the back wall of the container.

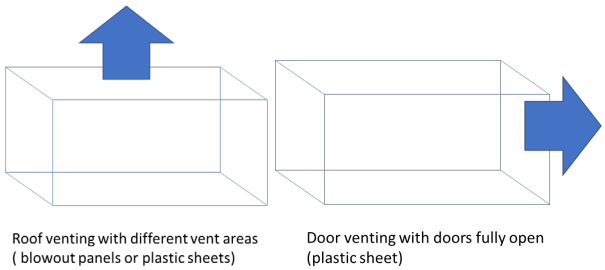


Figure X.2(a) Test Vent Orientations – Roof and Door

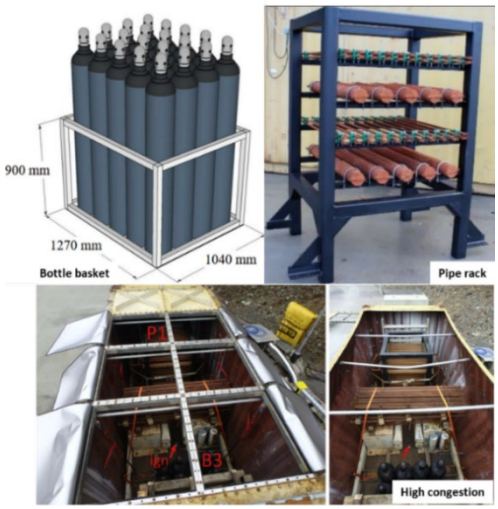


Figure X.2(b) Different Obstacles in the Tests: Bottle Basket, Pipe Rack and High Congestion

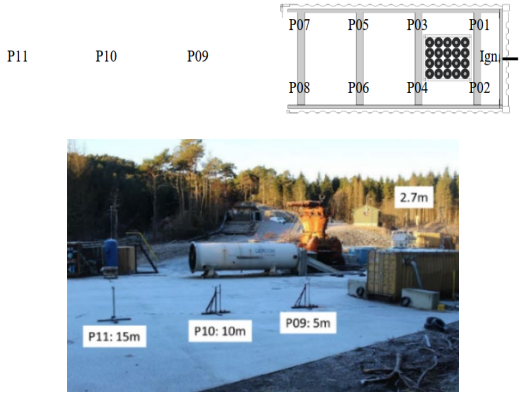


Figure X.2(c) Position for Internal (P01-P08) and External (P09-P11) Pressure Sensors

X.3 Determination of Internal Overpressure and Impulse Based on NFPA 68 (2018). Nomenclature. See Table X.3 for specification of the parameters used in the models.

NFPA 68 (2018) model predicts deflagration internal overpressure, duration (and hence impulse) as a function of deflagration vent area. It can also be set up to determine the

deflagration vent area required to meet a defined maximum allowable internal over-pressure.

To allow calculation at different flammable gas concentrations, only two simple and logical modifications are required.

1) Use the laminar burning velocity, S_u, for the specified averaged gas concentration, rather than the conservative stoichiometric value.
2) Use the maximum closed volume deflagration pressure, P_{max}, for the specific average gas concentration, rather than the conservative stoichiometric value.

Laminar burning velocity is a fundamental combustion property for a specific gas or gas mixture which can be determined experimentally. For example, the laminar burning velocities for different concentrations of H_2/CO mixtures (including pure hydrogen and pure CO) across the range of lower flammability limit (LFL) and upper flammability limit (UFL) are experimentally measured by Chen et al. at normal temperature and pressure [5]. Varghese et al. [6] measured the laminar burning velocities of methane – air mixtures at different concentrations within the LFL and UFL. S_u is affected by different initial gas/mixture temperature and pressure [7], but for enclosure deflagration venting calculation, the enclosure is usually at ambient temperature and atmospheric pressure so S_u and P_{max} at ambient temperature and atmospheric pressure are used. For each specific gas or gas mixture, the maximum closed volume deflagration pressures can be calculated by NASA CEA program [8] for a certain gas concentration in air. Figure X.3(a) and Figure X.3(b) show the variations of S_u and P_{max} versus the gas concentrations in air which are obtained from references [5, 6]. By using the correlations of S_u and P_{max} versus the gas concentration in air and applying them to the equations 7.2.1a & 7.2.1b for non-choked flow or 7.2.2a & 7.2.2b for choked flow in NFPA 68 (2018), a new model based on NFPA 68 "standard" model which considers the actual enclosure gas concentration is developed for calculation of enclosure deflagration venting.

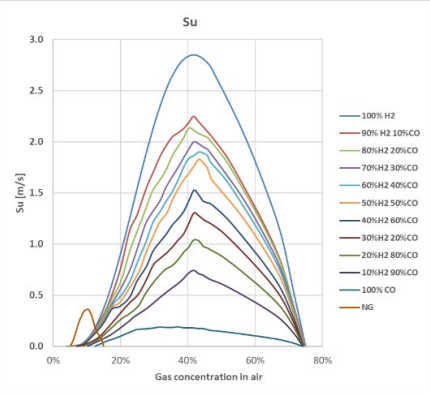


Figure X.3(a) Laminar Burning Velocity S_u versus Gas Concentration in Air for Pure H_2, Different Compositions of Syngas, Pure CO, and Natural Gas (CH_4)

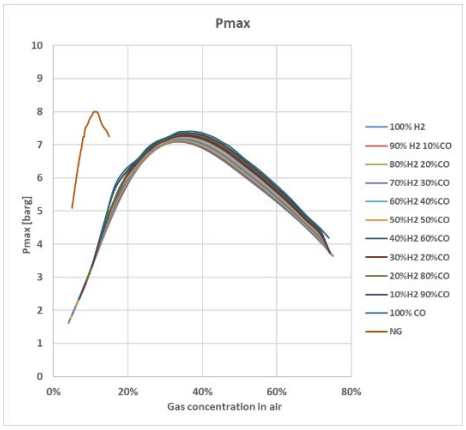


Figure X.3(b) Maximum Closed Volume Deflagration Pressure P_{max} versus Gas Concentration in Air for Pure H_2, Different Compositions of Syngas, Pure CO, and Natural gas (CH_4)

The values presented here are for: hydrogen, 90% H_2/10% CO, 80% H_2/20% CO, 70% H_2/30% CO, 60% H_2/40% CO, 50% H_2/50% CO, 40% H_2/60% CO, 30% H_2/70% CO, 20% H_2/80% CO, 10% H_2/90% CO, 100% CO, and natural gas (100% CH_4). If any other gas or mixture is of interest, S_u for the new gas or mixture should be obtained from experimental data and the corresponding P_{max} can be calculated by NASA CEA and then be built into the model.

Determination of the appropriate average gas concentration will be application specific. One typical approach is:

a) Select a representative hole size and determine the leak release rate into the enclosure. If the release rate is significantly greater than the normal process flow rate and the inventory of gas is low, it may be decided to limit the release rate to the normal flowrate.
b) Based on the air changes per hour, perform a simple mixing calculation, assuming good mixing, to obtain the average concentration in the enclosure
c) If the enclosure has flammable gas detection with automatic trip isolation, it may be decided to take credit for limited release duration, by calculating the average concentration as a function of time, with the release stopped after a defined time.

X.4 Determination of External Overpressure. Besides internal vented deflagration overpressure and impulse, it is also important to be able to predict the external blast when siting flammable enclosures. NFPA 68 does not predict the external overpressure which is a gap in industrial applications. HySEA Phase 1 tests with homogeneous and quiescent mixtures are used to study the relation of external blast overpressure with the distance and angle from the direction of venting. The locations of external overpressure sensors are shown in Figure X.2(c).

For door vent tests, all the 3 pressure sensors (P09, P10, and P11) are located in the direction of deflagration venting ("straight on"). The measured external overpressure data are correlated as a function of the maximum pressure developed in a vented enclosure during deflagration (P_{red}) and x (distance from vent) which fits quite well. The correlation is then used to predict the data measured at P10 above the container for roof vent tests which is also in the direction of deflagration venting. Figure X.4(a) shows a comparison of the external straight on overpressure test data with the correlation predictions. The roof venting test data are a bit scattered, but the correlation also works well. The correlation is:

$$P_{external} = \max(0, \min(P_{red}, (0.012\,x^2 - 0.36x + 3.4) * (-0.0813\,P_{red}^2 + 0.2271\,P_{red} - 0.0021)))$$

[X.4a]

where x is the external distance from vent, in the direction of venting ("straight on").

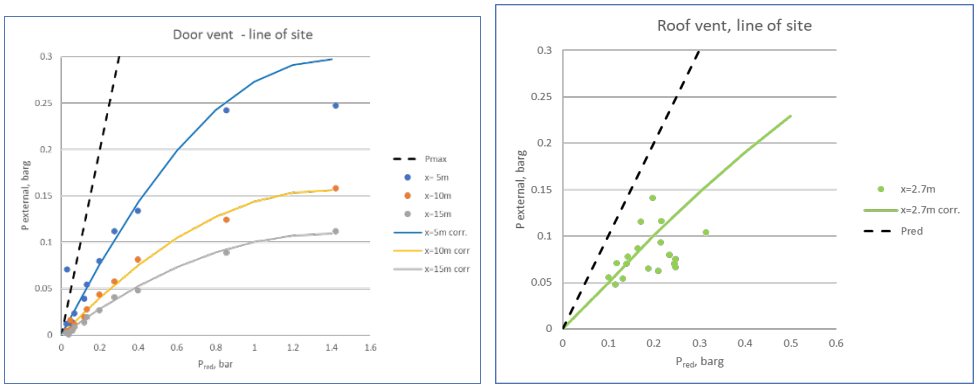


Figure X.4(a) Comparisons of External Straight on Overpressures Test Data with the Correlation Predictions for Phase I Door Vent and Roof Vent Cases.

Carson et al. [9] provides a method that can be adapted to estimate the ratio of overpressure at any angle to the straight-on overpressure. Figure X.4(b) illustrates the definitions of distance and angle from an external point of interest. The equation can be expressed as:

$$\frac{P_\phi}{P_{straight\ on}} = \frac{(c11*\phi+c12)(\frac{X}{D_v})^{(c21\phi+c22)}}{c12*(\frac{X}{D_v})^{c22}} \quad [X.4b]$$

Where

ϕ = angle from straight on [degrees]

X = distance to target [m]

D_v = equivalent diameter of vent

c11 = -0.138, c12 = 27.7, c21 = -8.79 E-4, and c22 = -1.36.

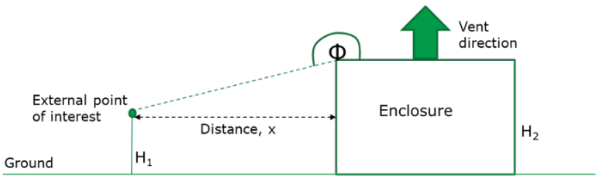


Figure X.4(b) External Point of Interest with Distance X and Angle Φ from Vent Centerline

For roof vent tests, the angles ϕ of external overpressure sensors located at P09 (X = 5m) and P10 (X = 15m) are 101° and 94°, and X/D is in range of (2-10) depending on test vent area and pressure measurement location. Using Equation [X.4b], the value of ($P/P_{straight\ on}$) is predicted to be about 0.45 for these tests as shown in Figure X.4(c). The external overpressure test data at P09 and P11 are then compared with correlation predictions at an angle about 100° from straight on as shown in Figure X.4(d). There is more scatter in this data than for the door vent straight on data, but the correlation method works reasonably well.

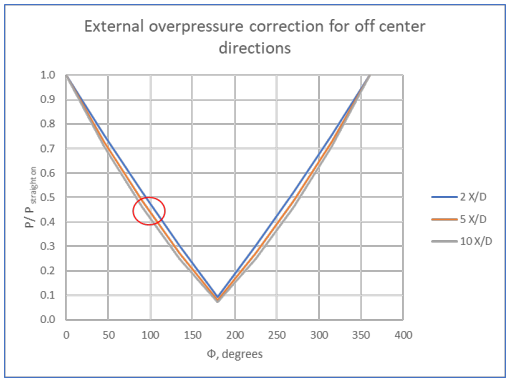


Figure X.4(c) External Overpressure Correction ($P/P_{straight\ on}$) for Off Center Directions

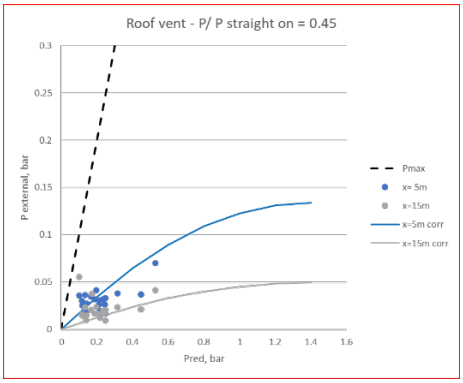


Figure X.4(d) Comparisons of External Overpressure Test Data (P09 and P11) Against the Correlation Predictions at an Angle about 100° from Straight on for Roof Vent Tests

X.5 Determination of External Fireball. The empirical correlation for external fireball size in NFPA 68 (2018) only depends on the protected enclosure volume and number of vents. The equation, therefore, does not take into account the vent geometry, flammable gas/air mixture properties, or vent area. Ventdef proposes a new method to calculate the fireball diameter using the theoretical "constant pressure deflagration expansion ratio", σ.

When the premixed flammable cloud burns, the temperature of the gas will increase. From the ideal gas law:

$$\frac{P}{\rho T} = Constant \qquad [X.5a]$$

If the pressure is fixed, an increase in temperature will result in a reduction in density and an increase in volume. The parameter characterizing the expansion for constant pressure combustion is called "constant pressure deflagration expansion ratio" σ. It is used to predict the maximum volume of the hot combustion gases and can be calculated by NASA CEA program.

For each specific gas or gas mixture, σ is calculated for different gas concentrations in air. For the gases/mixtures considered in the model, the variations of σ versus different gas concentrations in air are shown in Figure X.5(a). Using σ, the volume of the venting fireball can be calculated as

$$V_f = V_u * \sigma \qquad [X.5b]$$

Where

V_f = combusted gas volume which equals to the fireball volume [m^3]

V_u = un-combusted gas volume which equals to the enclosure volume [m^3]

σ = theoretical "constant pressure deflagration expansion ratio"

Part of the fireball volume may exist inside the enclosure, or the whole fireball might exit the enclosure pushed by the deflagration overpressure. To be conservative, the total fireball volume V_f is taken as the external fireball volume. Same as NFPA 68 (2018), it is assumed that the external fireball is spherical. Thus, the external fireball diameter can be calculated by:

$$D_f = (\frac{V_f}{\pi/6})^{1/3} \qquad [X.5c]$$

Where

D_f = external fireball diameter [m]

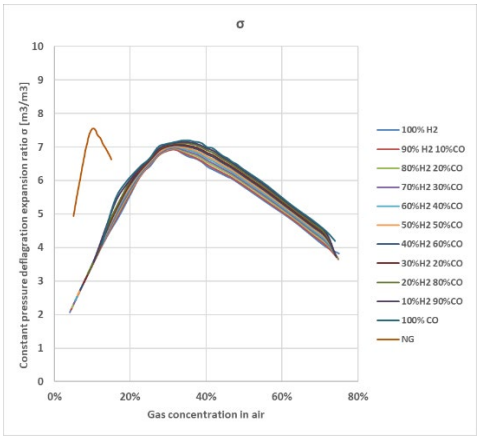


Figure X.5(a) "Constant Pressure Deflagration Expansion Ratio", σ, for Pure H_2, Different Compositions of Syngas, Pure CO, and Natural gas (CH_4) Calculated by NASA CEA.

This theoretical model is compared against HySEA test videos, FLACS CFD modeling, NFPA 68 (2018) and EN14994 correlations. A summary of the experimental conditions for tests that modelled in FLACS CFD is shown in Table X.5.

X.6 Validation of Model Predictions versus HySEA Test Data

X.6.1 Validation of Internal Overpressure and Impulse Predictions. Comparison of model predictions of internal overpressure and impulse are compared with all the 66 HySEA tests reported in reference [4]. NFPA 68 (2018) is based on homogeneous and quiescent mixtures, while HySEA tests include a number of tests that are homogeneous & quiescent and also a number that have stratified gas (hydrogen rich layer at top of the container) and / or internal releasing turbulent jets. For the latter cases, Ventdef was run using the nominal average concentration in the container.

There are four types of obstructions involved in HySEA tests. Table X.6.1 lists the total external surface area A_{obs} calculated for the four types of obstructions. For some tests, Fike commercial vent panels (nominal static opening pressure P_{stat} 0.1 barg) were used, for others plastic sheets ($0 < P_{stat} < 0.1$ barg) were used. In all the runs of Ventdef, P_{sat} is assumed to be 0.1 bar. The impulse is calculated by $I = 0.5 * P_{red} * t_f$. Ventdef predictions for P_{red}, t_f and I are plotted

across the full tested range for the two venting configurations (roof and door) and for each obstruction type. Figure X.6.1(a) to Figure X.6.1(d) show the comparisons of HySEA test results with Ventdef predictions for both roof venting and door venting with different venting areas. Within the range of conditions tested, Ventdef acts quite well at predicting P_{red}, t_f and I for a wide range of conditions that span homogeneous and inhomogeneous, quiescent and non-quiescent, range of obstruction levels up to high congestion. It even worked well for the case without blowout panels where the door was from close (prior to ignition) to open (during the deflagration).

Table X.6.1 Total external surface area of different obstructions

Obstruction	A_{obs}, m^2
No obstruction	0
Pipe rack	14.4
Bottle basket	23
High Congestion	83

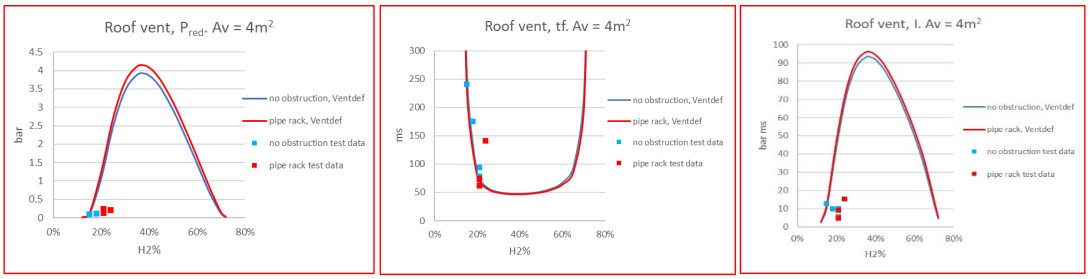


Figure X.6.1(a) Comparison of HySEA Test Data with Ventdef Predictions for Cases with Roof Venting A_v = 4 m^2.

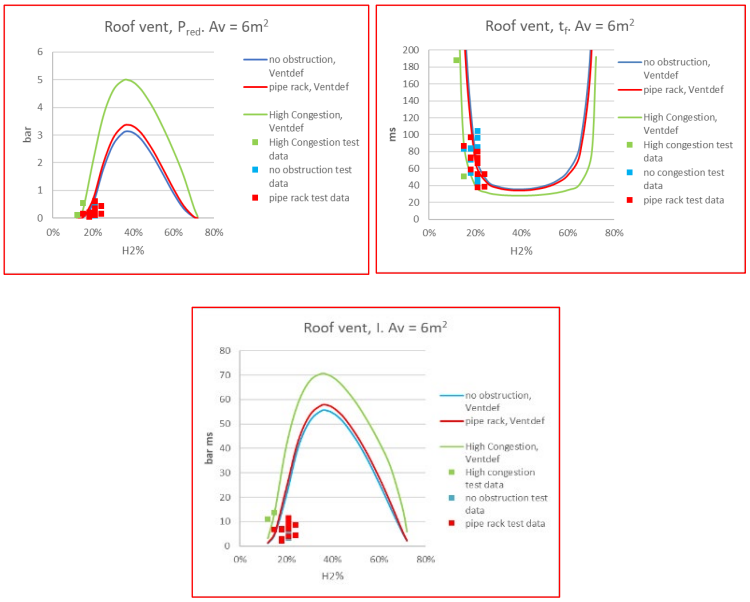


Figure X.6.1(b) Comparison of HySEA Test Data with Ventdef Predictions for Cases with Roof Venting A_v = 6 m^2.

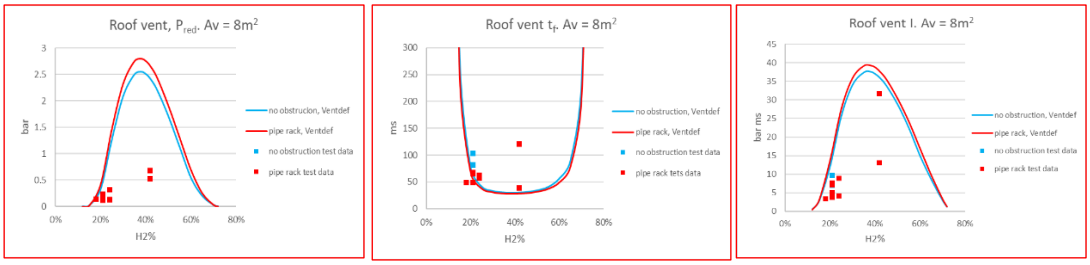


Figure X.6.1(c) Comparison of HySEA Test Data with Ventdef Predictions for Cases with Roof Venting A_v = 8 m².

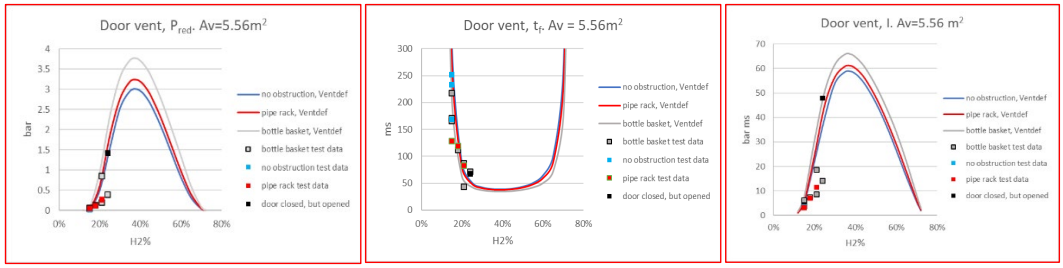
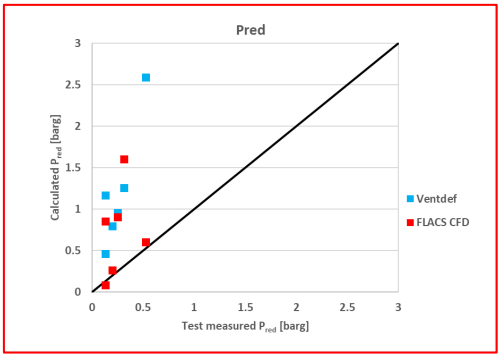


Figure X.6.1(d) Comparison of HySEA Test Data with Ventdef Predictions for Cases with Door Venting A_v = 5.56 m².

Figure X.6.1(e) presents the comparison on HySEA test data with Ventdef predictions and CFD results for the cases listed in Table E.5. For P_{red}, Ventdef predictions are slightly higher than the test data for all 6 cases and so does CFD results except for test 10. In CFD simulation, the bottle basket in test 10 is simplified as a block which reduces the value of A_{obs} and thus reduces resulting P_{red}. Both Ventdef and CFD simulations under-predict the blast duration for all the 6 tests. The comparison of impulses has similar trends to P_{red}, except that Ventdef matches quite well with the impulse of test 34 and CFD under-predicts the impulse. In general, Ventdef predicts a bit higher P_{red} and impulse for all the 6 cases which is good to be reasonably conservative.

In terms of these 6 cases, CFD results have somewhat better agreement than Ventdef as a number of the CFD predictions are actually a good match. A thorough comparison between FLACS predictions and all HySEA Phase I tests is done by Lakshmipathy et al. [10] for all HySEA Phase I tests. It was concluded that both the engineering models and FLACS tools tend to overpredict the maximum overpressures measured in the experiments. CFD predictions of P_{red} are a bit different from the values reported by Lakshmipathy et al. [10] which may be due to the simplification of some detailed geometries (steel frames, bolts, etc.) in this work.



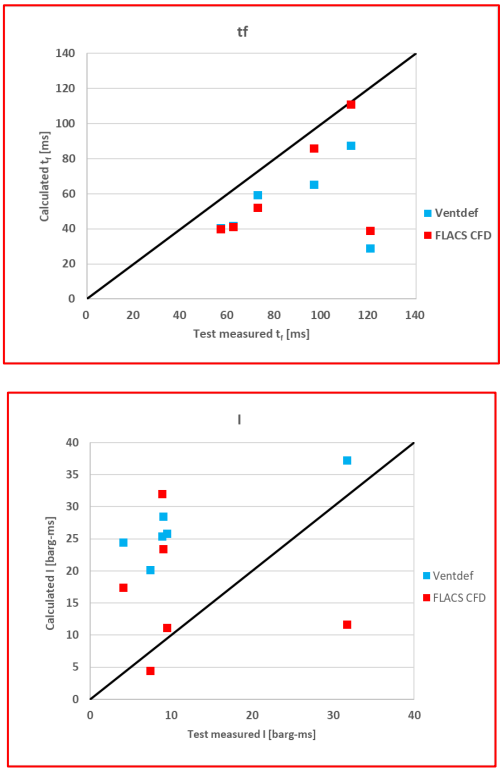
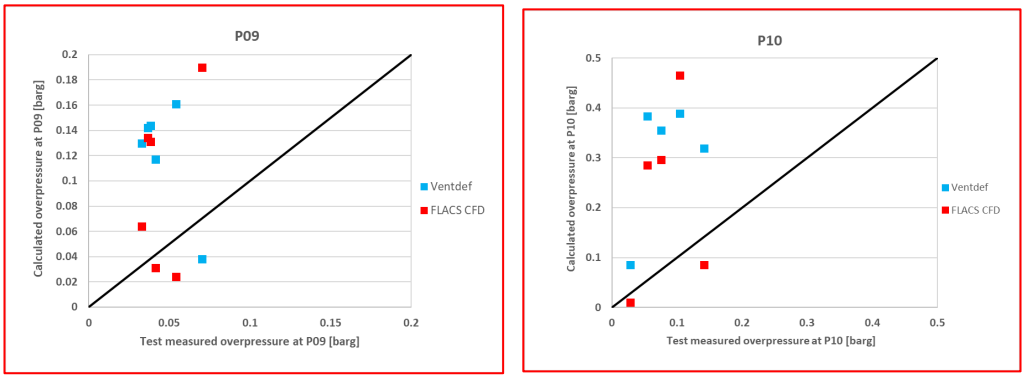


Figure X.6.1(e) Comparison of Internal Overpressures, Durations and Impulses on Test Data with Ventdef Predictions and CFD Results for Cases Listed in Table E.5.

X.6.2 Validation of External Overpressure Predictions. Figure X.6.2(a) summarizes the comparison of external overpressures for test data, Ventdef predictions, and CFD predictions measured at locations of P09 – P11. Ventdef predictions are reasonably conservative for all the three locations except for test 34 (P10 at x = 2.7 m is not measured) in which the measured overpressures at P09 and P11 are a bit higher than Ventdef predictions. Except test 10 and test 26, CFD simulations also tend to reasonably overpredict the overpressures for other tests. In general, among the 6 tests compared, Ventdef and CFD predict similar results for most of the cases.



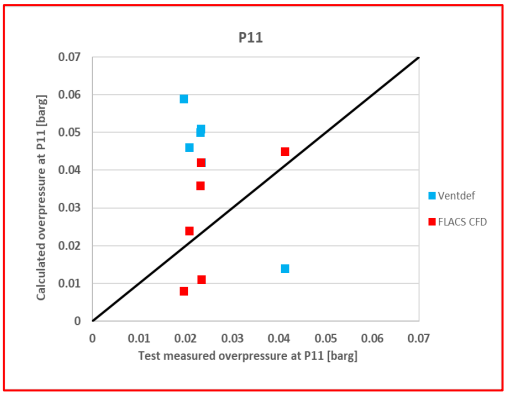


Figure X.6.2(a) Comparison of External Overpressures on Test Data with Ventdef Predictions and CFD Results for Cases Listed in Table E.5.

X.6.3 Validation of External Fireball Predictions. The explosion events for HySEA tests were recorded with two high-speed video cameras and one video camera [4]. From the high-speed camera videos, fireball dimensions are estimated for the tests listed in Table E.5 with homogeneous mixtures.

For HySEA tests listed in Table E.5, fireball volumes predicted by various methods, such as Ventdef, FLACS CFD modeling, NFPA 68 correlation and EN 14994 equation, are compared with the fireball sizes estimated from the HySEA test videos. All of the fireball volumes including test data, CFD results and Ventdef predictions in this paper are the external fireball only, and do not include the volume in the container and are, therefore, on a common basis.

Taking the fireball volume predicted by Ventdef as the basis, Figure X.6.3(a) shows the comparison of fireball volumes calculated by various methods. Obviously, EN 14994 predicts the maximum fireball volumes across all ranges of H_2 concentrations and NFPA 68 (2018) predictions rank second which is still much higher than the experimental test data and the other two methods. The HySEA test data is a bit smaller than those predicted by Ventdef and FLACS modeling, but the gaps become smaller as the H_2 concentration increases. Based on the comparisons, it can be concluded that FLACS is a bit better than the Ventdef predictions, but both are good and much better than the alternative models which significantly overpredict the fireball sizes.

Many researchers have demonstrated that the non-dimensional vent coefficient K_v has critical impact to the venting deflagration overpressure and flame behavior [11-14]. At different K_v ranges, the flame behaviors can be very different. As shown in Table E.5, the K_v values for HySEA tests cases studied in this paper vary from 1.29 - 1.83 which are all less than 2. Wang et al. [15] found that with a K_v value of 5.0, the venting fireball expanded to its maximum size over several milliseconds and was then pushed downward by the high-speed vented outflow to form a flame jet. Similar flame jet rather than a fireball is also shown by Colella et al. [16] in the FLACS simulation with a K_v value of 4.33. The “flame jet” may have a much further extent along the venting direction than the fireball diameter. It is to be noted that Ventdef fireball model is currently only validated against the experimental data with $K_v < 2$. This is applicable to most of the industrial enclosure deflagration venting designs where typically most of the roof area will need to be set as the blowout panels.

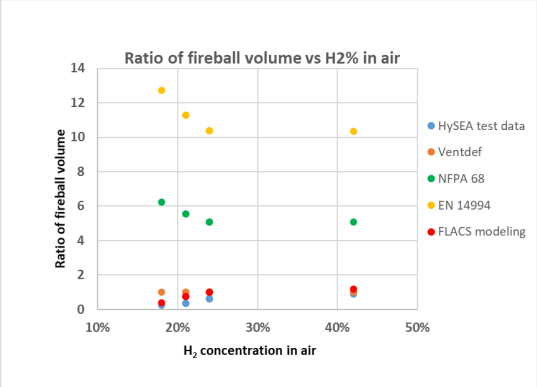


Figure X.6.3(a) Comparison on Ratios of Fireball Volumes Estimated from HySEA Test Data, NFPA 68 (2018), EN 14994 and FLACS Modeling to Ventdef.

X.6.4 Conclusions. NFPA 68 (2018), can be modified for different gas concentrations simply by using concentration specific laminar burning velocity and P_{max} values. This approach has been successfully validated against test data over a wide range of conditions that span homogeneous and inhomogeneous, quiescent and non-quiescent, a range of obstruction levels up to high congestion, and different deflagration vent areas.

Moreover, models for calculating the blast overpressure external to the vent and external fireball size are established. The model predictions match the test data reasonably well.

Table X.3 Parameters Used in the Models

Symbol	Units	Description
A_s	m^2	Enclosure internal surface area
A_{obs}	m^2	Total external surface area of equipment and internal structures inside the enclosure
A_v	m^2	Vent area
C_d	-	Vent flow discharge coefficient
G_u	kg/(m².s)	Unburned gas-air mixture sonic flow mass flux
D_f	m	Fireball diameter
D_v	m	Equivalent vent panel diameter
I	barg-ms	Impulse
K_v	-	non-dimensional vent coefficient

n	-	Number of evenly distributed vents
P_o	barg	Enclosure pressure prior to ignition
$P_{external}$	barg	External blast overpressure
P_{max}	barg	Maximum pressure developed in a contained deflagration by ignition of the same gas-air mixture
P_{red}	barg	Maximum pressure developed in a vented enclosure during a vented deflagration
P_{stat}	barg	Nominal deployment or burst pressure of the vent
t_f	s	duration
V_{en}	m^3	Volume of vented enclosure
V_f	m^3	Combusted gas volume which equals to the fireball volume
V_u	m^3	Un-combusted gas volume which equals to the enclosure volume
x	m	External distance from vent to target
S_u	m/s	Fundamental burning velocity of gas-air mixture
r_u	kg/m^3	Mass density of unburned gas-air mixture
λ	-	Ratio of gas-air mixture burning velocity accounting for turbulence and flame instability in vented deflagration to the fundamental (laminar) burning velocity
g_b	-	Ratio of specific heats for burned gas-air mixture
σ	-	Theoretical “constant pressure deflagration expansion ratio”
ϕ	degree	Angle from straight on

Table X.5 Summary of HySEA Tests Modeled in FLACS [3, 4]

Test number #	Configuration	Venting direction	Hydrogen conc. (%)	A_v (m^2)	K_v $(= \frac{V_{en}^{2/3}}{A_v})$	P_{red} (barg)
10	Bottle basket, doors open	Door	18	5.64	1.83	0.130
26	Frame only, panels	Roof	21	6	1.72	0.245
27	Pipe rack, panels	Roof	21	6	1.72	0.301

19	Pipe rack, roof open	Roof	24	8	1.29	0.136
20	Pipe rack, panels	Roof	24	8	1.29	0.136
34	Pipe rack, roof open	Roof	42	8	1.29	1.076

Reference

[1] Shen A., Miller D. Ventdef: A new engineering model for vented gas deflagration based on NFPA 68 (2018). Process Safety Progress, Volume 41, Issue 4, pages 738-750, 2022.

[2] NFPA 68. Standard on explosion protection by deflagration venting. 2018.

[3] Skjold T, Lucas M, Hisken H, Atanga G, Lakshmipathy S, Bernard L, Van Wingerden M, van Wingerden K, Wen J, Rao VCM, Sinha A, Carcassi M, Schiavetti M, Pini T, Snoeys J, Hanssen AG, Wang C, Jallais S, Vyazmina E, Miller D & Bauwens CR. Review of the HySEA project. 13th International Symposium on Hazards, Prevention, and Mitigation of Industrial Explosions. Braunschweig, Germany, July 27 – 31, 2020.

[4] Skjold T, Hisken H, Lakshmipathy S, Atanga G, Bernard L, Van Wingerden M, Olsen KL, Holme MN, Turoy NM, Mykleby M, van Wingerden K. Vented hydrogen deflagrations in containers: Effect of congestion for homogeneous and inhomogeneous mixtures. International Journal of Hydrogen Energy 44 (2019) 8819 – 8832.

[5] Chen D, Zhou Q, Zhao Q, Zhang Y, Xu T, Hui S. Experimental study on the laminar flame speed of hydrogen/carbon monoxide/air mixtures. Fuel 88 (2009) 1858 – 1863, 2009.

[6] Varghese RJ, Kolekar H, Kishore V, Kumar S. Measurement of laminar burning velocities of methane-air mixtures simultaneously at elevated pressures and elevated temperatures. Fuel 257 (2019) 116120.

[7] Elia M, Ulinski M, Metghalchi M. Laminar burning velocity of methane-air-diluent mixtures. Transactions of the ASME, Vol. 123, January 2001.

[8] Chemical Equilibrium with Applications (CEA) program, NASA.

[9] Carson RA, Sahni O. Scaling laws for the peak overpressure of a cannon blast. J. Fluids Eng., Feb 2017, 139 (2): 021204

[10] Lakshmipathy S, Skjold T, Hisken H, Atanga G. Consequence models for vented hydrogen deflagrations: CFD vs. engineering models. International Journal of Hydrogen Energy. Volume 44, Issue 17, 2019

[11] Daubech J, Proust C, Gentilhomme O, Jamois C, Mathieu L. Hydrogen-air vented explosions: new experimental data. In: 5th International Conference on Hydrogen Safety. Brussels, Belgium.

[12] Tang Z, Li J, Guo J, Zhang S, Duan Z. Effect of vent size on explosion overpressure and flame behavior during vented hydrogen-air mixture deflagrations. Nuclear Engineering and Design 361 (2020) 110578.

[13] Kumar RK, Skraba T, Greig DR. Vented combustion of hydrogen-air mixtures in large volumes. Nucl. Eng. Des. 99(1987), 205 – 315.

[14] Rocourt X, Awamat S, Sochet I, Jallais S, 2014. Vented hydrogen-air deflagration in a small enclosed volume. Int. J. Hydrogen Energy 39 (35), 20462-20466.

[15] Wang J, Guo J, Yang F, Zhang J & Lu S. Effects of hydrogen concentration on the vented deflagration of hydrogen-air mixtures in a 1-m3 vessel. International Journal of Hydrogen Energy 43 (2018) 21161 – 21168.

[16] Colella F, Ibarreta A, Wolf M, Yen M, O'Hern SC, T. J. Myers. Modeling of explosion venting fireballs.22nd annual

international symposium, October 22-24, 2019.

Public Input No. 217-NFPA 2-2023 [Section No. 10.1]

10.1 Scope.

This chapter shall apply to the design, construction, and installation of GH_2 systems to be utilized for vehicle fueling.

10.1.1 Application.

The requirements of this chapter shall apply to fueling operations, irrespective of the system capacity of either the fueling source or the vehicle being fueled.

10.1.1.1

Hydrogen dispensing systems for vehicular fueling shall comply with Chapter 10.

10.1.1.2

The storage, use, and handling of GH_2 in any quantity shall also comply with the requirements of Chapters 1 and 4 and the applicable requirements of Chapters 5 through 7.

10.1.1.3

Hydrogen generation systems shall be designed in accordance with Chapter 13.

10.1.1.4

Where there is a conflict between a fundamental requirement and a use-specific requirement, the use-specific requirement shall apply.

10.1.1.5*

This chapter shall not apply to facilities that fill containers or trailers for the purposes of transporting hydrogen when in accordance with and regulated by 49 CFR 100–199.

Additional Proposed Changes

File Name	Description	Approved
Chapter_10_Scope_Changes.docx	Chapter 10 Scope Changes	

Statement of Problem and Substantiation for Public Input

Rationale for Minor Changes to Scope Section for Chapters 10 and 11:
1) Wording and format are inconsistent between Chapters 10 and 11.
a. Create common language by merging from both, but primarily from Chapter 10.
b. Align with same format.
2) Clarify and broaden that GH2 dispensing systems may also be supplied from a LH2 source.
3) Clarify that Chapter 10 is for GH2 dispensing and Chapter 11 is for LH2 dispensing, regardless of source.

Submitter Information Verification

Submitter Full Name: Carl Rivkin
Organization: Nikola Corporation
Street Address:
City:
State:

Zip:

Submittal Date: Thu Dec 28 17:16:18 EST 2023

Committee: HYD-AAA

Committee Statement

Resolution: FR-38-NFPA 2-2024

Statement: The revisions clarify and broaden that GH2 dispensing systems may also be supplied from a LH2 source and also clarify that Chapter 10 is for GH2 dispensing and Chapter 11 is for LH2 dispensing, regardless of source.

Chapter 10:

10.1 Scope. This chapter shall apply to the design, siting, construction, ~~and~~ installation and operation of ~~GH2~~ dispensing systems to be utilized for GH2 fueling of vehicles.

10.1.1* Application. The requirements of this chapter shall apply to GH2 fueling operations, irrespective of the system capacity, ~~of either the fueling~~ the hydrogen source, or the vehicle being fueled.

10.1.1.1 GH2 ~~Hydrogen~~ dispensing systems for vehicular fueling shall comply with Chapter 10.

10.1.1.2 The storage, use, and handling of ~~GH2~~ hydrogen in any quantity shall also comply with the requirements of Chapter 1 and 4 and the applicable requirements of Chapters 5 through ~~7~~8.

10.1.1.3 Hydrogen generation systems shall be designed in accordance with Chapter 13.

10.1.1.4 Where there is a conflict between a fundamental requirement and a use-specific requirement, the use specific requirement shall apply

10.1.1.5* This chapter shall not apply to facilities that fill containers or trailers for the purposes of transporting hydrogen when in accordance with and regulated by 49 CFR 100-199.

NOTE: Add Annex to 10.1.1 to explain that multiple sources of hydrogen may be used for GH2 dispensing, including LH2.

Public Input No. 271-NFPA 2-2024 [Section No. 10.2.3]

~~10.2.3~~ –

~~Vehicles shall not be considered a source of ignition with respect to the requirements of this chapter.~~

-

Statement of Problem and Substantiation for Public Input

This paragraph gets lost where it is and easy to overlook. Move to 10.5.1.1.4.1 in General for Dispensing where it fits with other ignition sources.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 272-NFPA 2-2024 [New Section after 10.5.1.1.4]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 23:54:56 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-217-NFPA 2-2024
Statement: Material remains the same but relocate to 10.5.1.1.4.1 in the General section for Dispensing where it fits with other material on ignition sources

Public Input No. 273-NFPA 2-2024 [Section No. 10.2.4]

~~10.2.4~~ –

~~Where an overpressure incident that results in operation of the overpressure protection system occurs, the dispenser pressure control system shall be examined and certified by a qualified technician prior to being returned to service.~~

Statement of Problem and Substantiation for Public Input

This is a very specific requirement to have in section 10.2 and can get lost. It's better to keep it with related material as section 10.5.1.2.3.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 274-NFPA 2-2024 [New Section after 10.5.1.2.2]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 00:03:49 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-55-NFPA 2-2024
Statement: This is a very specific requirement to have in section 10.2 and it's better aligned with related material in 10.5.1.2 a new section.

Public Input No. 275-NFPA 2-2024 [Section No. 10.3.1]

10.3.1 ~~Design and Construction of Cylinders, Containers, and Tanks.~~ General Design Considerations

10.3.1.1

Components shall be designed, installed, or protected so their operation is not affected by freezing rain, sleet, snow, ice, mud, insects, or debris.

10.3.1.2

Cylinders, containers, and tanks shall be fabricated, installed, and maintained in accordance with Chapters 6, 7, and ~~7~~ 8 of this document.

Statement of Problem and Substantiation for Public Input

Change title to General Design Considerations since current 10.3.1.1 does not fit under a title covering Cylinders, Containers, and Tanks. There is not need for a specific title that covers just one paragraph. Add Chapter 8 to 10.3.1.2 since LH2 can be used as a source of H2 for GH2 fuel stations.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 00:09:48 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-40-NFPA 2-2024

Statement: Change title to General Design Considerations since current 10.3.1.1 does not fit under a title covering Cylinders, Containers, and Tanks. There is not need for a specific title that covers just one paragraph. Add Chapter 8 to 10.3.1.2 since LH2 can be used as a source of H2 for GH2 fuel stations.

Public Input No. 277-NFPA 2-2024 [New Section after 10.3.2.1]

TITLE OF NEW CONTENT

Type your content here ...

10.3.2.X Pressure relief devices for piping and dispensing systems shall meet the requirements of the ASME Pressure Piping Code B31.

Statement of Problem and Substantiation for Public Input

Pressure relief devices for piping systems should meet the requirements for relief systems as specified in the Piping Code, not the Pressure Vessel Code. Otherwise, relief valves for this purpose are prone to chatter and fail.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 276-NFPA 2-2024 [Section No. 10.3.2.1]	Adding the requirement for piping systems

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 00:24:54 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-117-NFPA 2-2024

Statement: Section 10.3.2.1 is proposed to clarify that 10.3.2.1 applies the ASME BPV requirements for pressure vessels only. Pressure relief devices for piping systems should meet the requirements for relief systems in the B31 Piping Code, as referred to in this revision, and not the ASME BPV. Otherwise, relief valves for this purpose are prone to chatter and fail.

Public Input No. 276-NFPA 2-2024 [Section No. 10.3.2.1]

10.3.2.1

Pressure relief devices for protection of pressure vessels shall be designed and installed in accordance with ~~10.6.3.1 shall be examined and tested in accordance with~~ the applicable requirements of the ASME *Boiler and Pressure Vessel Code*.

Statement of Problem and Substantiation for Public Input

This is a design section of the Chapter, but this paragraph currently refers to devices "designed and installed in accordance with 10.6.3.1". 10.6.3.1 is about maintenance, not design. This paragraph should require compliance with the BPV Code directly.
Devices that reference the BPV are to protect presure vessels, not piping. Devices to protect piping systems that do not have the design dynamics of a vessel should meet the requirements of ASME B31. Otherwise the valves are prone to chatter and fail.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 277-NFPA 2-2024 [New Section after 10.3.2.1]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 00:16:20 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-41-NFPA 2-2024

Statement: Section 10.3 is for design, but refers to Section 10.6.3.1 which is for maintenance. This makes for a confusing duplicative and circular reference. This paragraph only applies to design and installation, not for testing which is covered in 10.6.3.1.

The revision concisely maintains the original requirement to meet the ASME BPV Code.

The ASME BPV Code governs pressure vessel construction and the relief devices to protect those vessels. ASME B31 governs piping, so this revision clarifies that this requirement for compliance to ASME BPV is only required for pressure vessels. Devices that protect piping systems should meet the requirements of ASME B31, which have different requirements. Otherwise, ASME BPV valves are prone to chatter and fail when installed to protect piping systems.

Public Input No. 280-NFPA 2-2024 [Section No. 10.3.2.3]

10.3.2.~~3~~ 2.1

The set pressure of the overpressure protection device for the dispensing system shall not exceed 138 percent of the ~~service~~ nominal working pressure of the fueling nozzle it supplies.

Statement of Problem and Substantiation for Public Input

This paragraph should be moved to be a dependent paragraph under 10.3.2.2.
Changing from "service" pressure which is defined as 70 F reference temperature to a new definition of "nominal working pressure" which is used within CSA and other standards for fuel containers that use 59 F as a reference temperature.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 278-NFPA 2-2024 [New Section after 3.3.197.7]	Defines NWP term

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 00:59:36 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-43-NFPA 2-2024
Statement: This existing paragraph is being moved to be a dependent paragraph under 10.3.2.2 since it further defines the requirement for the relief device. Changed from "service" pressure which is defined as 70 F reference temperature to a new definition of "nominal working pressure" which is used within CSA and other standards for fuel containers that use 59 F as a reference temperature.

Public Input No. 281-NFPA 2-2024 [Section No. 10.3.2.6]

10.3.2.6

Pressure relief valves for ~~GH~~ 2 ~~service~~ hydrogen service shall not be fitted with lifting devices.

10.3.2.6.1

The adjustment, if external, shall be provided with a means for sealing the adjustment to resist tampering.

10.3.2.6.2

If at any time it is necessary to break such a seal, the valve shall be removed from service until it has been reset and sealed.

10.3.2.6.3

Adjustments shall be made only by the manufacturer or other companies having competent personnel and facilities for the repair, adjustment, and testing of such valves.

10.3.2.6.4

The organization making such adjustment shall attach a permanent tag with the setting, capacity, and date.

Statement of Problem and Substantiation for Public Input

This is a generic restriction for all hydrogen (LH2 or GH2) relief valves and since LH2 systems may be used for supply to a GH2 dispensing system, it's better to broaden the applicability to "hydrogen" to cover both LH2 and GH2.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 01:05:24 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-44-NFPA 2-2024
Statement: This is a generic restriction for all hydrogen (LH2 or GH2) relief valves and since LH2 systems may be used for supply to a GH2 dispensing system, it's better to broaden the applicability to "hydrogen" to cover both LH2 and GH2. Qualified person is defined in the standard and the requirement is changing to use the defined term

Public Input No. 158-NFPA 2-2023 [Section No. 10.3.5.1 [Excluding any Sub-Sections]]

Pipe, tubing, and fittings shall be suitable for hydrogen service and for maximum ~~pressures~~ and ~~minimum and maximum temperatures.~~ minimum pressures, temperatures, and flow rates.

10.3.5.2 _ Piping components in contact with hydrogen shall be compatible with hydrogen service conditions.

Statement of Problem and Substantiation for Public Input

The proper sizing of fuel lines is critical to hydrogen fueling systems because it impacts the pressure drop which, in turn, can cause overheating in the vehicle supply container (tank). Per SAE J2601, Section A.3.4:

A.3.4 Pressure Drop in Fuel Line from Dispenser to Vehicle
The pressure drop coefficient used for calculating the mass flow rate is calibrated from the reference pressure drop situation defined in 7.2. The pressure drop under reference conditions determines the value of the coefficient. A high pressure drop leads to two effects that both yield a higher CHSS gas temperature at the end of fueling: First, the fueling is delayed (i.e., the peak mass flow occurs at a later time). This consequently delays the temperature rise inside the CHSS and gives the gas less time to exchange heat with the internal liner surface. Secondly, more Joule-Thomson heating is introduced into the CHSS because a higher station pressure is required to generate a given mass flow rate, and the enthalpy of hydrogen fuel gas increases with pressure.

This topic is being submitted on behalf of the NFPA2 Fueling Task Force.

Submitter Information Verification

Submitter Full Name: Spencer Quong
Organization: Quong & Associates Inc.
Affiliation: Toyota
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 21 14:51:08 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-45-NFPA 2-2024
Statement: The proper sizing of fuel lines is critical to hydrogen fueling systems because it impacts the pressure drop which, in turn, can cause overheating in the vehicle supply container (tank). The second half of 10.3.5.1 is a separate requirement and should be separated.

Public Input No. 282-NFPA 2-2024 [Section No. 10.3.6.5 [Excluding any Sub-Sections]]

The use of ~~hose~~ hosefor hydrogen service in a ~~hydrogen~~ dispensing ~~system shall~~ system shall be limited ~~to vehicle fueling hose.~~ to vehicle fueling hose for the supply of hydrogen or vent recovery , inlet connections to compression or pumping equipment, sections of hose not exceeding 6” in length in a pipeline to provide flexibility where necessary, and connection of hydrogen containers delivered to the facility for fuel supply.

Statement of Problem and Substantiation for Public Input

The current language can be interpreted as excluding these other appropriate uses of hoses at hydrogen refueling stations. The current language is also not limited to hydrogen so would also nominally prevent the use of hose for air/nitrogen and other gases used for other purposes.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 01:12:37 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-82-NFPA 2-2024
Statement: The current language can be interpreted as excluding these other appropriate uses of hoses at hydrogen refueling stations. This language is also consistent with similar requirements in 11.3.6.1.5. The current language is also not limited to hydrogen so would also nominally prevent the use of hose for air/nitrogen and other gases used for other purposes. The 18” length allows for installation of current breakaway connections.

Public Input No. 283-NFPA 2-2024 [New Section after 10.3.6.5.1]

TITLE OF NEW CONTENT

Type your content here ...

10.3.6.5.2 Vehicle fuel hose length at motor fuel dispensing facilities shall not exceed 18'.

Statement of Problem and Substantiation for Public Input

There is no current limit on the length of vehicle fueling hose at motor fuel stations. From a hose safety and separation distance perspective, a maximum hose length seems prudent. A hose of 100' length could be used to dispenser hydrogen 100' from the applicable safeguards and separation distances. 18' was chosen to be consistent with current Chapter 11 hose length restriction and is sufficient to fuel vehicles properly parked in front of a dispenser. NFPA 30 A currently limits fueling hose to 50' but the high pressure hydrogen hoses are of greater safety concern.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 01:24:28 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-224-NFPA 2-2024

Statement: There is no current limit on the length of vehicle fueling hose at motor fuel stations. From a hose safety and separation distance perspective, a maximum hose length is prudent. Breakaway function can also be negatively affected with a long hose that can easily be entangled or wrapped around adjacent equipment. A hose of 100' length could be used to dispenser hydrogen 100' from the applicable safeguards and required separation distances. 18' was chosen to be consistent with current Chapter 11 and NFPA 30A hose length restriction and is sufficient to fuel vehicles properly parked in front of a dispenser.

Public Input No. 220-NFPA 2-2023 [Section No. 10.3.6.6.1]

10.3.6.6.1

Such devices shall be arranged to separate using a force not less than 49.4 lb (220 N) and not greater than ~~150 lb~~ 225 lb (~~667 N~~ 1000 N) when applied in any direction that the vehicle would move.

Statement of Problem and Substantiation for Public Input

Currently the breakaway separation force requirements in applicable national and international standards are inconsistent.

Here is a list of standards addressing the breakaway force, and the values currently specified:

NFPA 2: Breakaway separation 667
ISO 19880-1:2020 Breakaway separation between 220 N and 1000 N
ISO 19880-2* Breakaway separation between 220 N and 1000 N
ISO 19880-3:2018 Breakaway separation between 220 N and 1000 N
CSA HGV 4.4*:2013 Breakaway separation 667
ISO 17268: 2020 Nozzle/Receptacle axial load 1000
SAE J2600*: 2015 Nozzle/Receptacle axial load 1000
SAE J2578: 2014 Drive-away protection force 668
*Currently open

On November 14, 2023, over 40 experts representing station designers and operators, engineers, vehicle manufacturers, fueling hose manufacturers, nozzle manufacturers, and breakaway manufacturers met to discuss the implications of this requirement not being harmonized. Breakaway manufacturers indicated the separation force on any individual breakaway device can be set to a single range. Station designers and operators noted that they can, and often do, specify a maximum separation force lower than the maximum specified in ISO standards. The value is within the range allowed by the ISO standards, and allows for protection of older equipment designed to 667 N maximum separation force. Therefore, there was agreement that industry would seek to propose modifications as necessary to harmonize the breakaway separation force requirements to be between 220 N minimum and 1000 N maximum, with the understanding that a station designer/operator could source breakaway devices set to any range within the stated minimum and maximum force.

The inclusion of a minimum separation force is desired to avoid inadvertent separation through foreseeable circumstances, where the force is well below the force necessary to cause damage to any of the equipment, including the dispenser, hose, and vehicle receptacle.

Submitter Information Verification

Submitter Full Name: Karen Quackenbush
Organization: FCHEA
Affiliation: FCHEA
Street Address:
City:
State:
Zip:
Submittal Date: Fri Dec 29 12:11:25 EST 2023

Committee: HYD-AAA

Committee Statement

Resolution: FR-47-NFPA 2-2024

Statement: Currently the breakaway separation force requirements in applicable national and international standards are inconsistent. Station designers and operators noted that they can, and often do, specify a maximum separation force lower than the maximum specified in ISO standards. The value is within the range allowed by the ISO standards, and allows for protection of older equipment designed to 667 N maximum separation force. Therefore, there was agreement that industry would seek to harmonize the breakaway separation force requirements to be between 220 N minimum and 1000 N maximum, with the understanding that a station designer/operator could source breakaway devices set to any range within the stated minimum and maximum force.

The inclusion of a minimum separation force is desired to avoid inadvertent separation where the force is well below the force necessary to cause damage to any of the equipment, including the dispenser, hose, and vehicle receptacle.

Public Input No. 284-NFPA 2-2024 [New Section after 10.3.6.6.2]

TITLE OF NEW CONTENT

Type your content here ...

10.3.6.7 Hose supports shall be constructed to prevent the hose from touching the ground if the hose is not protected from abrasion and damage by a sleeve or cover.

Statement of Problem and Substantiation for Public Input

This is language that is in Chapter 11 and is prudent for Chapter 10 GH2 systems as well.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 01:30:12 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-48-NFPA 2-2024

Statement: This language is in Chapter 11 and is prudent for Chapter 10 GH2 systems. Hose abrasion is a recognized concern and hose covers are a frequent safeguard deployed in most dispensing applications. It is important for the hose jacket to remain intact to prevent corrosion and weakening of the hose.

Public Input No. 285-NFPA 2-2024 [Section No. 10.3.7.1.1]

10.3.7.1.1

Shutoff valves shall have a ~~rated service~~ design pressure not less than the ~~rated service~~ maximum operating pressure of the ~~entire system~~ portion of the dispensing system in which they are installed and shall be designed with a minimum safety factor of 3.

Statement of Problem and Substantiation for Public Input

Many stations have maximum operating pressures suitable for H70 service and this paragraph as currently written (i.e. "entire") would require all valves to be rated for H70 even if used on the H35 portion of the system.
Service pressure is not the correct term to use for this requirement for two reasons: 1) the normal maximum operating pressure of the systems is much higher than service pressure, and 2) service pressure is not defined properly for H2 systems.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 01:32:40 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-49-NFPA 2-2024

Statement: Many stations have maximum operating pressures suitable for H70 service and this paragraph as currently written (i.e. "entire") would require all valves to be rated for H70 even if used on the H35 portion of the system.

Service pressure is not the correct term to use for this requirement for two reasons: 1) the maximum allowable working pressure of the systems is much higher than service pressure, and 2) service pressure is not defined properly for H2 systems.

Design pressure is the term used within ASME B31 for piping systems and components. Valves are designed to have a safety factor in them and reiteration of the safety factor is not necessary here.

Public Input No. 288-NFPA 2-2024 [Section No. 10.3.8]

10.3.8 ~~Transfer~~

Dispensing systems shall be capable of depressurizing to facilitate disconnection.

Statement of Problem and Substantiation for Public Input

Changing from "transfer" to "dispensing" to make language more consistent within this dispensing section.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 10:04:43 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-83-NFPA 2-2024
Statement: Changing from "transfer" to "dispensing" to make language more consistent within this dispensing section of Chapter 10. “Transfer” commonly describes the movement of product from a delivery vehicle into a stationary system that then might be used for dispensing.

Public Input No. 289-NFPA 2-2024 [Section No. 10.3.13.5 [Excluding any Sub-Sections]]

An emergency manual shutdown activation device shall be provided at the dispensing area and also at a location remote from the dispensing area.

Statement of Problem and Substantiation for Public Input

The current language is not clear and implies that the actual shutdown device (e.g. valve, disconnect, etc) must be in those locations whereas the intent is it to be the activation device (e.g. button) used to initiate the shutdown system.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 10:07:45 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-50-NFPA 2-2024
Statement: The current language is not clear and implies that the actual shutdown device (e.g. valve, disconnect, etc) must be at the dispensing area whereas the intent is that the activation device (e.g. button) used to initiate the shutdown system should be accessible. The actual shutdown device is often located at the remote equipment area.

Public Input No. 290-NFPA 2-2024 [Section No. 10.3.13.5.2]

~~**10.3.13.5.2** –~~

~~When GH 2 is being produced from the conversion of LH 2 , the emergency shutdown system also shall shut off the liquid supply and power to the LH 2 transfer equipment necessary for the conversion process.~~

Statement of Problem and Substantiation for Public Input

Dispensing systems have emergency shutdown system requirements to adequately isolate individual dispensers from the supply system. The 10.3.13.5.1 paragraph immediately before this paragraph is an example.
There is not a need to stop the LH2 to GH2 conversion equipment to stop the flow of hydrogen to those individual dispensers. It is an unrelated activity. For example and for consistency, there are not requirements to stop the production of GH2 from water or natural gas, or supply from a pipeline system when a dispenser alarms.
Most fuel stations have multiple, and frequently geographically dispersed, dispensers where it is unnecessary to shut off the common source to all dispensers, especially when isolated with independent systems.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 10:11:59 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-51-NFPA 2-2024
Statement: Dispensing systems have emergency shutdown system requirements to adequately isolate individual dispensers from the supply system. The 10.3.13.5.1 paragraph immediately before this paragraph is an example. Conversion of LH2 to GH2 is an unrelated activity from dispensing and there is no need to stop the LH2 to GH2 conversion equipment to stop the flow of hydrogen to those individual dispensers.

Most fuel stations have multiple, and frequently geographically dispersed, dispensers where it is unnecessary to shut off the common source to all dispensers, especially when dispensers are isolated with independent systems.

Public Input No. 291-NFPA 2-2024 [Section No. 10.3.13.7 [Excluding any Sub-Sections]]

The dispensing system emergency shutdown system shall include an automatic emergency shutoff valve ~~at~~ to isolate the source of hydrogen ~~storage and~~ supply ~~system~~ .

Statement of Problem and Substantiation for Public Input

The intent is to clarify that the intent of the automatic shutoff valve is to isolate the dispensing system from the hydrogen supply source. As written, the existing language implies, but does not require, the automatic shutoff valve to isolate the hydrogen supply. The "storage and supply" systems is also vague and is better referred to as the "source" to broaden applicability. For example, the current language could be interpreted as shutting the LH2 tank emergency isolation valve which would not stop the flow of hydrogen to the dispenser from equipment downstream.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 10:31:12 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-52-NFPA 2-2024
Statement: The intent is to clarify that the intent of the automatic shutoff valve is to isolate the dispensing system from the hydrogen supply source. As written, the existing language implies, but does not require, the automatic shutoff valve to isolate the hydrogen supply. The original "storage and supply system" wording is also vague and is better referred to as the "source" to broaden applicability.

Public Input No. 292-NFPA 2-2024 [Section No. 10.4.5]

10.4.5 System Testing.

10.4.5.1*

Hydrogen dispensing systems shall be leak tested after final installation ~~to prove them free from leaks at a pressure equal to at least the normal service pressure of that portion of the system.~~

~~10.4.5.2~~ ~~–~~

~~This leak test shall be in addition to the~~ in accordance with ASME B31, Code for Pressure Piping, ~~testing~~ as required by 10.3.5.2 .

10.4.5.

~~3~~

~~Leakage~~ 1.1 Leakage shall not occur when tested ~~in accordance with the requirements of ASME B31, *Code for Pressure Piping,*~~ either pneumatically or hydrostatically. The test pressure shall be not less than 110 percent of the rated service pressure when tested pneumatically, using an inert gas as the medium, nor less than 150 percent of the rated service pressure when tested hydrostatically.

10.4.5.4 – 2

The ~~assembly~~ dispensing system shall also be leak tested using hydrogen prior to entering service to prove the system free from leaks at a pressure equal to at least the normal service pressure of that portion of the system . This leak test shall be in addition to the test required in 10.4.5.1.

~~10.4.5.5~~ 2.1 *

Where hydrogen ~~is to be used~~ is used as the leak test media, the system shall first be purged with an inert gas to ensure ~~that all oxygen is removed~~ that oxygen content is reduced below 1% .

Statement of Problem and Substantiation for Public Input

The order of the existing testing requirement is confusing and mixes the content of the two required leak tests: 1) Leak test to prove mechanical integrity and 2) Final leak check with hydrogen at maximum operating pressure.
Reordering the existing requirements makes it clear which requirements apply to each test. For example, 10.4.5.3 applies to the first test while 10.4.5.2 and 10.4.5.4 apply to the second test.
A minor change was made to require an O2 threshold of 1% instead of "all".

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 10:41:04 EST 2024

Committee: HYD-AAA

Committee Statement

Resolution: FR-53-NFPA 2-2024

Statement: The order of the existing testing requirement is confusing and mixes the content of the two required leak tests: 1) Leak test to prove mechanical integrity and 2) Final leak check with hydrogen at maximum operating pressure.

Reordering the existing requirements makes it clear which requirements apply to each test. For example, 10.4.5.3 applies to the first test while 10.4.5.2 and 10.4.5.4 apply to the second test.

A minor change was made to require an O2 threshold of 1% instead of "all".

Public Input No. 72-NFPA 2-2023 [Sections 10.5.1.1.1, 10.5.1.1.2]

Sections 10.5.1.1.1, 10.5.1.1.2

10.5.1.1.1* Fueling Hose Integrity Tests.

Controllers on hydrogen dispensing systems shall be designed to verify the integrity of the fuel hose, breakaway, nozzle, ~~and receptacle by~~ receptacle and vehicle high pressure piping. This shall be done by pressurizing these components to at least the vehicle back pressure and monitoring pressure decay over a period of at least five seconds ~~prior~~ to determine if a leak is present prior to the start of the main fueling process .

10.5.1.1.2

Hydrogen dispensing integrity checks once the fueling event has started shall be as follows:

(1) 350 bar fueling events shall have a second integrity check repeated at 80 to 90 percent of the dispenser nozzle service pressure by stopping flow and checking the pressure decay over a period of at least five seconds to determine if a leak is present .

(2) 700 bar fueling events with a starting pressure of less than 200 bar shall have a second integrity test at 40 to 50 percent and third integrity test at 80 to 90 percent of the dispenser nozzle service pressure by stopping flow and checking the pressure decay over a period of at least five seconds to determine if a leak is present .

(3) 700 bar fueling events with a starting pressure of greater than 200 bar shall have a second integrity test at 80 to 90 percent of the dispenser nozzle service pressure by stopping flow and checking the pressure decay over a period of at least five seconds to determine if a leak is present .

Statement of Problem and Substantiation for Public Input

For heavy duty vehicles with larger onboard storage systems and dispensers with higher fueling capacity, Considerably more time than five seconds, may be required to determine if there are leaks in the fueling hose assembly, and Onboard fuel delivery system.
this proposal is based on discussions in the chapter 10 task group and is intended to propose wording that captures the key elements of concern.

See also the PI 71 that adds the following explanatory material:

Medium and Heavy Duty (MD/HD) vehicles, Classes 5 to 8, will have large onboard storage systems. Dispensers designed to support MD and HD fueling will have the capability of fueling faster (5 to 10 kg per minute) than light duty vehicles (1-2 kg per minute). The time to equalize and stabilize the hose pressure between the stop valve in the dispenser and the vehicle tank(s) system to determine if there are leaks in the fueling hose assembly and onboard high pressure fuel delivery system can take considerably more time than five seconds.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 71-NFPA 2-2023 [Section No. A.10.5.1.1.1]	annex note

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC

Affiliation: BoydH2
Street Address:
City:
State:
Zip:
Submittal Date: Fri Dec 01 11:55:00 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-111-NFPA 2-2024

Statement: The changes in 10.5.1.1.1 clarify that the integrity test checks for leaks, not only in the hose assembly, but also the vehicle. The use of “back pressure” is not defined, but intended to be the pressure in the fuel supply container (i.e., vehicle tank per 3.3.50.2).

The five second detection time was originally determined for light duty vehicle dispensers. Because larger vehicles with larger dispensing systems are entering the market place, the integrity test may require a longer time to determine if a leak is present. For the same sized leak and over the same time period, a system with a larger volume will have a smaller pressure drop compared to a system

with a smaller volume. Changing the requirement to allow for different monitoring times will ensure that these systems will be able to find a leak.

In 10.5.1.1.2, “service” is changed to “nominal working pressure” because the use of service pressure is “The settled pressure of the fuel container at a uniform gas temperature of 70°F (21°C) and full gas content” (3.3.197.7). Nominal working pressure is a new term defined for H2 fueling.

The repetition of the last part of each numbered section (“…by stopping flow…”) is not needed because it is discussed in 10.5.1.1.1.

The annex note is to support proposed changes to the dispensing process leak testing requirements to support the introduction of medium and heavy duty fuel cell vehicle fleets to support carbon emission reduction targets

Public Input No. 159-NFPA 2-2023 [Sections 10.5.1.1.1, 10.5.1.1.2]

Sections 10.5.1.1.1, 10.5.1.1.2

10.5.1.1.1* Fueling Hose Integrity Tests.

Controllers on hydrogen dispensing systems shall be designed to verify the integrity of the fuel hose, breakaway, nozzle, ~~and receptacle by~~ receptacle, and vehicle fuel system and fuel supply container. This shall be done by pressurizing these components to at least the ~~vehicle back pressure and monitoring~~ pressure in the fuel supply container and monitoring the pressure decay over a period of ~~at least five seconds prior to the start of fueling~~ time sufficient to determine if a leak is present .

10.5.1.1.2

Hydrogen dispensing integrity checks once the fueling event has started shall be as follows:

(1) 350 bar fueling events shall have a second integrity check repeated at 80 to 90 percent of the dispenser nozzle ~~service~~ pressure ~~by stopping flow and checking the pressure decay over a period of five seconds~~ .

(2) 700 bar fueling events with a starting pressure of less than 200 bar shall have a second integrity test at 40 to 50 percent and third integrity test at 80 to 90 percent of the dispenser nozzle ~~service~~ pressure ~~by stopping flow and checking the pressure decay over a period of at least five seconds~~ .

(3) 700 bar fueling events with a starting pressure of greater than 200 bar shall have a second integrity test at 80 to 90 percent of the dispenser nozzle ~~service~~ pressure ~~by stopping flow and checking the pressure decay over a period of at least five seconds~~ .

Statement of Problem and Substantiation for Public Input

The changes in 10.5.1.1.1 clarify that the integrity test should check for leaks, not only in the hose assembly, but also the vehicle. The use of “back pressure” is not defined, but intended to be the pressure in the fuel supply container (i.e., vehicle tank per 3.3.50.2).

The 5 second detection time was originally determined for light duty vehicle dispensers. Because larger vehicles with larger dispensing systems are entering the market place, the integrity test may require a longer time to determine if a leak is present. For the same sized leak and over the same time period, a system with a larger volume will have a smaller pressure drop compared to a system with a smaller volume. Changing the requirement to allow for different monitoring times will ensure that these systems will be able to find a leak.

In 10.5.1.1.2, “service” is deleted because the use of service pressure is “The settled pressure of the fuel container at a uniform gas temperature of 70°F (21°C) and full gas content” (3.3.197.7). However, during the integrity test, the temperature is not fixed and the fuel container is not full. The repetition of the last part of each numbered section (“…by stopping flow…”) is not needed because it is discussed in 10.5.1.1.1.

This PI was submitted on behalf of the Fueling Task Group

Submitter Information Verification

Submitter Full Name: Spencer Quong
Organization: Quong & Associates Inc.
Affiliation: Toyota

Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 21 14:59:09 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-111-NFPA 2-2024

Statement: The changes in 10.5.1.1.1 clarify that the integrity test checks for leaks, not only in the hose assembly, but also the vehicle. The use of “back pressure” is not defined, but intended to be the pressure in the fuel supply container (i.e., vehicle tank per 3.3.50.2).

The five second detection time was originally determined for light duty vehicle dispensers. Because larger vehicles with larger dispensing systems are entering the market place, the integrity test may require a longer time to determine if a leak is present. For the same sized leak and over the same time period, a system with a larger volume will have a smaller pressure drop compared to a system

with a smaller volume. Changing the requirement to allow for different monitoring times will ensure that these systems will be able to find a leak.

In 10.5.1.1.2, “service” is changed to “nominal working pressure” because the use of service pressure is “The settled pressure of the fuel container at a uniform gas temperature of 70°F (21°C) and full gas content” (3.3.197.7). Nominal working pressure is a new term defined for H2 fueling.

The repetition of the last part of each numbered section (“…by stopping flow…”) is not needed because it is discussed in 10.5.1.1.1.

The annex note is to support proposed changes to the dispensing process leak testing requirements to support the introduction of medium and heavy duty fuel cell vehicle fleets to support carbon emission reduction targets

Public Input No. 272-NFPA 2-2024 [New Section after 10.5.1.1.4]

TITLE OF NEW CONTENT

Type your content here ...'=

10.5.1.1.4.1 Vehicles shall not be considered a source of ignition with respect to requirements of this chapter.

Statement of Problem and Substantiation for Public Input

This proposal pairs up the discussion on ignition sources in one location. Alternatively 10.5.1.1.4 could refer to existing 10.2.3 in addition to 4.11, but it's easier not to have to refer to other paragraphs.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 271-NFPA 2-2024 [Section No. 10.2.3]	Move to new location

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 23:58:35 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-217-NFPA 2-2024
Statement: Material remains the same but relocate to 10.5.1.1.4.1 in the General section for Dispensing where it fits with other material on ignition sources

Public Input No. 274-NFPA 2-2024 [New Section after 10.5.1.2.2]

TITLE OF NEW CONTENT

Type your content here ...

10.5.1.2.3 Where an overpressure incident that results in operation of the overpressure protection system occurs, the dispenser pressure control system shall be examined and certified by a qualified technician prior to being returned to service.

Statement of Problem and Substantiation for Public Input

This paragraph is better located with overpressure related material in 10.5.1.2.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 273-NFPA 2-2024 [Section No. 10.2.4]	Relocation of text

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 00:05:54 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-55-NFPA 2-2024
Statement: This is a very specific requirement to have in section 10.2 and it's better aligned with related material in 10.5.1.2 a new section.

Public Input No. 160-NFPA 2-2023 [Section No. 10.5.1.5]

10.5.1.5* Fueling Protocols for Medium- and Heavy-Duty Hydrogen Motor Vehicles.

10.5.1.5.1

The dispenser shall use a standard fueling protocol, as their default protocol .

10.5.1.5.1.1*

The dispenser using a standard ~~fueling~~ automotive protocol shall be listed, approved, or tested to CSA Technical Specification HGV 4 .3.5, *Test Methods for Hydrogen Fueling Parameter Evaluation for Heavy Duty Vehicles.*

10.5.1.5.2

For all public dispensers and dispensers intended to fuel both light- and medium-/heavy-duty hydrogen motor vehicles, the non-light-duty vehicle protocol shall be treated as a nonstandard fueling protocol and meet the requirements of 10.5.1.4.2.1 through 10.5.1.4.2.3.

10.5.1.5.2.1

All public dispensers and dispensers intended to fuel ~~light~~ medium -/heavy- duty hydrogen motor vehicles that can fuel a hydrogen vehicle using a nonstandard automotive fueling protocol shall have means to prevent the fueling of vehicles not designed to use the dispenser.

Statement of Problem and Substantiation for Public Input

When the current version of NFPA2 was published, there were no fueling protocols for medium/heavy duty vehicles. Now, SAE J2601/5 is a published standard which provides a protocol for buses, trucks, etc. CSA TS HGV 4.3.5 will be the accompanying standard which is used to validate SAE J2601/5. The language in this section matches 10.5.1.4 for light duty vehicles. Vehicles are designed to standard fueling protocols, so it is important for stations to use this as their default otherwise, damage to the vehicle and fuel supply container (vehicle tank) may occur.

This Public Input is submitted on behalf of the NFPA 2 Fueling Task Group.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 161-NFPA 2-2023 [New Section after A.10.1.1.5]	Annex Material
Public Input No. 162-NFPA 2-2023 [Section No. A.10.5.1.5.1.1]	Annex Material
Public Input No. 163-NFPA 2-2023 [Section No. 2.3.11]	Reference
Public Input No. 164-NFPA 2-2023 [Section No. 2.3.6]	Reference
Public Input No. 161-NFPA 2-2023 [New Section after A.10.1.1.5]	
Public Input No. 162-NFPA 2-2023 [Section No. A.10.5.1.5.1.1]	
Public Input No. 163-NFPA 2-2023 [Section No. 2.3.11]	
Public Input No. 164-NFPA 2-2023 [Section No. 2.3.6]	

Submitter Information Verification

Submitter Full Name: Spencer Quong
Organization: Quong & Associates Inc.
Affiliation: Toyota

Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 21 17:01:58 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-39-NFPA 2-2024

Statement: SAE published J2601/5 as a TIR and it provides a fast fueling protocol for H35 and H70 dispensers serving a wide range of buses, trucks, etc. CSA TS HGV 4.3.5 will be the accompanying standard which is used to validate SAE J2601/5 when issued. It is likely to be published before 2nd draft and can be resubmitted as a Public Comment.

Public Input No. 293-NFPA 2-2024 [Section No. 10.5.2.1.1.1]

10.5.2.1.1.1

Compression, gas processing, dispensing equipment, and storage containers connected for public use shall be allowed to be located inside of buildings reserved exclusively for these purposes or in rooms within or attached to buildings used for other purposes in accordance with Chapters 6, 7, _ and ~~7~~ _ 8 .

Statement of Problem and Substantiation for Public Input

Adding Chapter 8 since many GH2 dispensing systems will be supplied with LH2.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 11:10:09 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-56-NFPA 2-2024
Statement: Adding Chapter 8 since many GH2 dispensing systems will be supplied with LH2.

Public Input No. 294-NFPA 2-2024 [Section No. 10.5.2.1.1.2]

10.5.2.1.1.2

Dispensing equipment shall be installed on foundations with anchoring systems designed to meet the requirements of the adopted building code for the appropriate seismic and wind conditions. [~~**52:** 9.3.3~~] _

Statement of Problem and Substantiation for Public Input

Drop the extract tag. Meeting the appliable building code is a general requirement and removal of the extract tag is a simplification.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 11:11:37 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-57-NFPA 2-2024
Statement: Meeting the applicable building code is a general requirement and removal of the extract tag is a simplification.

Public Input No. 166-NFPA 2-2023 [New Section after 10.5.2.2.1]

10.5.2.2.1.5

The outdoor installation of hydrogen dispensers shall meet the separation distances shown in Table 10.5.2.2.1.5 .

Table 10.5.2.2.1.5 Separation Distances for Outdoor Gaseous Hydrogen Dispensing Systems

System Component	Exposure	Required Separation ft	Required Separation m
Dispensing equipment	Nearest important building or line of adjoining property that can be built upon or from any source of ignition	20	6.0
Dispensing equipment	Nearest public street or public sidewalk	20	6.0
Dispensing equipment	Nearest rail of any railroad main track	20	6.0
Point of transfer	Any important building other than buildings of Type I or Type II construction with exterior walls having a fire resistance rating of not less than not less than 2 hours	20	6.0
Point of transfer	Buildings of Type I or II construction with exterior walls having a fire resistance rating of not less than 2 hours or walls constructed of concrete or masonry, or of other material having a fire resistance rating of not less than 2 hours	No limit	No limit
Point of transfer	Storage containers	6	2.0

..

Statement of Problem and Substantiation for Public Input

The medium-/heavy-duty vehicles require larger dispensing systems which have increased flow rates. In the event of a leak or other incident, more hydrogen could be released or a larger jet fire could occur. Therefore, additional separation distances are necessary to protect the exposure.

This public input is submitted on behalf of the NFPA2 Fueling Task Group

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 165-NFPA 2-2023 [Section No. 10.5.2.2.1.4]	Seperation of Light Duty and Medium-/Heavy Duty dispensing separation distances
Public Input No. 165-NFPA 2-2023 [Section No. 10.5.2.2.1.4]	

Submitter Information Verification

Submitter Full Name: Spencer Quong
Organization: Quong & Associates Inc.
Affiliation: Toyota

Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 21 17:37:22 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: There is a limited technical basis to establish a separation distance for medium duty and heavy duty vehicles and establishing a separation distance without technical data is problematic. Separation will most likely be a function of pressure and nozzle size.

Public Input No. 165-NFPA 2-2023 [Section No. 10.5.2.2.1.4]

10.5.2.2.1.4

The outdoor installation of hydrogen dispensers ~~shall~~ for light-duty vehicles shall meet the separation distances shown in Table 10.5.2.2.1.4.

Table 10.5.2.2.1.4 Separation Distances for Outdoor Gaseous Hydrogen Dispensing Systems

System Component	Exposure	Required Separation ft	Required Separation m
Dispensing equipment	Nearest important building or line of adjoining property that can be built upon or from any source of ignition	10	3.0
Dispensing equipment	Nearest public street or public sidewalk	10	3.0
Dispensing equipment	Nearest rail of any railroad main track	10	3.0
Point of transfer	Any important building other than buildings of Type I or Type II construction with exterior walls having a fire resistance rating of not less than not less than 2 hours	10	3.0
Point of transfer	Buildings of Type I or II construction with exterior walls having a fire resistance rating of not less than 2 hours or walls constructed of concrete or masonry, or of other material having a fire resistance rating of not less than 2 hours	No limit	No limit
Point of transfer	Storage containers	3	1.0

Statement of Problem and Substantiation for Public Input

The separation distances in this section were created for light-duty vehicle dispensing. A new medium/heavy-duty table is proposed in a related PI.

This Public Input is submitted on behalf of the Fueling Task Group.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 166-NFPA 2-2023 [New Section after 10.5.2.2.1]	Seperation of Light Duty and Medium-/Heavy Duty dispensing separation distances
Public Input No. 166-NFPA 2-2023 [New Section after 10.5.2.2.1]	

Submitter Information Verification

Submitter Full Name: Spencer Quong

Organization: Quong & Associates Inc.
Affiliation: Toyota
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 21 17:34:25 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: There is a limited technical basis to establish a separation distance for medium duty and heavy duty vehicles and establishing a separation distance without technical data is problematic. Separation will most likely be a function of pressure and nozzle size.

Public Input No. 295-NFPA 2-2024 [Section No. 10.5.3.4.1.2]

~~10.5.3.4.1.2~~ –

~~Fuel dispensing indoors shall be in accordance with 10.5.3.4 .~~

Statement of Problem and Substantiation for Public Input

Redundant with the previous paragraph 10.5.3.4.1.1 “Indoor dispensing to nonpublic users shall meet the provisions of 10.5.3.4”

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 11:14:52 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-58-NFPA 2-2024
Statement: This paragraph is redundant with the previous paragraph 10.5.3.4.1.1 “Indoor dispensing to nonpublic users shall meet the provisions of 10.5.3.4”

Public Input No. 114-NFPA 2-2023 [Section No. 10.5.3.4.1.4]

10.5.3.4.1.4

Deflagration vents shall be permitted to consist of any of the following:

(1) Walls of light material

(2) Lightly fastened hatch covers

(3) Lightly fastened, outward-opening doors in exterior walls

(4) Lightly fastened walls or roofs

(5) Other methods in accordance with NFPA 69 and chapter 9

Statement of Problem and Substantiation for Public Input

this directs explosion control to chapter 9

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 108-NFPA 2-2023 [Section No. 7.1.23.15.1 [Excluding any Sub-Sections]]	
Public Input No. 109-NFPA 2-2023 [Section No. 7.3.2.2.2.3]	
Public Input No. 110-NFPA 2-2023 [Section No. 7.3.2.2.3.3]	
Public Input No. 111-NFPA 2-2023 [Section No. 7.3.2.5]	
Public Input No. 112-NFPA 2-2023 [Section No. 8.3.2.2.2.1(B)]	
Public Input No. 113-NFPA 2-2023 [Section No. 8.3.2.2.3.2]	
Public Input No. 175-NFPA 2-2023 [Chapter 9]	Chapter 9

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control Task Group
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 14 10:52:51 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-35-NFPA 2-2024
Statement: Other NFPA 69 methods are now detailed in chapter 9 and that is being cross referenced in this section

Public Input No. 300-NFPA 2-2024 [Section No. 10.5.3.4.3.2]

10.5.3.4.3.2

Fast-fill fueling indoors shall be permitted in accordance with 10.5. 2.2.1, 10.5. 3.2.3, 10.5.3.4.1, and 10.5.3.4.3.

Statement of Problem and Substantiation for Public Input

Adding 10.5.2.2.1 to this list. Moved from the paragraph 10.5.3.4.3.3 to consolidate to this paragraph. Related PI changed reference from 10.5.2.2.1 in that paragraph to a reference that was more applicable.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 296-NFPA 2-2024 [Section No. 10.5.3.4.3.3]	Moving content to previous paragraph

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 11:51:34 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-59-NFPA 2-2024

Statement: The reference in 10.5.3.4.3.3 to 10.5.2.2.1 is not applicable to indoor fast fill fueling when the balance of the fueling equipment is outdoors. The appropriate reference that applies to indoor fast fill fueling with the equipment outdoors is 10.5.3.4.1.8.

The word "permitted" was changed to "allowed" per similar changes made to several paragraphs for the same wording from the 2023 code cycle. The word “permitting” can be confused with permitting the system with the local AHJ.

Public Input No. 296-NFPA 2-2024 [Section No. 10.5.3.4.3.3]

10.5.3.4.3.3

Fast-fill fueling indoors shall be ~~permitted where~~ allowed where storage, gas processing, and compression equipment is located outdoors in compliance with 10.5.~~2~~3.~~2~~4.1.8

Statement of Problem and Substantiation for Public Input

The reference to 10.5.2.2.1 is confusing since it does not seem applicable to allow fast fill fueling indoors when the balance of equipment is outdoors.
10.5.2.2.1 is nearly all related to dispensing equipment, not the balance of the fuel station. If the intent is to bring this into Section 10.5.3.4.3 for Indoor, then it seems like the better location for this to be referenced is the paragraph preceding: 10.5.3.4.3.2 "Fast fill fueling indoors shall be permitted in accordance with 10.5.3.2.3, 10.5.3.4.1, and 10.5.3.4.3"
The intent seems to be to allow indoor fast fueling without ventilation by installing the balance of the equipment outside. Then the appropriate reference is 10.5.3.4.1.8.
Also changed "permitted" to "allowed" per a PI from the 2023 code cycle.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 300-NFPA 2-2024 [Section No. 10.5.3.4.3.2]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 11:16:47 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-59-NFPA 2-2024

Statement: The reference in 10.5.3.4.3.3 to 10.5.2.2.1 is not applicable to indoor fast fill fueling when the balance of the fueling equipment is outdoors. The appropriate reference that applies to indoor fast fill fueling with the equipment outdoors is 10.5.3.4.1.8.

The word "permitted" was changed to "allowed" per similar changes made to several paragraphs for the same wording from the 2023 code cycle. The word “permitting” can be confused with permitting the system with the local AHJ.

Public Input No. 304-NFPA 2-2024 [New Section after 10.5.3.4.3.7]

TITLE OF NEW CONTENT

Type your content here ...

10.5.3.4.3.7 Defueling. If GH2 is to be removed from the vehicle storage system, GH2 shall be discharged into a closed transfer system or vented outdoors through a vent pipe system installed and constructed in accordance with CGA G-5.5, *Hydrogen Vent Systems*

Statement of Problem and Substantiation for Public Input

This is same content, relocated from 10.5.3.4.3.7 since this activity may be separate from the Dispensing Equipment. Separating into its own paragraph makes it more general and could be done through the dispensing equipment or a system elsewhere in the facility.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 301-NFPA 2-2024 [Section No. 10.5.3.4.3.7]	Relocated requirement

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 12:22:00 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-84-NFPA 2-2024

Statement: Added “Emergency” to Automatic Shutoff valve to indicate this valve is in addition to the normal operational valve. An emergency valve provides redundancy for the normal operational valve if failure of the operational valve is the reason for the ESD was activated. Changed to “dispensing station” so it’s clear that the ESD referenced is at the dispensing area.

All dispensers do not have a "control arm", nor is that a code requirement, so requirement was changed to when the dispenser operation is stopped.

Added a requirement that the dispensing area also be covered by the gas detection system since a detector within the enclosure would not detect leaks in the surrounding area from the hose, nozzle, or vehicle being filled.

Changed from 25% of LFL to 1% H2 since there have been numerous questions raised

about which H2 LFL to use and it has been clarified to specify that it is 1% of H2.

Changed to “isolate the hydrogen source outside the room” to clarify that the isolation valve needs to be outside the room.

Relocated the defueling requirement since defueling does not need to be done at the dispenser.

Public Input No. 301-NFPA 2-2024 [Section No. 10.5.3.4.3.7]

10.5.3.4.3.7 Dispensing Equipment for Indoor Fast-Fill of HPITs.

In addition to the requirements of 10.5.3.2.1, 10.5.3.2.3, and 10.5.3.4.3, the following applies to dispensing equipment for indoor fast-fill of HPITS:

(1) *Protocol.*Gas dispensing equipment for indoor fast-fill of HPITs shall use the fueling protocol of SAE J2601-3, *Fueling Protocol for Gaseous Hydrogen Powered Industrial Trucks*.

(2) *Emergency Automatic Shutoff Valve.* Hydrogen gas piping used to transport GH_2 between the bulk hydrogen compressed gas storage system and a dispenser at a fast-fill station shall have a valve that closes when either of the following occurs:

(a) The power supply to the dispenser is shut off.

(b) Any emergency shutdown device at the ~~refueling station~~ dispensing station is activated.

(3) *Manual Shutoff Valve.* A quarter-turn manual shutoff valve shall be provided at a fast-fill station upstream of the breakaway device, where it is readily accessible to the person dispensing hydrogen, unless one of the following occurs:

(a) The self-closing valve referred to in 10.5.3.4.3.7(2) is located immediately upstream of the dispenser.

(b) The dispenser is equipped with a self-closing valve that closes each time the ~~control arm is turned to the OFF position~~ dispenser opeation is stopped or when the ESD is activated.

(4) *Shutdown.* Actuation or failure of the following systems shall automatically shut down the gas flow from the dispenser, stop the flow of gas to the room, and start or continue to run the mechanical ventilation system where mechanical ventilation systems are required:

(a) Gas detection system

(b) Fire alarm system

(c) Fire detection system

(d) ESD

(e) Sensors or controls used to prevent overtemperature or overpressurization of the on-board fuel container

(f) Required ventilation systems

(g) Dispenser leak monitoring system

(5) *Reactivation.* Reactivation of the dispenser and gas flow into the room after system shutdown required by 10.5.3.4.3.7(2) or 10.5.3.4.3.7(4) shall be both of the following:

(a) By manual restart and shall be

(b) Conducted by trained personnel

(6)* *Gas Detection System.* The ~~dispenser enclosure or housing~~ dispensing system shall be equipped with a gas detection system to detect hydrogen leakage above the dispensing area and within the dispenser enclosure that shall comply with all of the following:

(7) Actuate when a maximum of

~~25 percent of the lower flammable limit (LFL)~~

(a) 1% hydrogen is detected

(b) Shut down the dispenser,

~~stop the flow of gas into~~

(a) isolate the hydrogen source outside the room, and start or continue to run the mechanical ventilation system

~~when mechanical ventilation systems are required~~

(a) when installed

(b) Sound a local alarm and provide visual indication where a maximum of

~~25 percent of the lower flammable limit (LFL)~~

(a) 1% hydrogen is detected

(b) Remain functional during maintenance operations on the ventilation system.

(8) *Electrical.* Electrical equipment on dispensers shall be in accordance with 10.4.6.1.

(9) *Temperature Limits.* Dispensing systems shall be provided with a means to prevent the on-board fuel system from exceeding prescribed temperature limits during fueling operations.

(10) *Pressure Limits.* Dispensing systems shall be provided with a means to prevent the on-board fuel system from exceeding prescribed pressure limits during fueling operations.

(11) *Ignition Source Control.* The owner/operator shall not allow hot work/open flames within 15 ft (4.6 m) of the refueling location unless the dispenser is shut down, depressurized, and purged with an inert gas.

(12) ~~*Defueling.* If GH~~ $_2$ ~~is to be removed from the vehicle storage system, GH~~ $_2$ ~~shall be discharged into a closed transfer system or vented outdoors through a vent pipe system installed and constructed in accordance with CGA G-5.5, *Hydrogen Vent Systems*~~

Statement of Problem and Substantiation for Public Input

Add “Emergency” to Automatic Shutoff valve to indicate this valve is in addition to the normal operational valve. The emergency valve should be in addition to the normal operational valve to be available if failure of the operational valve is the reason for the ESD was activated.
Change to “dispensing station” so it’s clear that the ESD referenced is at the dispensing area.
All dispensers do not have a "control arm" so should be changed to when the dispenser operation is stopped
Add a requirement that the dispensing area also be covered by the gas detection system since a detector within the enclosure would not detect leaks in the surrounding area from the hose, nozzle, or vehicle being filled.
Change from 25% of LFL to 1% H2 since there have been numerous questions raised about the LFL percentage.
Change to “isolate the hydrogen source outside the room” to clarify that the isolation valve needs to be outside the room.
Relocate the defueling requirement since defueling does not need to be done at the dispenser.

NOTE: The Terra system shows the proposed changes in a confusing matter due to formatting. Look at original text for additional clarity as to the changes.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 304-NFPA 2-2024 [New Section after 10.5.3.4.3.7]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 11:54:47 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-84-NFPA 2-2024

Statement: Added “Emergency” to Automatic Shutoff valve to indicate this valve is in addition to the normal operational valve. An emergency valve provides redundancy for the normal operational valve if failure of the operational valve is the reason for the ESD was activated. Changed to “dispensing station” so it’s clear that the ESD referenced is at the dispensing area.

All dispensers do not have a "control arm", nor is that a code requirement, so requirement was changed to when the dispenser operation is stopped.

Added a requirement that the dispensing area also be covered by the gas detection system since a detector within the enclosure would not detect leaks in the surrounding area from the hose, nozzle, or vehicle being filled.

Changed from 25% of LFL to 1% H2 since there have been numerous questions raised about which H2 LFL to use and it has been clarified to specify that it is 1% of H2.

Changed to “isolate the hydrogen source outside the room” to clarify that the isolation valve needs to be outside the room.

Relocated the defueling requirement since defueling does not need to be done at the dispenser.

Public Input No. 153-NFPA 2-2023 [Section No. 10.5.4]

~~**10.5.4** – Indoor Nonpublic Residential Fueling. (Reserved)~~

Statement of Problem and Substantiation for Public Input

Submitted on behalf of Home Fueling Appliance Task Group in response to CI-86. The task group would like to remove this section and create a new section in Chapter 10 reserved for indoor home fueling with the goal of providing language no later than next revision.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 155-NFPA 2-2023 [New Section after 10.8]	

Submitter Information Verification

Submitter Full Name: Bryan Gordon
Organization: Home Fueling Task Group
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 20 13:51:51 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-93-NFPA 2-2024
Statement: For better organization of the code, this section has been moved to become a new reserved section in Chapter 10 for indoor home fueling.

Public Input No. 305-NFPA 2-2024 [Section No. 10.6.3.1]

10.6.3.1*

Pressure relief ~~valves protecting ASME pressure vessels~~ devices designed and installed in accordance with 7.1.5.5.2 to protect pressure vessels and pressure relief devices to protect dispensing systems shall be repaired, adjusted, inspected and tested in accordance with applicable regulations and design standards . .

Statement of Problem and Substantiation for Public Input

The proposed text merges 10.6.3.1 and 10.6.3.3. These sections overlap and merging them adds clarity and avoid confusion. These two paragraphs also technically only applied to vessel relief devices and not those that are on the balance of the dispensing system. For example, the dispenser relief devices protecting the dispenser and vehicle being filled would not be included.

10.6.3.3 (A) stands alone once 10.6.3.3 is merged with 10.6.3.1 and could be promoted to a new 10.6.3.3 if desired. It's not clear why the (A) paragraph exists since there is no (B). It's also not clear why (A) is needed since it is redundant with existing (and revised) 10.6.3.1, 10.6.3.2 and 10.6.3.3 since CGA S1.3 is referenced in 7.1.5.5.2 already. It might make sense to delete (A) entirely with the reorganization.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 12:32:46 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-60-NFPA 2-2024
Statement: Previously these two paragraphs only directly applied to vessel relief devices and not those that are on the balance of the dispensing system. The requirement now matches up the requirements for pressure vessels with its appropriate requirement reference

Public Input No. 306-NFPA 2-2024 [Section No. 10.6.3.7(A)]

~~(A)~~ – **10.6.3.7.1**

The calibration indicator shall be readily visible to the hydrogen dispensing system user and shall not obscure other display functions of the dispenser.

Statement of Problem and Substantiation for Public Input

This might be a manual of style issue, but why is there a paragraph (A) when there is no (B)? Show with a dependent paragraph number under 10.6.3.7.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 12:51:46 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-61-NFPA 2-2024
Statement: There is no B and the requirement is being renumbered appropriately.

Public Input No. 155-NFPA 2-2023 [New Section after 10.8]

Indoor Nonpblic Residential Home Refueling Appliances

(Reserved)

Statement of Problem and Substantiation for Public Input

In conjunction with PI-153 and the disposition of CI-86. The home fueling task group has determined that additional work is required to create language around indoor non public residential fueling appliances including adequate offsets and building design considerations. This reserved section will allow the home fueling appliance task group to develop additional language around indoor residential hydrogen fueling and move the requirements to its own section within the document.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 153-NFPA 2-2023 [Section No. 10.5.4]	

Submitter Information Verification

Submitter Full Name: Bryan Gordon
Organization: Home Fueling Task Group
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 20 13:55:06 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-93-NFPA 2-2024
Statement: For better organization of the code, this section has been moved to become a new reserved section in Chapter 10 for indoor home fueling.

Public Input No. 216-NFPA 2-2023 [Section No. 11.1]

11.1 Scope.

This chapter applies to the design, siting, construction, installation, and operation of containers, pressure vessels, pumps, vaporization equipment, and associated equipment used for the storage or dispensing of LH_2 as an engine fuel for vehicles of all types.

11.1.1 Application.

This chapter shall apply to the storage, use, and handling of LH_2 in connection with self-propelled vehicles powered by hydrogen.

11.1.1.1

The storage, use, and handling of LH_2 in connection with self-propelled vehicles powered by hydrogen shall also comply with the requirements of Chapters 1 and 4 and the applicable requirements of Chapters 5 through 8.

11.1.1.2

Chapters 4 and 6 through 8 contain fundamental requirements that shall apply to all hydrogen systems.

11.1.1.2.1

The use-specific requirements of this chapter for the storage, use, and handling of LH_2 shall apply.

11.1.1.2.2

Where there is a conflict between a fundamental requirement and a use-specific requirement, the use-specific requirement shall apply.

11.1.1.3

The requirements of Chapter 11 shall be applicable to LH_2 systems only. Where LH_2 is converted to GH_2, those portions of the system utilized for GH_2 shall be in accordance with Chapter 10.

Additional Proposed Changes

File Name	Description	Approved
Chapter_11_Scope_Changes.docx	Chapter 11 Scope Changes	

Statement of Problem and Substantiation for Public Input

Rationale for Minor Changes to Scope Section for Chapters 10 and 11:
1) Wording and format are inconsistent between Chapters 10 and 11.
a. Create common language by merging from both, but primarily from Chapter 10.
b. Align with same format.
2) Clarify and broaden that GH2 dispensing systems may also be supplied from a LH2 source.
3) Clarify that Chapter 10 is for GH2 dispensing and Chapter 11 is for LH2 dispensing, regardless of source.

Submitter Information Verification

Submitter Full Name: Carl Rivkin

Organization: Nikola Corporation
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 28 17:04:07 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-81-NFPA 2-2024

Statement: The changes clarify and broaden that GH2 dispensing systems may also be supplied from a LH2 source. The changes also clarify that Chapter 10 is for GH2 dispensing and Chapter 11 is for LH2 dispensing, regardless of source.

Chapter 11:

11.1.1 Scope. This chapter shall apply ~~applies~~ to the design, siting, construction, installation and operation of ~~containers, pressure vessels, pumps, vaporization equipment, and associated equipment used for the storage or dispensing~~ of LH2 ~~as an engine fuel for vehicles of all types.~~ dispensing systems to be utilized for LH2 fueling of vehicles.

11.1.1* Application. The requirements of this chapter shall apply to ~~the storage, use, and handling of~~ LH2 fueling operations, irrespective of the system capacity of either the fueling source or the vehicle being fueled. ~~in connection with self-propelled vehicles powered by hydrogen.~~

.

11.1.1.1 ~~The storage, use, and handling of LH2 in connection with self-propelled vehicles powered by hydrogen shall also comply with the requirements of Chapters 1 and 4 and the applicable requirements of Chapters 5 through 8.~~ LH2 dispensing systems for vehicular fueling shall comply with Chapter 11.

11.1.1.2 ~~Chapters 4 and 6 through 8 contain fundamental requirements that shall apply to all hydrogen systems.~~ The storage, use, and handling of hydrogen in any quantity shall also comply with the requirements of Chapter 1 and 4 and the applicable requirements of Chapters 5 through 8.

~~11.1.1.2.1 The use specific requirements of this chapter for the storage, use, and handling of LH2 shall apply.~~

~~11.1.1.2.2~~ 11.1.1.3 Where there is a conflict between a fundamental requirement and a use-specific requirement, the use-specific requirement shall apply.

~~11.1.1.3~~ 11.1.1.4 The requirements of Chapter 11 shall be applicable to LH2 systems only. Where LH2 is converted to GH2, those portions of the system utilized for GH2 shall be in accordance with Chapter 10.

Public Input No. 228-NFPA 2-2024 [New Section after 11.2.4.1]

TITLE OF NEW CONTENT

Type your content here ...

11.2.5.1 All facility LH2 piping and equipment other than the refueling line to the vehicle shall be behind these barriers to deflect LH2 that has been released due to equipment malfunction.

Statement of Problem and Substantiation for Public Input

This proposal moves the last sentence of 11.2.5, with minor edits for clarification, to a separate paragraph since it's a separate requirement.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 227-NFPA 2-2024 [Section No. 11.2.5]	Moved text from modification of 11.2.5
Public Input No. 229-NFPA 2-2024 [New Section after 11.2.5]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 02 23:42:25 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-112-NFPA 2-2024

Statement: Change to 11.2.5 aligns to the revised scope of Chapter 11 to apply to LH2 dispensing stations. The intent to require protection from LH2 remains the same, but more concisely. The last sentence is maintained as a new paragraph 11.2.5.1 since it's a separate requirement.

A requirement for the refueling line to insulated with a vacuum jacket since other insulation types do not provide sufficient protection to the dispenser operator from hazardous conditions including cryogenic surfaces and creation of liquified air. The vacuum jacket also provides additional double wall protection for the refueling line.Change to 11.2.6 clarifies that this requirement applies to LH2-related activities, eliminates wording redundancy, and deletes the reference to internal combustion vehicles since that is too narrow.

Change to 11.2.6.1 only permits vehicle equipment powering dispensing functions

because to minimize the ignition sources and is vehicle agnostic. Requirements for fire extinguishing equipment are changed to align with the requirements of Chapter 10.

Public Input No. 229-NFPA 2-2024 [New Section after 11.2.5]

TITLE OF NEW CONTENT

Type your content here ...

11.2.5.2 The refueling line to the vehicle shall be insulated with a vacuum jacket.

Statement of Problem and Substantiation for Public Input

This proposal adds a requirement for the refueling line to be insulated, and insulated with a vacuum jacket. Other insulation types do not provide sufficient protection to the dispenser operator from hazardous conditions including cryogenic surfaces and creation of liquified air. The vacuum jacket also provides additional double wall protection for the refueling line.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 228-NFPA 2-2024 [New Section after 11.2.4.1]	Provides additional requirement for the liquid refueling line

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 02 23:48:46 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-112-NFPA 2-2024

Statement: Change to 11.2.5 aligns to the revised scope of Chapter 11 to apply to LH2 dispensing stations. The intent to require protection from LH2 remains the same, but more concisely. The last sentence is maintained as a new paragraph 11.2.5.1 since it's a separate requirement.

A requirement for the refueling line to insulated with a vacuum jacket since other insulation types do not provide sufficient protection to the dispenser operator from hazardous conditions including cryogenic surfaces and creation of liquified air. The vacuum jacket also provides additional double wall protection for the refueling line.Change to 11.2.6 clarifies that this requirement applies to LH2-related activities, eliminates wording redundancy, and deletes the reference to internal combustion vehicles since that is too narrow.

Change to 11.2.6.1 only permits vehicle equipment powering dispensing functions

because to minimize the ignition sources and is vehicle agnostic. Requirements for fire extinguishing equipment are changed to align with the requirements of Chapter 10.

Public Input No. 227-NFPA 2-2024 [Section No. 11.2.5]

11.2.5 Personnel Protection.

LH_2 refueling ~~sites utilizing or dispensing LH 2 shall provide personnel protection barriers such as~~ sites shall provide protection of personnel and vehicles from LH2 exposure with walls, cabinets, vacuum-~~jacketed pipe~~ jacketing , ~~and similar barriers to protect the fueling operator and the vehicle being fueled from contact with a release of LH 2 . All facility piping other than the refueling line to the vehicle shall be behind the barrier, to deflect any LH 2 that is released due to an equipment malfunction.~~ or similar barriers.

Statement of Problem and Substantiation for Public Input

This proposed change aligns the intent to the revised scope of Chapter 11 to apply to LH2 dispensing stations. The intent to require protection from LH2 remains the same, but more concisely. The last sentence is maintained as a new paragraph to be inserted after this paragraph since it's a separate requirement.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 228-NFPA 2-2024 [New Section after 11.2.4.1]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 02 23:32:17 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-112-NFPA 2-2024

Statement: Change to 11.2.5 aligns to the revised scope of Chapter 11 to apply to LH2 dispensing stations. The intent to require protection from LH2 remains the same, but more concisely. The last sentence is maintained as a new paragraph 11.2.5.1 since it's a separate requirement.

A requirement for the refueling line to insulated with a vacuum jacket since other insulation types do not provide sufficient protection to the dispenser operator from hazardous conditions including cryogenic surfaces and creation of liquified air. The vacuum jacket also provides additional double wall protection for the refueling line.Change to 11.2.6 clarifies that this requirement applies to LH2-related activities, eliminates wording redundancy, and deletes the reference to internal combustion

vehicles since that is too narrow.

Change to 11.2.6.1 only permits vehicle equipment powering dispensing functions because to minimize the ignition sources and is vehicle agnostic. Requirements for fire extinguishing equipment are changed to align with the requirements of Chapter 10.

Public Input No. 230-NFPA 2-2024 [Section No. 11.2.6 [Excluding any Sub-Sections]]

Smoking materials, including matches and lighters, shall not be used within 25 ft (7.6 m) of areas used for LH2 fueling, servicing vehicle LH2 fuel systems ~~of internal combustion engines~~ , or ~~receiving or dispensing of LH~~ 2 ~~.~~ delivery of LH2 to the facility.

Statement of Problem and Substantiation for Public Input

The intent remains the same, but this proposal clarifies that this requirement applies to LH2-related activities and also eliminates some redundancy. It also deletes the reference to internal combustion vehicles since that is too narrow.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 02 23:56:37 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-112-NFPA 2-2024

Statement: Change to 11.2.5 aligns to the revised scope of Chapter 11 to apply to LH2 dispensing stations. The intent to require protection from LH2 remains the same, but more concisely. The last sentence is maintained as a new paragraph 11.2.5.1 since it's a separate requirement.

A requirement for the refueling line to insulated with a vacuum jacket since other insulation types do not provide sufficient protection to the dispenser operator from hazardous conditions including cryogenic surfaces and creation of liquified air. The vacuum jacket also provides additional double wall protection for the refueling line.Change to 11.2.6 clarifies that this requirement applies to LH2-related activities, eliminates wording redundancy, and deletes the reference to internal combustion vehicles since that is too narrow.

Change to 11.2.6.1 only permits vehicle equipment powering dispensing functions because to minimize the ignition sources and is vehicle agnostic. Requirements for fire extinguishing equipment are changed to align with the requirements of Chapter 10.

Public Input No. 232-NFPA 2-2024 [New Section after 11.2.6.1]

TITLE OF NEW CONTENT

Type your content here ...

11.2.6.1.1 Vehicle equipment required for dispensing function or emergency use may continue to operate during fueling operations when approved.

Statement of Problem and Substantiation for Public Input

The intent of this paragraph is to move content from 11.2.6.1 and provide additional clarity to the operation of vehicle equipment.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 231-NFPA 2-2024 [Section No. 11.2.6.1]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 00:06:49 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-112-NFPA 2-2024

Statement: Change to 11.2.5 aligns to the revised scope of Chapter 11 to apply to LH2 dispensing stations. The intent to require protection from LH2 remains the same, but more concisely. The last sentence is maintained as a new paragraph 11.2.5.1 since it's a separate requirement.

A requirement for the refueling line to insulated with a vacuum jacket since other insulation types do not provide sufficient protection to the dispenser operator from hazardous conditions including cryogenic surfaces and creation of liquified air. The vacuum jacket also provides additional double wall protection for the refueling line.Change to 11.2.6 clarifies that this requirement applies to LH2-related activities, eliminates wording redundancy, and deletes the reference to internal combustion vehicles since that is too narrow.

Change to 11.2.6.1 only permits vehicle equipment powering dispensing functions because to minimize the ignition sources and is vehicle agnostic. Requirements for fire extinguishing equipment are changed to align with the requirements of Chapter 10.

Public Input No. 231-NFPA 2-2024 [Section No. 11.2.6.1]

11.2.6.1

The ~~motors~~ propulsion equipment of ~~all equipment~~ vehicles being fueled shall be shut off during the fueling operation~~ except for emergency generators, pumps, communication devices, and so forth, where continuing operation is essential.~~ .

Statement of Problem and Substantiation for Public Input

This proposed language requires the propulsion equipment (engines, motors, fuel cells, etc) to be shut off during fueling meeting the intent of the previous language. A portion of this paragraph is moved to a dependent paragraph in another PI.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 232-NFPA 2-2024 [New Section after 11.2.6.1]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 00:02:28 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-112-NFPA 2-2024

Statement: Change to 11.2.5 aligns to the revised scope of Chapter 11 to apply to LH2 dispensing stations. The intent to require protection from LH2 remains the same, but more concisely. The last sentence is maintained as a new paragraph 11.2.5.1 since it's a separate requirement.

A requirement for the refueling line to insulated with a vacuum jacket since other insulation types do not provide sufficient protection to the dispenser operator from hazardous conditions including cryogenic surfaces and creation of liquified air. The vacuum jacket also provides additional double wall protection for the refueling line.Change to 11.2.6 clarifies that this requirement applies to LH2-related activities, eliminates wording redundancy, and deletes the reference to internal combustion vehicles since that is too narrow.

Change to 11.2.6.1 only permits vehicle equipment powering dispensing functions because to minimize the ignition sources and is vehicle agnostic. Requirements for fire extinguishing equipment are changed to align with the requirements of Chapter 10.

Public Input No. 233-NFPA 2-2024 [Section No. 11.2.7 [Excluding any Sub-Sections]]

~~Portable fire extinguishers shall be selected, installed, inspected, and maintained in accordance with NFPA 10 and 11.2.7.1 through 11.2.7.3 of this code and 9.2.5.2.5 of NFPA 30A.~~
~~[**30A:** 9.2.5.2.1]~~ A minimum 10 lb (4.54 kg) ABC dry chemical portable fire extinguisher having an agent discharge rate of at least 1 lb/sec (.45 kg/sec) shall be provided at teh dispensing area in approved locations not more than 50 ft (15.2 m) away from the dispensing area.

Statement of Problem and Substantiation for Public Input

This proposal aligns Chapter 11 with paragraph 10.4.7 in Chapter 10. The following paragraphs are deleted to also align content with Chapter 10.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 234-NFPA 2-2024 [Section No. 11.2.7.1]	
Public Input No. 235-NFPA 2-2024 [Section No. 11.2.7.2]	
Public Input No. 236-NFPA 2-2024 [Section No. 11.2.7.3]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 00:12:01 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-112-NFPA 2-2024

Statement: Change to 11.2.5 aligns to the revised scope of Chapter 11 to apply to LH2 dispensing stations. The intent to require protection from LH2 remains the same, but more concisely. The last sentence is maintained as a new paragraph 11.2.5.1 since it's a separate requirement.

A requirement for the refueling line to insulated with a vacuum jacket since other insulation types do not provide sufficient protection to the dispenser operator from hazardous conditions including cryogenic surfaces and creation of liquified air. The vacuum jacket also provides additional double wall protection for the refueling line.Change to 11.2.6 clarifies that this requirement applies to LH2-related activities, eliminates wording redundancy, and deletes the reference to internal combustion vehicles since that is too narrow.

Change to 11.2.6.1 only permits vehicle equipment powering dispensing functions because to minimize the ignition sources and is vehicle agnostic. Requirements for fire extinguishing equipment are changed to align with the requirements of Chapter 10.

Public Input No. 234-NFPA 2-2024 [Section No. 11.2.7.1]

~~**11.2.7.1**~~ –

~~All portable fire extinguishers installed to achieve compliance with this code shall be a minimum of 4.54 kg (10 lb) ABC dry chemical having an agent discharge rate of 0.45 kg/sec (1 lb/sec) or greater. [**30A:** 9.2.5.2.2]~~

Statement of Problem and Substantiation for Public Input

Align with Chapter 10 and see related PI justification.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 233-NFPA 2-2024 [Section No. 11.2.7 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 00:16:11 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-112-NFPA 2-2024

Statement: Change to 11.2.5 aligns to the revised scope of Chapter 11 to apply to LH2 dispensing stations. The intent to require protection from LH2 remains the same, but more concisely. The last sentence is maintained as a new paragraph 11.2.5.1 since it's a separate requirement.

A requirement for the refueling line to insulated with a vacuum jacket since other insulation types do not provide sufficient protection to the dispenser operator from hazardous conditions including cryogenic surfaces and creation of liquified air. The vacuum jacket also provides additional double wall protection for the refueling line.Change to 11.2.6 clarifies that this requirement applies to LH2-related activities, eliminates wording redundancy, and deletes the reference to internal combustion vehicles since that is too narrow.

Change to 11.2.6.1 only permits vehicle equipment powering dispensing functions because to minimize the ignition sources and is vehicle agnostic. Requirements for fire extinguishing equipment are changed to align with the requirements of Chapter 10.

Public Input No. 235-NFPA 2-2024 [Section No. 11.2.7.2]

~~**11.2.7.2**~~ –

~~The maximum travel distance from a minimum 9.1 kg (20 lb) ABC dry chemical extinguisher having an agent discharge rate of 0.45 kg/sec (1 lb/sec) or greater shall be permitted to be 30.5 m (100 ft). [**30A:** 9.2.5.2.3]~~

Statement of Problem and Substantiation for Public Input

Align with Chapter 10 and see related PI justification.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 233-NFPA 2-2024 [Section No. 11.2.7 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 00:18:21 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-112-NFPA 2-2024

Statement: Change to 11.2.5 aligns to the revised scope of Chapter 11 to apply to LH2 dispensing stations. The intent to require protection from LH2 remains the same, but more concisely. The last sentence is maintained as a new paragraph 11.2.5.1 since it's a separate requirement.

A requirement for the refueling line to insulated with a vacuum jacket since other insulation types do not provide sufficient protection to the dispenser operator from hazardous conditions including cryogenic surfaces and creation of liquified air. The vacuum jacket also provides additional double wall protection for the refueling line.Change to 11.2.6 clarifies that this requirement applies to LH2-related activities, eliminates wording redundancy, and deletes the reference to internal combustion vehicles since that is too narrow.

Change to 11.2.6.1 only permits vehicle equipment powering dispensing functions because to minimize the ignition sources and is vehicle agnostic. Requirements for fire extinguishing equipment are changed to align with the requirements of Chapter 10.

Public Input No. 236-NFPA 2-2024 [Section No. 11.2.7.3]

~~**11.2.7.3** – New Fire Extinguishers.~~

~~Newly installed fire extinguishers, including replacements or exchanges, shall meet the requirements of 9.2.5.2 of NFPA 30A. [**30A:** 9.2.5.2.4]~~

Statement of Problem and Substantiation for Public Input

Align with Chapter 10 and see related PI justification.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 233-NFPA 2-2024 [Section No. 11.2.7 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 00:19:51 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-112-NFPA 2-2024

Statement: Change to 11.2.5 aligns to the revised scope of Chapter 11 to apply to LH2 dispensing stations. The intent to require protection from LH2 remains the same, but more concisely. The last sentence is maintained as a new paragraph 11.2.5.1 since it's a separate requirement.

A requirement for the refueling line to insulated with a vacuum jacket since other insulation types do not provide sufficient protection to the dispenser operator from hazardous conditions including cryogenic surfaces and creation of liquified air. The vacuum jacket also provides additional double wall protection for the refueling line.Change to 11.2.6 clarifies that this requirement applies to LH2-related activities, eliminates wording redundancy, and deletes the reference to internal combustion vehicles since that is too narrow.

Change to 11.2.6.1 only permits vehicle equipment powering dispensing functions because to minimize the ignition sources and is vehicle agnostic. Requirements for fire extinguishing equipment are changed to align with the requirements of Chapter 10.

Public Input No. 237-NFPA 2-2024 [Section No. 11.2.8.6]

~~**11.2.8.6** –~~

~~Static protection shall be required where LH~~ 2 ~~cargo transport vehicles are unloaded, except where cargo transport vehicles or marine equipment are loaded or unloaded by conductive hose, flexible metallic tubing, or pipe connections through or from tight (top or bottom) outlets where both halves of metallic couplings are electrically bonded.~~

Statement of Problem and Substantiation for Public Input

Maintain requirement with minor clarifications, but move to 11.4.5 "Cargo transport unloading". The only change to wording is to remove the details of the tight connection (top and bottom) which otherwise add confusion to the requirement.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 238-NFPA 2-2024 [New Section after 11.4.5.3]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 00:24:35 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-218-NFPA 2-2024
Statement: The section is moving under cargo transport unloading as it is related to cargo transport unloading.

Public Input No. 239-NFPA 2-2024 [Section No. 11.2.9]

11.2.9 Piping Systems and Components.

~~Piping~~ LH2 piping and piping components shall be in accordance with Chapter 8. ~~1.4.~~

Statement of Problem and Substantiation for Public Input

Adds piping components to the requirement (per the title) and widens requirement to all of Chapter 8 since 8.1.4 is not the only requirement in Chapter 8 that is applicable.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 00:34:48 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-63-NFPA 2-2024

Statement: Paragraph 8.1.4 is not the only requirement in Chapter 8 that is applicable to piping so this widens to all of Chapter 8. Adds piping components to the requirement to be consistent with the title of this paragraph.

A specific reference for relief devices for vaporizers is not required based on other requirements for relief devices provided by Chapter 8 and 11.3.1.5.2.

Public Input No. 240-NFPA 2-2024 [Section No. 11.2.10]

~~**11.2.10** – Pressure Relief Devices — Vaporizers.~~

~~The discharge from pressure relief devices serving the vaporizer system shall be connected to a vent pipe system.~~

-

Statement of Problem and Substantiation for Public Input

A specific reference for relief devices for vaporizers is not required based on other requirements for relief devices, for example as provided by Chapter 8 and 11.3.1.5.2.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 00:39:28 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-63-NFPA 2-2024

Statement: Paragraph 8.1.4 is not the only requirement in Chapter 8 that is applicable to piping so this widens to all of Chapter 8. Adds piping components to the requirement to be consistent with the title of this paragraph.

A specific reference for relief devices for vaporizers is not required based on other requirements for relief devices provided by Chapter 8 and 11.3.1.5.2.

Public Input No. 241-NFPA 2-2024 [Section No. 11.2.13]

~~**11.2.13** – LH 2 to GH 2 Systems.~~

~~In addition to the emergency shutdown systems described in Section 11.3 , the emergency shutdown system also shall shut off the liquid supply and power to the LH 2 transfer equipment necessary for producing GH 2 from LH 2 .~~

-

Statement of Problem and Substantiation for Public Input

This paragraph is not needed since 11.1.1.3 already exists and directs the user to Chapter 10 requirements for GH2 dispensing systems.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 00:44:51 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-64-NFPA 2-2024
Statement: This paragraph is not needed since 11.1.1.3 already exists and directs the user to Chapter 10 requirements for GH2 dispensing systems. LH2 and GH2 dispensing are separate activities and each dispensing system has appropriate controls to shut down the transfer of hydrogen required in an emergency at the respective dispenser

Public Input No. 242-NFPA 2-2024 [Section No. 11.3.1.1]

11.3.1.1 System Component Qualifications.

The following systems and system components shall be listed or approved:

(1) Hose and hose connections

(2) ~~Vehicle~~ Dispensing hose vehicle fueling ~~connections~~ connection (nozzle)

(3) Electrical equipment used with ~~LH~~ 2 ~~systems~~
~~Gas~~

(4) LH2 systems

(5) Fire and gas detection equipment and alarms

(6) ~~Hydrogen~~ LH2 dispensers

(7) Pressure switches

(8) Flow meters

Statement of Problem and Substantiation for Public Input

Clarify it's the dispenser connection that is being referred to in this section, not the vehicle. Also add fire detection equipment.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 00:49:36 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-65-NFPA 2-2024
Statement: Clarifies that the vehicle connection specified is on the fueling station, not on the vehicle. Adds fire detection equipment to gas detection requirement which is consistent with consistent with Chapter 10. Clarifies and aligns the dispenser to the scope of Chapter 11

Public Input No. 244-NFPA 2-2024 [New Section after 11.3.1.4]

TITLE OF NEW CONTENT

Type your content here ...

11.3.1.4.1Vehicle fueling areas shall be constructed with a length and width to accommodate the types of vehicles to be fueled.

Statement of Problem and Substantiation for Public Input

Add requirement which is also in Chapter 10.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 01:09:07 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-221-NFPA 2-2024

Statement: 11.3.1.4.1 adds basic requirement to the fueling area to accommodate the vehicles to be fueled, and is aligned with Chapter 10.

11.3.1.4.2 is relocated from 11.3.3.1.5.2 since it's appropriate to be in a General category that applies to all LH2 fueling.

11.3.1.4.3 consolidates content of Chapter 10 (10.5.2.2.1.3) with the existing concrete requirement of 11.3.3.1.5.2. These requirements are aligned with the new section title broadened to “area”.

Public Input No. 245-NFPA 2-2024 [New Section after 11.3.1.4]

TITLE OF NEW CONTENT

Type your content here ...

11.3.1.4.2 Combustible materials, including asphalt, shall not be used for the construction or surfacing of the fueling area. *(See 8.3.2.3.1.5 .)*

Statement of Problem and Substantiation for Public Input

Relocated from 11.3.3.1.5.2 since it's more appropriate to be in a General category for all LH2 fueling.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 01:10:25 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-221-NFPA 2-2024

Statement: 11.3.1.4.1 adds basic requirement to the fueling area to accommodate the vehicles to be fueled, and is aligned with Chapter 10.

11.3.1.4.2 is relocated from 11.3.3.1.5.2 since it's appropriate to be in a General category that applies to all LH2 fueling.

11.3.1.4.3 consolidates content of Chapter 10 (10.5.2.2.1.3) with the existing concrete requirement of 11.3.3.1.5.2. These requirements are aligned with the new section title broadened to “area”.

Public Input No. 247-NFPA 2-2024 [New Section after 11.3.1.4]

TITLE OF NEW CONTENT

Type your content here ...

11.3.1.4.X The vehicle fueling pad shall be of concrete or a material having a resistivity not exceeding 1 megohm as determined by an approved method unless hte vehicle is grounded by other means, such as a grounding cable.

Statement of Problem and Substantiation for Public Input

This merges content of Chapter 10 (10.5.2.2.1.3) with the concrete requirement of 11.3.3.1.5.2

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 01:31:04 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-221-NFPA 2-2024

Statement: 11.3.1.4.1 adds basic requirement to the fueling area to accommodate the vehicles to be fueled, and is aligned with Chapter 10.

11.3.1.4.2 is relocated from 11.3.3.1.5.2 since it's appropriate to be in a General category that applies to all LH2 fueling.

11.3.1.4.3 consolidates content of Chapter 10 (10.5.2.2.1.3) with the existing concrete requirement of 11.3.3.1.5.2. These requirements are aligned with the new section title broadened to “area”.

Public Input No. 243-NFPA 2-2024 [Section No. 11.3.1.4]

11.3.1.4 Dispensing Device ~~Protection.~~

~~The dispensing device~~

Area

LH2 dispensing systems shall be protected ~~from vehicle collision damage.~~ to minimize damage from vehicles and vandals.

Statement of Problem and Substantiation for Public Input

Align with Chapter 10 language in 10.4.1. Also change the title to "Area" since additional requirements will be added as dependent paragraphs that are appropriate in the General section of 11.3.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 246-NFPA 2-2024 [Section No. 11.3.3.1.5]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 01:05:26 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-220-NFPA 2-2024
Statement: This revision modifies the title and requirement to align with Chapter 10, 10.4.1.

Public Input No. 248-NFPA 2-2024 [Section No. 11.3.1.5.2.1]

11.3.1.5.2.1

Pressure relief devices for pressure vessels shall be in accordance with 7.1.5.5.

Statement of Problem and Substantiation for Public Input

Paragraph 7.1.5.5 is focused on relief devices used for pressure vessels, not for process piping. A paragraph is being proposed in another PI that is intended to address piping.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 12:45:15 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-87-NFPA 2-2024

Statement: 11.3.1.5.2.1 is modified to refer to “pressure vessels” to clarify that paragraph 8.1.4 addresses relief devices intended for pressure vessels in liquid service, not for process piping. Vessel relief device requirements for are different than those required for piping and require adherence to the B31 Piping Code, not the BPV. For example piping relief devices do not require pop-action and blowdown which can lead to valve chatter and failure.

11.3.1.5.2.2 is deleted since it’s redundant with 11.3.1.5.2.1 and 11.3.1.5.4, which already refer to the content on this paragraph.

The 140% setpoint is based on GH2 and GH2 safety standards. It is not appropriate for LH2 systems which will have vehicle fuel tank pressure relieving safety devices, unlike GH2 tanks. 90% is based on industry recognized margins below relief devices. The dispensing system must be designed to not lift a safety device on the vehicle during dispensing. This requirement is retroactive because the pressure relief valve setting was for gas and needs to be modified for liquid.

Public Input No. 250-NFPA 2-2024 [Section No. 11.3.1.5.2.2]

~~11.3.1.5.2.2~~ –

~~Pressure relief devices shall be so arranged that they discharge in accordance with Section 6.17 and 7.1.5.5.5 .~~

Statement of Problem and Substantiation for Public Input

This paragraph is redundant with 11.3.1.5.2.1 and 11.3.1.5.4, which already refer to the content on this paragraph.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 12:49:56 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-87-NFPA 2-2024

Statement: 11.3.1.5.2.1 is modified to refer to “pressure vessels” to clarify that paragraph 8.1.4 addresses relief devices intended for pressure vessels in liquid service, not for process piping. Vessel relief device requirements for are different than those required for piping and require adherence to the B31 Piping Code, not the BPV. For example piping relief devices do not require pop-action and blowdown which can lead to valve chatter and failure.

11.3.1.5.2.2 is deleted since it’s redundant with 11.3.1.5.2.1 and 11.3.1.5.4, which already refer to the content on this paragraph.

The 140% setpoint is based on GH2 and GH2 safety standards. It is not appropriate for LH2 systems which will have vehicle fuel tank pressure relieving safety devices, unlike GH2 tanks. 90% is based on industry recognized margins below relief devices. The dispensing system must be designed to not lift a safety device on the vehicle during dispensing. This requirement is retroactive because the pressure relief valve setting was for gas and needs to be modified for liquid.

Public Input No. 251-NFPA 2-2024 [Section No. 11.3.1.5.2.3]

11.3.1.5.2.3

An overpressure protection device meeting the requirements of ASME B31 , other than a rupture disc, shall be installed in the fueling transfer system to prevent overpressure in the vehicle.

Statement of Problem and Substantiation for Public Input

This relief device is on a piping system and it's appropriate for it to be in accordance with B31. Piping relief devices do not require pop-action and blowdown which leads to valve chatter when on piping systems.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 12:53:26 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-87-NFPA 2-2024

Statement: 11.3.1.5.2.1 is modified to refer to “pressure vessels” to clarify that paragraph 8.1.4 addresses relief devices intended for pressure vessels in liquid service, not for process piping. Vessel relief device requirements for are different than those required for piping and require adherence to the B31 Piping Code, not the BPV. For example piping relief devices do not require pop-action and blowdown which can lead to valve chatter and failure.

11.3.1.5.2.2 is deleted since it’s redundant with 11.3.1.5.2.1 and 11.3.1.5.4, which already refer to the content on this paragraph.

The 140% setpoint is based on GH2 and GH2 safety standards. It is not appropriate for LH2 systems which will have vehicle fuel tank pressure relieving safety devices, unlike GH2 tanks. 90% is based on industry recognized margins below relief devices. The dispensing system must be designed to not lift a safety device on the vehicle during dispensing. This requirement is retroactive because the pressure relief valve setting was for gas and needs to be modified for liquid.

Public Input No. 255-NFPA 2-2024 [New Section after 11.3.1.5.2.4]

TITLE OF NEW CONTENT

Type your content here ...

Pressure relief valves shall be inspected and tested at least every 3 years.

Statement of Problem and Substantiation for Public Input

Relocated same language from 10.3.1.10.5. Added "inspected".

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 256-NFPA 2-2024 [Section No. 11.3.1.10.5]	Moved location

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 18:20:19 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-87-NFPA 2-2024

Statement: 11.3.1.5.2.1 is modified to refer to “pressure vessels” to clarify that paragraph 8.1.4 addresses relief devices intended for pressure vessels in liquid service, not for process piping. Vessel relief device requirements for are different than those required for piping and require adherence to the B31 Piping Code, not the BPV. For example piping relief devices do not require pop-action and blowdown which can lead to valve chatter and failure.

11.3.1.5.2.2 is deleted since it’s redundant with 11.3.1.5.2.1 and 11.3.1.5.4, which already refer to the content on this paragraph.

The 140% setpoint is based on GH2 and GH2 safety standards. It is not appropriate for LH2 systems which will have vehicle fuel tank pressure relieving safety devices, unlike GH2 tanks. 90% is based on industry recognized margins below relief devices. The dispensing system must be designed to not lift a safety device on the vehicle during dispensing. This requirement is retroactive because the pressure relief valve setting was for gas and needs to be modified for liquid.

Public Input No. 252-NFPA 2-2024 [Section No. 11.3.1.5.2.4]

11.3.1.5.2.4

The set pressure of the overpressure protection device for the dispensing system shall not exceed ~~140 percent~~ 90% of the ~~service pressure of the fueling nozzle it supplies.~~ setpoint of the lowest setpoint of the vehicle fuel system pressure relief device.

Statement of Problem and Substantiation for Public Input

The 140% setpoint is based on GH2 and GH2 safety standards. It is not appropriate for LH2 systems which will have pressure relieving safety devices, unlike GH2 tanks. The dispensing system must be designed to not lift a safety device on the vehicle during dispensing.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 256-NFPA 2-2024 [Section No. 11.3.1.10.5]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 12:57:14 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-87-NFPA 2-2024

Statement: 11.3.1.5.2.1 is modified to refer to “pressure vessels” to clarify that paragraph 8.1.4 addresses relief devices intended for pressure vessels in liquid service, not for process piping. Vessel relief device requirements for are different than those required for piping and require adherence to the B31 Piping Code, not the BPV. For example piping relief devices do not require pop-action and blowdown which can lead to valve chatter and failure.

11.3.1.5.2.2 is deleted since it’s redundant with 11.3.1.5.2.1 and 11.3.1.5.4, which already refer to the content on this paragraph.

The 140% setpoint is based on GH2 and GH2 safety standards. It is not appropriate for LH2 systems which will have vehicle fuel tank pressure relieving safety devices, unlike GH2 tanks. 90% is based on industry recognized margins below relief devices. The dispensing system must be designed to not lift a safety device on the vehicle during dispensing. This requirement is retroactive because the pressure relief valve setting was for gas and needs to be modified for liquid.

Public Input No. 257-NFPA 2-2024 [Section No. 11.3.1.8]

11.3.1.8 Emergency Shutdown System.

~~An emergency shutdown system (ESD) shall be provided that includes a shut-off valve, which shall be provided within 10 ft (3.1 m) of the dispenser, for stopping liquid supply and shutting down transfer equipment. An actuator for the valve,~~

The LH2 dispensing system shall be equipped with an Emergency Shutdown System.

11.3.1.8.1 The Emergency Shutdown System (ESS) when activated shall shut off the power supply to LH2 transfer equipment to the dispenser and isolate the hydrogen supply from the source to the dispenser.

11.3.1.8.2 Dispensing equipment shall be provided with hydrogen gas detection, leak detection, and flame detection at the fueling area.

11.3.1.8.3 An emergency manual shutdown device to activate the ESS shall be provided within 20' of the dispensing area and also at a visible location remote, but not more than 100', from the dispensing area.

11.3.1.8.3.1 The emergency shutdown devices shall be distinctly marked for easy recognition with a permanently affixed

,

legible sign .

11.3.1.8.3.2 Where multiple emergency shutdown activation devices are provided for a disensing area ,

~~shall be provided with a shutdown control point located near the dispenser and another shutdown control point located at a safe, remote location.~~

all devices shall be interconnected.

11.3.1.8.4 The ESS shall include an automatic shut-off valves within 10’ (3.1 m) of the dispenser and at the LH2 storage and supply system.

11.3.1.8.4.1 These valves shall shut upon activation of the ESD device and also upon activation of the area leak, gas, or fire detection equipment.

11.3.1.8.4.2 The automatic emergency shut-off valves shall be fail closed.

11.3.1.8.4.3 Emergency shutoff valves shall also be installed on hydrogen vapor transfer lines if the dispenser is so equipped.

11.3.1.8.5 Control circuits shall be arranged so that when an ESD is activated or electric power is cut off, systems that shut down shall remain down until manually reset by a qualified technician after a safe condition is restored.

11.3.1.8.6 Where a dispenser may have more than one fueling position, emergency shutoff valves shall be installed for each fueling position.

Statement of Problem and Substantiation for Public Input

The existing paragraph has too many requirements for a single section. The proposed language breaks this into separate sections as well as adding language to make consistent with Chapter 10.

(10.3.13.5.1, 10.3.13.5, 10.3.13.7.2). Material from 11.3.3.4.7 has also been added.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 307-NFPA 2-2024 [Section No. 11.3.3.4.7]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 18:31:22 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-114-NFPA 2-2024

Statement: The existing 11.3.1.8 has many requirements included in a single paragraph . The proposed language separates these into separate paragraphs and adds material to make consistent with applicable safety requirements from Chapter 10 (10.3.13.5.1, 10.3.13.5, 10.3.13.7.2). Material from 11.3.3.4.7 has also been relocated here since is appropriate for this section.

Public Input No. 86-NFPA 2-2023 [Section No. 11.3.1.8]

11.3.1.8 Emergency Shutdown System.

An emergency shutdown system (~~ESD~~ ESS) shall be provided that includes a shut-off valve, and ESD which shall be provided within 10 ft (3.1 m) of the dispenser, for stopping liquid supply and shutting down transfer equipment. ~~An actuator~~ The ESD actuators for the ~~valve~~ ESS , shall be distinctly marked for easy recognition with a permanently affixed, legible sign~~,~~ . The ESS shall be provided with ~~a shutdown control point located near~~ an ESD located near the dispenser and another ~~shutdown control point~~ ESD located at a safe, remote location.

Additional Proposed Changes

File Name	Description	Approved
PC_No._84_Rejected_but_Held.pdf	NFPA 2 PC No. 84 Rejected but held	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as "Rejected but Held" in Public Comment No. 84 of A2022 Second Draft Report for NFPA 2 and per Regs. at 4.4.8.3.1 and needs to be reconsidered by the TC for the next edition of the document.

PI-230 proposed changing the location of the ESD on an HEE and the HEE task group will be proposing a revised requirement.

In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this is one of a series of public comment will provide consistency in the definitions and use of the terms ESS an ESD trough out the document.

This proposal also harmonizes the use of these term in CSA-HGV-4.1 and CSA-HGV-4.6. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation. This PI corrects the existing language of 11.3.1.8

Submitter Information Verification

Submitter Full Name:
Organization: Holds
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 09:29:02 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-114-NFPA 2-2024

Statement: The existing 11.3.1.8 has many requirements included in a single paragraph . The proposed language separates these into separate paragraphs and adds material to make consistent with applicable safety requirements from Chapter 10 (10.3.13.5.1, 10.3.13.5, 10.3.13.7.2). Material from 11.3.3.4.7 has also been relocated here since is appropriate for this section.

Public Comment No. 84-NFPA 2-2021 [Section No. 11.3.1.8]

11.3.1.8 Emergency Shutdown System.

An emergency shutdown system (~~ESD~~ ESS) shall be provided that includes a shut-off valve, ~~which~~ and ESD which shall be provided within 10 ft (3.1 m) of the dispenser, for stopping liquid supply and shutting down transfer equipment. ~~An actuator~~ The ESD actuators for the ~~valve~~ ESS , shall be distinctly marked for easy recognition with a permanently affixed, legible sign~~, shall~~ . The ESS shall be provided with ~~a shutdown control point located~~ an ESD located near the dispenser and another ~~shutdown control point~~ ESD located at a safe, remote location.

Additional Proposed Changes

File Name	Description	Approved
ESD-ESS_-_Rev5.pdf	Clarification of ESS and ESD functions and definition of ESS in NFPA-2	

Statement of Problem and Substantiation for Public Comment

PI-230 proposed changing the location of the ESD on an HEE and the HEE task group will be proposing a revised requirement.

In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this is one of a series of public comment will provide consistency in the definitions and use of the terms ESS an ESD trough out the document.

This proposal also harmonizes the use of these term in CSA-HGV-4.1 and CSA-HGV-4.6. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).

Emergency shutdown system (ESS)* — the system that responds to ESD activation.

This PI corrects the existing language of 11.3.1.8

Related Item

• PI-230

Submitter Information Verification

Submitter Full Name:	Robert Boyd
Organization:	Boyd Hydrogen LLC
Affiliation:	This proposal was developed during parallel discussions by members of the NFPA-2-HEE Task Group
Street Address:	
City:	
State:	

Zip:

Submittal Date: Wed Jun 02 18:43:40 EDT 2021

Committee: HYD-AAA

Committee Statement

Committee Action: Rejected but held

Resolution: The proposed revisions were not discussed during the First Draft meeting and are considered to be new material which cannot be acted upon at the Second Draft meeting.

Clarification of ESS and ESD and definition of ESS in NFPA-2

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comments will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This series of Public Comments also harmonizes the use of these terms with what is defined in CSA-HGV-4.1 *Hydrogen Dispensers,* and CSA-HGV-4.9 *Hydrogen Fueling Stations*

This document supports public comments: PC-79 , PC-80, PC-81, PC-82, PC-83, PC-84, PC-87 and PC-90

Problem Statement

The confusing use of the term ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Annex notes (new)

A.3.3.69. Emergency Shutdown Device (ESD).

Emergency Shutdown Devices (ESDs) may be any of the following devices that will "trip" the Emergency Shutdown System (ESS) to shut down the system into a safe mode:

1. A manually operated red pushbutton switch with a yellow background in compliance with NFPA-79,
2. A low pressure switch measuring hydrogen compressor suction pressure,
3. An UV/IR or hydrogen detector,
4. Or any other safety related input device that has a switch for electrical conductivity of signal or other means of connection to the ESS.

Most hydrogen Fueling station modules will include a separate ESS to stop the process of the module (production, compression, dispensing) in the event of an ESS activation.

Each hydrogen fueling station site will typically have all operating modules connected to a site-wide Emergency Shutdown System.

Emergency Shutdown System (ESS): The ESS responds to any activation of an ESD and shuts down the system safely.

Actions to take in NFPA-2

- Delete 3.3.63.1 (ESD definition, extract from NFPA 52)
- Modify 3.3.69 (ESD- use definition from ANSI/CSA HGV 4.1)

- Add new section after 3.3.69 (ESS-use definition from ANSI/CSA HGV 4.1) – this will go between ESD and Emergency Shutoff Valve
- Modify 3.3.70 Emergency Shutoff Valve drop link to see 3.3.250.1 and adopt current language: A designated valve designed to shut off the flow of liquids or gases

The following shows how the use of ESD and ESS need to be cleaned up and how important it is to define ESS

- 8.3.1.2.8.3 – propose to change "ESD" to "ESS" and "ESD system" change to "ESS"
  - Proposed language: "When an emergency shutdown is required, activation of the ESS shall shut down operation of all pumps and compressors. 55:11.2.8.3
- 8.3.1.2.9- propose to add acronym (ESS)
- 8.3.1.2.9.2- propose to change "system" to "device:
  - Proposed language: "An emergency shutdown device (ESD) shall be provided at the bulk source to stop the flow of liquid and gas into the use line when actuated."
- 8.3.2.1.9.4- Proposed language: "Reactivation of the ESS after activation shall require that the ESS be manually reset."
-
- 8.3.1.2.9.5- Proposed language: "The ESD manual activation shall be identified by means of a sign."
- 11.3.1.8: change "(ESD)" to "(ESS)". Revise language

This proposal was developed during parallel discussions by members of the NFPA-2-HEE Task Group

The following change was developed after a further review of NFPA-2 first draft are shown below:

8.3.1.2.8.3 Emergency Shutdown System Operation.
When an emergency shutdown (ESD) is required, activation of the **Emergency Shutdown System (ESS)** ~~**ESD** system~~ shall shut down operation of all pumps and compressors. [~~**55:**11.2.8.3~~]

Public Input No. 258-NFPA 2-2024 [Section No. 11.3.1.9]

11.3.1.9 Maximum Delivery Pressure.

The maximum delivery pressure at the vehicle tank inlet shall not exceed the maximum allowable pressure of the vehicle fuel tanks or 90% of the lowest setpoint relief device on the vehicle fuel tank, whichever is lower .

Statement of Problem and Substantiation for Public Input

The dispensing system should also not exceed 90% of the lowest relief device to prevent venting of hydrogen from these devices at the fueling station. This requirement is likely to change when fueling protocols and standardization of pressure classes is completed for LH2 fueling.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 18:46:26 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-66-NFPA 2-2024
Statement: The dispensing system should also not exceed 90% of the lowest relief device to prevent venting of hydrogen from these devices during fueling at the fueling station. This requirement may change when fueling protocols and standardization of pressure classes is completed for LH2 fueling but is a prudent safeguard until those protocols are established and published.

Public Input No. 259-NFPA 2-2024 [Section No. 11.3.1.10.4]

11.3.1.10.4

Where hydrogen is to be used as the leak test media, the system shall first be purged with an inert gas to ensure that all oxygen concentration is ~~removed~~ below 1% .

Statement of Problem and Substantiation for Public Input

It is impossible to remove "all oxygen", so a threshold should be used. 1% is commonly used as a safe purging level.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 18:50:38 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-67-NFPA 2-2024
Statement: It is impossible to remove "all oxygen", so a threshold should be used. 1% is commonly used as a safe purging level.

Public Input No. 256-NFPA 2-2024 [Section No. 11.3.1.10.5]

~~**11.3.1.10.5** –~~

~~Pressure relief valves shall be tested at least every 3 years.~~

Statement of Problem and Substantiation for Public Input

Moved to a more appropriate location regarding relief devices (10.3.1.10.5)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 252-NFPA 2-2024 [Section No. 11.3.1.5.2.4]	Moved location
Public Input No. 255-NFPA 2-2024 [New Section after 11.3.1.5.2.4]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 18:22:55 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-222-NFPA 2-2024
Statement: 11.3.1.5.2.5 relocates periodic testing of relief valves from 11.3.1.10.5 and adds “inspection” to align with Chapter 10.

Public Input No. 260-NFPA 2-2024 [Section No. 11.3.1.11]

11.3.1.11 Shutoff Valve and Breakaway Device.

~~Hose and arms shall be equipped with a shut-off valve at the fuel end and a breakaway device to minimize release of liquid and vapor in the event that~~ 11.3.1.11.1 A shutoff valve shall be installed on the vehicle end of the dispensing hose.

11.3.1.11.2 A breakaway device shall be installed to minimize the release of hydrogen if a vehicle pulls away while the hose remains connected. ~~Such a~~

11.3.1.11.3 The breakaway device shall be installed and maintained in accordance with the ~~manufacturer's instructions.~~ manufacturers instructions and to ensure proper activation in every direction that the vehicle may move.

Statement of Problem and Substantiation for Public Input

The paragraph is reorganized to separate requirements, as well as add material to make consistent with Chapter 10.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 18:53:03 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-68-NFPA 2-2024

Statement: Reorganized to separate requirements to independent paragraphs, as well as add requirements for proper activation in every direction of the breakaway material to make it consistent with Chapter 10.

Delete 11.3.1.12 material in lieu of the revised language in 11.3.1.8. A check valve should not be used as a shutoff valve and is eliminated as an option.

Public Input No. 261-NFPA 2-2024 [Section No. 11.3.1.12]

~~**11.3.1.12** – Emergency Shutoff Valve.~~

~~Where a hose or arm of nominal 3 in. (76 mm) diameter or larger is used for liquid transfer or where one of nominal 4 in. (100 mm) diameter or larger is used for vapor transfer, an emergency shutoff valve shall be installed in the piping of the transfer system within 10 ft (3.0 m) from the nearest end of the hose or arm.~~

~~**11.3.1.12.1** –~~

~~Where the flow is away from the hose, a check valve shall be permitted to be used as the shut-off valve.~~

~~**11.3.1.12.2** –~~

~~Where either a liquid or vapor line has two or more legs, an emergency shut-off valve shall be installed either in each leg or in the feed line before the legs.~~

Statement of Problem and Substantiation for Public Input

Delete this material in lieu of the revised language in 11.3.1.8. A check valve should not be used as a shutoff valve

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 18:59:29 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-68-NFPA 2-2024
Statement: Reorganized to separate requirements to independent paragraphs, as well as add requirements for proper activation in every direction of the breakaway material to make it consistent with Chapter 10.

Delete 11.3.1.12 material in lieu of the revised language in 11.3.1.8. A check valve should not be used as a shutoff valve and is eliminated as an option.

Public Input No. 262-NFPA 2-2024 [Section No. 11.3.1.14 [Excluding any Sub-Sections]]

~~A~~ An approved fueling connector and mating vehicle receptacle shall be used ~~for reliable, safe, and secure transfer of LH~~ 2 ~~or gas vapor to or from the vehicle with~~ for secure transfer of LH2 to the vehicle, and gas vapor from the vehicle if so equipped, with minimal leakage.

Statement of Problem and Substantiation for Public Input

Revised language to clarify intent of this paragraph.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 19:01:36 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-69-NFPA 2-2024
Statement: There is currently no standard for listing of these types of fueling connectors and adding approval allows use of these devices. Removed subjective language and clarified the action of the dispenser.

Public Input No. 263-NFPA 2-2024 [Section No. 11.3.1.16.1 [Excluding any Sub-Sections]]

A warning sign with the following words shall be posted at ~~dispensing stations and compressor or pumping~~ the dispenser and fuel processing areas:

STOP MOTOR, NO SMOKING, NO CELL PHONES, FLAMMABLE GAS

Statement of Problem and Substantiation for Public Input

Revised language to clarify the intent and clarity of the requirement.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 19:04:39 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-219-NFPA 2-2024
Statement: Moved to General 11.2 as this requirement applies to the entire fueling station.

Public Input No. 264-NFPA 2-2024 [Section No. 11.3.2 [Excluding any Sub-Sections]]

Indoor LH_2 ~~fueling~~ dispensing shall be prohibited.

Statement of Problem and Substantiation for Public Input

Changing to "dispensing" makes the language more consistent.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 19:06:32 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-71-NFPA 2-2024
Statement: Dispensing is the more applicable term to be consistent with the Chapter 11 scope.

Public Input No. 265-NFPA 2-2024 [Section No. 11.3.3.1.2]

11.3.3.1.2

_ Dispensing devices shall be ~~mounted on a concrete island or shall otherwise be protected against collision damage by means acceptable to the AHJ. Dispensing devices shall be securely bolted in place. [-] Dispensing devices shall also be located in a position where they cannot be struck by a vehicle that is out of control descending a ramp or other slope. Dispensing devices shall be~~ installed in accordance with the manufacturer's instructions. [~~**30A:** 6.3.4~~] _

Statement of Problem and Substantiation for Public Input

The removed requirements are redundant with other paragraphs or are unnecessary detail.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 19:09:54 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-72-NFPA 2-2024
Statement: Simplifies the paragraph to the basic requirements and eliminates redundant material which is now in 11.3.1.4.

Public Input No. 246-NFPA 2-2024 [Section No. 11.3.3.1.5]

~~**11.3.3.1.5** –~~

~~A vehicle fueling pad shall be provided in the area where vehicles are to be refueled.~~

~~**11.3.3.1.5.1** –~~

~~The pad shall be constructed with a length and width to accommodate the types of vehicles to be fueled and to provide a surface under the fueling hose.~~

~~**11.3.3.1.5.2** –~~

~~The vehicle fueling pad shall be of concrete construction.~~

~~**(A)** –~~

~~Combustible materials, including asphalt, shall not be used for the construction of or surfacing of the fueling pad. *(See 8.3.2.3.1.5 .)*~~

-

Statement of Problem and Substantiation for Public Input

Delete sections and move content to General requirements in11.3

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 243-NFPA 2-2024 [Section No. 11.3.1.4]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 01:19:24 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-86-NFPA 2-2024
Statement: These concepts behind these requirements have been incorporated into 11.3 as they are general requirements for the section and they are being deleted or moved here. See 11.3.1.4.

Public Input No. 307-NFPA 2-2024 [Section No. 11.3.3.4.7]

~~**11.3.3.4.7** * –~~

~~Fuel dispensing systems shall be provided with one or more clearly identified emergency shutoff devices or electrical disconnects. Such devices or disconnects shall be installed in approved locations but not less than 20 ft (6 m) or more than 100 ft (30 m) from the fuel dispensing devices that they serve. Emergency shutoff devices or electrical disconnects shall disconnect power to all dispensing devices; to all remote pumps serving the dispensing devices; to all associated power, control, and signal circuits; and to all other electrical equipment in the hazardous (classified) locations surrounding the fuel dispensing devices. When more than one emergency shutoff device or electrical disconnect is provided, all devices shall be interconnected. Resetting from an emergency shutoff condition shall require manual intervention and the manner of resetting shall be approved by the authority having jurisdiction. The emergency shutoff device shall disconnect simultaneously from the source of supply, all conductors of the circuits, including the grounded conductor, if any. Equipment grounding conductors shall remain connected. [**70:** 514.11(A)]~~

~~*Exception: Intrinsically safe electrical equipment need not meet this requirement.*~~
~~*[**70:** 514.11(A)]*~~

Statement of Problem and Substantiation for Public Input

This paragraph is an extract from NFPA 70 and should be deleted. It doesn't seem to meet the Manual of Style by including numerous requirements in one paragraph.
Many of the requirements are not applicable to H2 dispensing stations or are already included in other sections. This paragraph is not included in Chapter 10 for the same reasons. Also, the requirements in the paragraph are general in nature and should be in 11.3.1, particularly 11.3.1.8, and limited to Outdoor Public Fueling. Several PI's have been submitted to relocate material from existing 11.3.3.4.7 to 11.3.1.8

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 257-NFPA 2-2024 [Section No. 11.3.1.8]	

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 13:30:14 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-193-NFPA 2-2024

Statement: This paragraph is an extract from NFPA 70 and is deleted since many of the requirements are not applicable to H2 dispensing stations or are already included in other sections. Also, the requirements in the paragraph are general in nature and the concepts in these requirements are moving to 11.3.1.8.

Public Input No. 267-NFPA 2-2024 [Section No. 11.3.4.6.1]

11.3.4.6.1

The outdoor dispensing of LH_2 ~~in the open from~~ from a transport vehicle to a motor vehicle located at a separate fleet fueling area in connection with commercial, industrial, governmental, or manufacturing establishments and intended for fueling vehicles used in connection with their businesses shall be allowed if all of the requirements of 11.3.4.6.1 through 11.3.4.6.9 have been met.

Statement of Problem and Substantiation for Public Input

Outdoor is a better way of saying "in the open".

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 19:17:21 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-73-NFPA 2-2024
Statement: The term “outdoor” is consistent with other language and is a more applicable term than “in the open”. This also prevents the misinterpretation that this section can be applied in a large volume indoor area.

Public Input No. 268-NFPA 2-2024 [Section No. 11.3.4.6.4]

11.3.4.6.4

Smoking materials, including matches, lighters, and other sources of ignition, including torches, shall not be used within 25 ft (7.6 m) of the dispensing of LH_2 ~~in the open~~ _ from a transport vehicle to a motor vehicle.

Statement of Problem and Substantiation for Public Input

No need to say "in the open"

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 19:19:12 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-89-NFPA 2-2024
Statement: “In the open” is undefined and not a clear term in the context of this requirement. this revision aligns fire extinguisher language to be consistent, aligned with Chapter 10, and consolidated in 11.2.7.

Public Input No. 269-NFPA 2-2024 [Section No. 11.3.4.6.5]

11.3.4.6.5

~~Each area where dispensing of LH~~ 2 ~~in the open from a transport vehicle to a motor vehicle shall be provided with one or more listed fire extinguishers that have a minimum capability of 40-B:C.~~

~~**11.3.4.6.5.1** –~~

~~The fire extinguishers shall be within the dispensing operation.~~

~~**11.3.4.6.5.2** –~~

~~Fire extinguishers shall be inspected and maintained under NFPA 10.~~

Fire extinguishers shall be provided and meet the requirements of 11.2.7.

Statement of Problem and Substantiation for Public Input

Proposed language simplifies the requirement and makes consistent with other LH2 dispensing.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 19:21:20 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-89-NFPA 2-2024
Statement: “In the open” is undefined and not a clear term in the context of this requirement. this revision aligns fire extinguisher language to be consistent, aligned with Chapter 10, and consolidated in 11.2.7.

Public Input No. 266-NFPA 2-2024 [Section No. 11.3.4.6.9]

~~11.3.4.6.9~~ –

~~The transfer area shall meet the requirements of~~ ~~10.4.1.1~~ .

Statement of Problem and Substantiation for Public Input

This material is redundant with the requirements in the General section of this chapter.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 19:12:34 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-74-NFPA 2-2024
Statement: This material is redundant with the requirements in the General section of this chapter and new material in 11.3.1.4.

Public Input No. 270-NFPA 2-2024 [Section No. 11.4]

11.4 Storage.

11.4.1 ~~– General.~~

~~The storage of LH 2 in bulk and non-bulk LH 2 installations~~

The storage of LH2 shall be in accordance with the applicable requirements of Chapters 6 and 8 .

11.4.2 ~~– Indoor Storage.~~

~~Indoor storage of LH 2 to be used for vehicle fueling purposes shall be prohibited.~~

~~**11.4.3** – Outdoor Storage.~~ LH2 delivery locations from the cargo tanker to the LH2 storage system shall be sited in accordance with Chapter 8.

~~**11.4.3.1** – Ullage Space.~~

~~All cryogenic containers, vessels, and tanks shall provide and maintain ullage space to prevent overfilling of the vessel.~~

~~**11.4.3.2** – Stationary Storage Tanks.~~

~~**11.4.3.2.1** –~~

~~Points of transfer shall be located not less than 25 ft (7.6 m) from the nearest important building not associated with the LH 2 facility, from the line of adjoining property that can be built upon, or from fixed sources of ignition.~~

~~**11.4.3.2.2** –~~

~~Points of transfer shall include the maximum length of the off-loading LH 2 bulk supply tanker, and off-loading hoses. *(See also 8.3.4.5 .)*~~

~~**11.4.4** – Underground Storage.~~

~~**(Reserved)**~~

2.1 Separation distances between the delivery location and exposures shall be measured from the maximum extension of the transfer hose.

11.4.5 Cargo Transport Unloading.

11.4.5.1

Cargo transport unloading shall comply with 7.3.4.2 and 8.3.4.5 .

11.4.5.2

The delivery vehicle shall be located so that all parts of the vehicle are on the premises when delivery is made. [**30A:** 9.2.2.4]

11.4.5.3

The hydrogen site shall be designed with a traffic pattern for the cargo transport vehicle.

Statement of Problem and Substantiation for Public Input

Storage requirements should be minimized by referring to Chapter 8. Points of transfer language is clarified.

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 19:26:49 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-75-NFPA 2-2024
Statement: Storage requirements should be minimized, simplified, and made consistent by referring to Chapter 8. Points of transfer language is clarified to make the original intent clear that the hose must be addressed when calculating separation distances.

Public Input No. 238-NFPA 2-2024 [New Section after 11.4.5.3]

TITLE OF NEW CONTENT

Type your content here ...

11.4.5.4

Static protection shall be required where LH2 cargo transport vehicles are unloaded, except where cargo transport vehicles are unloaded by conductive hose, flexible metallic tubing, and pipe connections where both halves of metallic couplings are electrically bonded.

Statement of Problem and Substantiation for Public Input

Moves requirement for cargo vehicle unloading to a more appropriate section. Deletes reference to marine equipment since this is a paragraph for LH2 deliveries, not dispensing. Clarifies language on the pipe connections.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 237-NFPA 2-2024 [Section No. 11.2.8.6]	Moved to new location with minor edits

Submitter Information Verification

Submitter Full Name: David Farese
Organization: Durham Consulting LLC
Affiliation: Air Products
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jan 03 00:28:04 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-218-NFPA 2-2024
Statement: The section is moving under cargo transport unloading as it is related to cargo transport unloading.

Public Input No. 152-NFPA 2-2023 [New Section after 12.2.1.3]

12.2.2 Piping

Piping, valves, and fittings shall conform to ASME B31, *Code for Pressure Piping* .

Statement of Problem and Substantiation for Public Input

Note: If PI122 is adopted, this PI is not needed.

Note: This PI is similar to PI131 that adds 13.2.6 for hydrogen generators.

Piping systems for hydrogen systems should be designed and constructed to minimize the likelihood of a release (leak). Welded connections are generally considered the best way to achieve this, however, they are not always practical.

In addition many types of hydrogen systems include piping for fluids other than hydrogen. For example reformer based fuel cell systems often include piping for natural gas.

The Code for Pressure Piping, ASME B31, addresses the design, fabrication, assembly, and testing of piping systems for all types of fluid including hydrogen. ASME B31.12, Hydrogen Piping and Pipelines, addresses piping system for hydrogen in particular.

ASME B31 has been used successfully in hydrogen system for many decades. And, many product safety standards for hydrogen equipment such as CSA FC 1 for fuel cells and CSA B22734 for electrolyzers refer specifically to ASME B31.

Note: These standards and Codes such as NFPA 2 require additional safeguards to provide protection in the event of a release. This include measures such as ventilation to dilute or remove the hydrogen, elimination of effective ignition sources, hydrogen detectors to initiate safety systems, etc. Hydrogen systems do not rely solely on piping for safety.

The requirement of 6.5.1 to also meet sections of IFCG is both redundant and likely to cause confusion and possibly reduced safety as it has prohibitions and exceptions that are difficult to navigate.

And, the limitations of the IFGC sections are not appropriate for the piping for other fluids used in hydrogen systems and conflict with standard practices for that piping.

Finally, hydrogen is very often not used as a fuel gas which brings into doubt the applicability of any part of the IFGC.

ASME B31 is both necessary and sufficient.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 122-NFPA 2-2023 [Section No. 6.5.1 [Excluding any Sub-Sections]]	If PI122 is adopted, this PI is not needed.
Public Input No. 131-NFPA 2-2023 [New Section after 13.2.5]	This PI is similar to PI131 for new section 13.2.6.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 20 11:20:49 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-186-NFPA 2-2024

Statement: Piping systems for hydrogen systems need to be designed and constructed to minimize the likelihood of a release (leak). Welded connections are generally considered the best way to achieve this, however, they are not always practical.

In addition many types of hydrogen systems include piping for fluids other than hydrogen. For example reformer based fuel cell systems often include piping for natural gas.

The Code for Pressure Piping, ASME B31, addresses the design, fabrication, assembly, and testing of piping systems for all types of fluid including hydrogen. ASME B31.12, Hydrogen Piping and Pipelines, addresses piping system for hydrogen in particular.

ASME B31 has been used successfully in hydrogen system for many decades. And, many product safety standards for hydrogen equipment such as CSA FC 1 for fuel cells and CSA B22734 for electrolyzers refer specifically to ASME B31.

Note: These standards and Codes such as NFPA 2 require additional safeguards to provide protection in the event of a release. This include measures such as ventilation to dilute or remove the hydrogen, elimination of effective ignition sources, hydrogen detectors to initiate safety systems, etc. Hydrogen systems do not rely solely on piping for safety.

Public Input No. 125-NFPA 2-2023 [Section No. 13.1.1.1 [Excluding any Sub-Sections]]

This chapter shall apply to permanently installed hydrogen generation systems with rated capacity to generate greater than ~~1.3 oz/hr (~~ 36 g/hr~~) but less than 220 lb/hr (100 kg/hr)~~ .

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

There are 2 parts to this PI:
1. The first part deletes the 1.3 oz/hr. It is not clear if this was meant to be mass, weight, or volume and could be misinterpreted as fluid ounces. And, no one in the hydrogen generation industry uses theses units. So, the proposal is to only use the mass flow units.

2. The second part deletes the upper limit. This was originally based on the largest known "industrial" hydrogen generators at the time that this chapter was originally written. The intent was to exclude hydrogen generation facilities such as refineries that are typically outside the scope of NFPA codes & standards. In recent years hydrogen generators for "industrial" and similar applications have grown significantly in size. Many are now hydrogen production plants. These are designed and built using the same principles as the other hydrogen generators in Chapter 13 so, the requirements of Chapter 13 should apply to these larger hydrogen generators as well. Also, the hydrogen generator standards referenced in Chapter 13 do not have upper limits on size or production; this change aligns Chapter 13 with those standards. (If the upper limit is not removed, there would be no specific requirements for these larger hydrogen generators.)

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 126-NFPA 2-2023 [Section No. 13.1.1.1.1]	

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13 TG
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 20:51:05 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-11-NFPA 2-2024
Statement: The first part revises 1.3 oz/hr since it was not clear whether this was meant to be mass, weight, or volume and could be misinterpreted as fluid ounces. Additionally, the hydrogen generation industry uses theses units.

The second part deletes the upper limit. This The upper limit was originally based on the largest known "industrial" hydrogen generators at the time that this chapter was first written. Originally, hydrogen generation facilities such as refineries that are typically outside the scope of NFPA codes & standards were ecluded. In recent years hydrogen generators for "industrial" and similar applications have grown significantly in size. Many are now hydrogen production plants or facilities. These are designed and built using the same principles as the other hydrogen generators in Chapter 13 so, the requirements of Chapter 13 need to apply to these larger hydrogen generators as well. Also, the hydrogen generator standards referenced in Chapter 13 do not have upper limits on size or production; this change aligns Chapter 13 with those standards.

If the upper limit was not removed, there would be no specific requirements for these larger hydrogen generators.

The imperial units are being changed to more easily identify that the units are mass units.

Public Input No. 126-NFPA 2-2023 [Section No. 13.1.1.1.1]

13.1.1.1.1

~~Systems that generate hydrogen in excess of the quantity indicated in 13.1.1.1 shall be constructed, installed, and operated in accordance with nationally recognized standards~~ This chapter shall also apply to permanently installed hydrogen generation modules with rated capacity to generate greater than 36 g/hr .

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

There are 2 parts to this PI:
1. This original text was related to hydrogen generators with production rates higher than the upper limit in 13.1.1.1. Since the upper limit is being removed, the original text in this section is no longer needed.

2. A recent trend in hydrogen generation is the manufacturing and supply of hydrogen generation modules. These modules are subsets of complete hydrogen generators. They typically consist of one or more cell stacks, some related piping, and potentially some environmental control equipment such as heaters or HVAC equipment. These modules should be addressed in Chapter 13.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 125-NFPA 2-2023 [Section No. 13.1.1.1 [Excluding any Sub-Sections]]	Change to 13.1.1.1 affects this section.
Public Input No. 128-NFPA 2-2023 [Section No. 13.2.1.1]	
Public Input No. 129-NFPA 2-2023 [Section No. 13.2.2 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13 TG
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 21:09:28 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-12-NFPA 2-2024

Statement: 1. This original text was related to hydrogen generators with production rates higher than the upper limit in 13.1.1.1. Since the upper limit is being removed, the original text in this section is no longer needed.

2. A recent trend in hydrogen generation is the manufacturing and supply of hydrogen generation modules. These modules are subsets of complete hydrogen generators. They typically consist of one or more cell stacks, some related piping, and potentially some environmental control equipment such as heaters or HVAC equipment. Therefore, these modules should be addressed in Chapter 13

Public Input No. 128-NFPA 2-2023 [Section No. 13.2.1.1]

13.2.1.1

Listed or approved hydrogen ~~generators~~ generator systems and modules shall not be required to meet the requirements of Chapter 7 except as noted in this chapter.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

Expanded requirement to include modules as well as hydrogen generators; see 13.1.1.1.1.

A recent trend in hydrogen generation is the manufacturing and supply of hydrogen generation modules. These modules are subsets of complete hydrogen generators. They typically consist of one or more cell stacks, some related piping, and potentially some environmental control equipment such as heaters or HVAC equipment. These modules should be addressed in Chapter 13.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 126-NFPA 2-2023 [Section No. 13.1.1.1.1]	These sections address hydrogen generation modules.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 21:31:22 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-13-NFPA 2-2024

Statement: A recent trend in hydrogen generation is the manufacturing and supply of hydrogen generation modules. These modules are subsets of complete hydrogen generators. They typically consist of one or more cell stacks, some related piping, and potentially some environmental control equipment such as heaters or HVAC equipment. Therefore, these modules should be addressed in Chapter 13.

The first paragraph of A13.2.1 contradicts the application statement at the beginning of Chapter 13; see 13.1.1. For example, Chapter 13 applies only to permanently installed hydrogen generators not portable or transportable hydrogen generators and it may include hydrogen production operated by gas producers, distributors, etc. Therefore, this paragraph should be deleted.

The addition of the word “system” in the second paragraph is an editorial change to use the same terminology as used in the rest of Chapter 13 i.e., "hydrogen generation systems"

Public Input No. 129-NFPA 2-2023 [Section No. 13.2.2 [Excluding any Sub-Sections]]

Hydrogen generation ~~system(s)~~ systems and modules shall be ~~installed~~ installed in accordance with the manufacturer's instructions.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

Expanded requirement to include modules as well as hydrogen generators; see 13.1.1.1.1.

A recent trend in hydrogen generation is the manufacturing and supply of hydrogen generation modules. These modules are subsets of complete hydrogen generators. They typically consist of one or more cell stacks, some related piping, and potentially some environmental control equipment such as heaters or HVAC equipment. These modules should be addressed in Chapter 13.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 126-NFPA 2-2023 [Section No. 13.1.1.1.1]	These sections address hydrogen generation modules.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 21:39:01 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-14-NFPA 2-2024
Statement: A recent trend in hydrogen generation is the manufacturing and supply of hydrogen generation modules. These modules are subsets of complete hydrogen generators. They typically consist of one or more cell stacks, some related piping, and potentially some environmental control equipment such as heaters or HVAC equipment. These modules should be addressed in Chapter 13.

Public Input No. 130-NFPA 2-2023 [Section No. 13.2.2.1]

13.2.2.1

All safety-related controls for the installation of the hydrogen ~~generator~~ generation systems shall comply with NFPA 79.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

This is an editorial change to use the same terminology as used in the rest of Chapter 13 i.e., "hydrogen generation systems".

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 21:41:18 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-14-NFPA 2-2024
Statement: A recent trend in hydrogen generation is the manufacturing and supply of hydrogen generation modules. These modules are subsets of complete hydrogen generators. They typically consist of one or more cell stacks, some related piping, and potentially some environmental control equipment such as heaters or HVAC equipment. These modules should be addressed in Chapter 13.

Public Input No. 131-NFPA 2-2023 [New Section after 13.2.5]

13.2.6 Piping

Piping, valves, and fittings shall conform to ASME B31, Code for Pressure Piping.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

NOTE: If PI122 is accepted, this PI is not needed.

Piping systems for hydrogen systems should be designed and constructed to minimize the likelihood of a release (leak). Welded connections are generally considered the best way to achieve this, however, they are not always practical - especially for hydrogen generators.

Many types of hydrogen generators include piping for fluids other than hydrogen. For example electrolyzer based hydrogen generators include piping for water and reformer based hydrogen generators often include piping for natural gas.

The Code for Pressure Piping, ASME B31, addresses the design, fabrication, assembly, and testing of piping systems for all types of fluid including hydrogen. ASME B31.12, Hydrogen Piping and Pipelines, addresses piping system for hydrogen in particular.

ASME B31 has been used successfully in hydrogen system for many decades. And, many product safety standards for hydrogen equipment such as ISO 22734 and CSA B22734 for electrolyzers and ISO 16110-1 and CSA/ANSI FC5 for reformers refer specifically to ASME B31.

Note: These standards and Codes such as NFPA 2 require additional safeguards to provide protection in the event of a release. This include measures such as ventilation to dilute or remove the hydrogen, elimination of effective ignition sources, hydrogen detectors to initiate safety systems, etc. Hydrogen generators do not rely solely on piping for safety.

Without this addition to Chapter 13 the piping for hydrogen generators would be required to comply with 6.5.1 that requires the piping to also meet sections of IFCG that are both redundant and likely to cause confusion and possibly reduced safety as they have prohibitions and exceptions that are difficult to navigate. This prohibition include flanged and threaded connections that are commonly and safely used in hydrogen generators.

And, the limitations of the IFGC sections are not appropriate for the piping for other fluids used in hydrogen systems and conflict with standard practices for that piping.

Finally, hydrogen is very often not used as a fuel gas which brings into doubt the applicability of any part of the IFGC.

ASME B31 is both necessary and sufficient.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 122-NFPA 2-2023 [Section No. 6.5.1 [Excluding any Sub-Sections]]	Both address piping; if PI122 is accepted, this PI is not needed.
Public Input No. 132-NFPA 2-2023 [New Section after A.13.2.1]	

Public Input No. 152-NFPA 2-2023 [New Section after 12.2.1.3]

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 21:43:50 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-25-NFPA 2-2024

Statement: Piping systems for hydrogen systems should be designed and constructed to minimize the likelihood of a release (leak). Welded connections are generally considered the best way to achieve this, however, they are not always practical.

In addition, many types of hydrogen systems include piping for fluids other than hydrogen. For example, electrolyzer based hydrogen generators include piping for water and reformer-based hydrogen generators often include piping for natural gas.

The Code for Pressure Piping, ASME B31, addresses the design, fabrication, assembly, and testing of piping systems for all types of fluid including hydrogen. ASME B31.12, Hydrogen Piping and Pipelines, addresses piping system for hydrogen in particular.

ASME B31 has been used successfully in hydrogen systems for many decades. And, many product safety standards for hydrogen equipment such as CSA FC 1 for fuel cells and CSA/ANSI B22734 for electrolyzers refer specifically to ASME B31.

For the renumbered 6.5.1.2 is a contradiction between the International Fuel Gas Code (IFGC) and the American Society of Mechanical Engineers (ASME) B31 piping codes in the pressure testing requirements of hydrogen systems for high-pressure applications. The contradiction concerns the acceptable resultant hoop (circumferential) stress from a pneumatic or hydrostatic pressure test. The requirement in the IFGC is limiting and would require a lower test pressure and, in some cases, below the MAWP, where the B31 codes state that no test pressure reduction is required. B31 allows for testing up to the yield. For example, a 1" stainless steel tube has a wall thickness of 0.083". If they follow the IFGC Section 705, it limits the pressure test based on 50% of the hoop stress, resulting in a pressure test at 2507psig.

Meanwhile, the Barlow formula provided by B31 can establish an MAWP of 3100psig. ASME B31 would require a pressure test at 1.1xMAWP.

Public Input No. 133-NFPA 2-2023 [Section No. 13.3.1 [Excluding any Sub-Sections]]

Water electrolyzers shall be listed to ISO 22734, *Hydrogen generators using water electrolysis process—Industrial, commercial, and residential applications*,or ~~approved~~ CSA B22734, *Hydrogen generators using water electrolysis process—Industrial, commercial, and residential applications (ISO 22734, MOD)* .

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

The binational, U.S. & Canadian, adoption of ISO 22734, CSA 22734 was published this year and should replace the reference to ISO 22734.
However, the Chapter 13 TG thinks it prudent to keep the ISO 22734 reference for one more code cycle to give users of this code time to make the transition so, the proposal is simply to add CSA 22734 for now.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 136-NFPA 2-2023 [Section No. A.13.3.1]	

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 22:05:27 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-15-NFPA 2-2024
Statement: The binational, U.S. & Canadian, adoption of ISO 22734, CSA/ANSI B22734 was published in 2023 and should replace the reference to ISO 22734. However, the Chapter 13 TG thinks it prudent to keep the ISO 22734 reference for one more code cycle to give users of this code time to make the transition to CSA/ANSI B22734 so, the proposal is simply to add CSA/ANSI B22734 for now. The binational adoption of ISO 22734 was published as CSA/ANSI B22734.

Public Input No. 26-NFPA 2-2023 [Section No. 13.3.1 [Excluding any Sub-Sections]]

Water electrolyzers shall be listed to ISO 22734, *Hydrogen generators using water electrolysis process—Industrial, commercial, and residential applications*,or CSA/ANSI B22734, *Hydrogen generators using water electrolysis process – Industrial, commercial, and residential applications,* or approved.

Statement of Problem and Substantiation for Public Input

Rationale: The 2023 edition of CSA/ANSI B22734, Hydrogen generators using water electrolysis process – Industrial, commercial, and residential applications, which is an adoption with Canadian and U.S. deviations of the identically titled ISO 22734 standard, has been published and is a suitable additional listing reference.

Submitter Information Verification

Submitter Full Name: Mark Duda
Organization: CSA Group
Street Address:
City:
State:
Zip:
Submittal Date: Tue Sep 05 08:36:38 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-15-NFPA 2-2024

Statement: The binational, U.S. & Canadian, adoption of ISO 22734, CSA/ANSI B22734 was published in 2023 and should replace the reference to ISO 22734. However, the Chapter 13 TG thinks it prudent to keep the ISO 22734 reference for one more code cycle to give users of this code time to make the transition to CSA/ANSI B22734 so, the proposal is simply to add CSA/ANSI B22734 for now. The binational adoption of ISO 22734 was published as CSA/ANSI B22734.

Public Input No. 134-NFPA 2-2023 [New Section after 13.3.1.1]

13.3.1.2
Water electrolyzers outside the scope of ISO 22734 and CSA B22734 such as solid oxide electrolyzers shall be approved to the applicable parts of those standards.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

The scopes of ISO 22734 and CSA B22734 do not include all technologies for water electrolyzers. However, most of the requirements in ISO 22734 and CSA B22734 do apply to the excluded electrolyzers and they should comply with those requirements.

Note: The requirement proposed is that these excluded electrolyzers be approved to the applicable parts of the standards.
This allows approval by an AHJ since these excluded electrolyzers cannot be certified ("listed") to ISO 22734 or CSA B22734.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 135-NFPA 2-2023 [New Section after A.13.3.1.1]	

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13 TG
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 22:10:26 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-119-NFPA 2-2024
Statement: The scopes of ISO 22734 and CSA/ANSI B22734 do not include all technologies for water electrolyzers and specifically exclude some such as solid oxide electrolyzers. However, most of the requirements in ISO 22734 and CSA/ANSI B22734 do apply to those excluded electrolyzers and they should comply with those requirements as approved. This allows approval by an AHJ since these excluded electrolyzers cannot be certified ("listed") to ISO 22734 or CSA/ANSI B22734.

Public Input No. 137-NFPA 2-2023 [New Section after 13.3.1.1]

13.3.1.3

Water electrolyzer modules shall be listed to CSA FC6 / CSA 62282-2-100 , Fuel cell technologies – Part 2-100: Fuel cell & water electrolysis modules – Safety or shall be in accordance with 13.3.1.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

Water electrolyzer modules may or may not be able to be certified ("listed") to ISO 22734 or CSA B22734.
In general the modules do not contain many sections included in a full electrolyzer and cannot meet all the requirements of those standards.
There is a standard specifically for fuel cell modules, CSA FC6, and the binational, U.S. & Canadian, adoption of this standard is being expanded to include water electrolyzer modules.
(Water electrolyzers are essentially "fuel cells running backwards".)
To ensure the safety of these modules they should at least be listed to the new standard, CSA FC6 / CSA 62282-2-100.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 22:30:02 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: CI-21-NFPA 2-2024

Statement: Water electrolyzer modules may or may not be able to be certified ("listed") to ISO 22734 or CSA/ANSI B22734. In general, the modules do not contain many equipment subsections that are included in a full electrolyzer, and the modules cannot meet all the requirements of those standards. There is a standard specifically for fuel cell modules, CSA FC6 62282-2-100 / CSA C22.2 No. 62282-2-100, and the binational, U.S. & Canadian, adoption of this standard is being expanded to include water electrolyzer modules. (Water electrolyzers are essentially "fuel cells running backwards".) To ensure the safety of these modules they should at least be listed to the new standard, CSA FC6 62282-2-100 / CSA C22.2 No. 62282-2-100. CSA FC6 has not been issued yet and its publication is pending.

Public Input No. 139-NFPA 2-2023 [New Section after 13.3.2.5]

13.3.2.5.1

Oxygen and inert gas vent terminations from water electrolysis systems shall be in accordance with EIGA 154/16 Safe Location of Oxygen and Inert Gas Vents.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

Electrolyzers produce oxygen in addition to hydrogen.
They also may use inert gases.
Requirement for vent terminations for these gases was missing; this PI addresses that.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 138-NFPA 2-2023 [Section No. 13.3.2.5]	Subsection

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 22:41:15 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-20-NFPA 2-2024
Statement: Electrolyzers produce oxygen in addition to hydrogen. They also may use inert gases. Requirements for vent terminations for these gases is needed to prevent hazards from being created from improper venting.

Public Input No. 140-NFPA 2-2023 [New Section after 13.3.2.5]

13.3.2.6*

Listed multiple factory matched water electrolysis systems may be permitted without fire-rated separation between the water electrolysis systems.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

It is not uncommon to construct larger water electrolysis systems using multiple factory-matched water electrolysis systems or modules co-located adjacent to each other.

Factory matched water electrolysis systems listed to CSA B22734 or ISO 22734 undergo a mandatory structured risk assessment to comply with these listing standards. Particular attention is given in this risk assessment to mitigating the hazards of process hydrogen and oxygen hazards within the equipment and to the installation environment. These listed systems are then validated and verified to apply multiple process safeguards and layers of protection that mitigate potential hazards associated with the process H2 and O2 volumes, so that fire-separation distance is not necessary.

For example, these listed water electrolysis systems stop hydrogen and oxygen generation upon detection of leaks, overpressure, excessive temperature, and other critical process upset conditions, removing the source of H2 and O2. Further, these systems then typically vent the internal hydrogen and oxygen pressurized inventory to a safe area via process vent terminals. These measures are implemented before conditions can escalate into a loss of containment and a fire condition.

Note: Requirements to apply fire separation distances from water electrolysis systems to gas storage and other exposures may still apply.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 141-NFPA 2-2023 [New Section after A.13.3.1.1]	
Public Input No. 142-NFPA 2-2023 [New Section after 13.3.2.5]	

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 22:46:08 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-223-NFPA 2-2024

Statement: It is not uncommon to construct larger water electrolysis systems using multiple, smaller, factory-matched water electrolysis systems or modules co-located adjacent to each other.

Parts of Chapter 7 could be interpreted as requiring separation between these systems or modules to prevent the spread of fire from one unit to another. Some examples are 7.1.9.1, 7.2.1.1, 7.2.2.2.2.2, 7.2.2.3.2, & 7.3.2.3.1.2.

Water electrolysis systems and modules listed to CSA/ANSI B22734 or ISO 22734 undergo a mandatory structured risk assessment to comply with these listing standards. Particular attention is given in this risk assessment to mitigating the hazards of process hydrogen and oxygen hazards within the equipment and to the installation environment. These listed systems are then validated and verified to apply multiple process safeguards and layers of protection that mitigate potential hazards associated with the process hydrogen and oxygen volumes, so that fire-separation distances between these water electrolysis systems is not necessary.

For example, these listed water electrolysis systems stop hydrogen and oxygen generation upon detection of leaks, overpressure, excessive temperature, and other critical process upset conditions, removing the source of hydrogen and oxygen. Further, these systems then typically vent the internal, pressurized hydrogen and oxygen inventory to a safe area via process vent terminals. These measures are implemented before conditions can escalate into a loss of containment and a fire condition. Unlike equipment that uses hydrogen as an input or that processes hydrogen, electrolyzers produce the hydrogen from water and electricity and stop the production of hydrogen immediately upon shutdown. Electrolyzers typically contain large quantities of water that help mitigate the risks from external fires. And, the primary hazard to an electrolyzer from an external fire is damage to the electrolyzer equipment and not to personnel.

Fire and explosion hazard protection requirements are located in section 4.4.1 of ISO 22734 and CSA/ANSI B22734. In addition, these standards require protection against the spread of fire including fire resistant enclosures; see section 4.3.3.3 of ISO 22734 and CSA/ANSI B22734.

Public Input No. 142-NFPA 2-2023 [New Section after 13.3.2.5]

13.3.2.6.1

Listed multiple factory matched water electrolysis modules may be permitted without fire-rated separation between the water electrolysis modules.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

Note: This PI is similar to PI140 except that it is for modules rather than electrolyzers.

It is not uncommon to construct larger water electrolysis systems using multiple factory-matched water electrolysis modules co-located adjacent to each other.

Factory matched water electrolysis modules listed to CSA FC6 / CSA 62282-2-100 undergo a mandatory structured risk assessment to comply with these listing standards. Particular attention is given in this risk assessment to mitigating the hazards of process hydrogen and oxygen hazards within the equipment and to the installation environment. These listed modules are then validated and verified to apply multiple process safeguards and layers of protection that mitigate potential hazards associated with the process H2 and O2 volumes, so that fire-separation distance is not necessary.

For example, these listed water electrolysis systems stop hydrogen and oxygen generation upon detection of leaks, overpressure, excessive temperature, and other critical process upset conditions, removing the source of H2 and O2. Further, these systems then typically vent the internal hydrogen and oxygen pressurized inventory to a safe area via process vent terminals. These measures are implemented before conditions can escalate into a loss of containment and a fire condition.

Note: Requirements to apply fire separation distances from water electrolysis modules to gas storage and other exposures may still apply.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 140-NFPA 2-2023 [New Section after 13.3.2.5]	Similar exemption.
Public Input No. 143-NFPA 2-2023 [New Section after A.13.3.1.1]	

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 22:56:27 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-223-NFPA 2-2024

Statement: It is not uncommon to construct larger water electrolysis systems using multiple, smaller, factory-matched water electrolysis systems or modules co-located adjacent to each other.

Parts of Chapter 7 could be interpreted as requiring separation between these systems or modules to prevent the spread of fire from one unit to another. Some examples are 7.1.9.1, 7.2.1.1, 7.2.2.2.2.2, 7.2.2.3.2, & 7.3.2.3.1.2.

Water electrolysis systems and modules listed to CSA/ANSI B22734 or ISO 22734 undergo a mandatory structured risk assessment to comply with these listing standards. Particular attention is given in this risk assessment to mitigating the hazards of process hydrogen and oxygen hazards within the equipment and to the installation environment. These listed systems are then validated and verified to apply multiple process safeguards and layers of protection that mitigate potential hazards associated with the process hydrogen and oxygen volumes, so that fire-separation distances between these water electrolysis systems is not necessary.

For example, these listed water electrolysis systems stop hydrogen and oxygen generation upon detection of leaks, overpressure, excessive temperature, and other critical process upset conditions, removing the source of hydrogen and oxygen. Further, these systems then typically vent the internal, pressurized hydrogen and oxygen inventory to a safe area via process vent terminals. These measures are implemented before conditions can escalate into a loss of containment and a fire condition. Unlike equipment that uses hydrogen as an input or that processes hydrogen, electrolyzers produce the hydrogen from water and electricity and stop the production of hydrogen immediately upon shutdown. Electrolyzers typically contain large quantities of water that help mitigate the risks from external fires. And, the primary hazard to an electrolyzer from an external fire is damage to the electrolyzer equipment and not to personnel.

Fire and explosion hazard protection requirements are located in section 4.4.1 of ISO 22734 and CSA/ANSI B22734. In addition, these standards require protection against the spread of fire including fire resistant enclosures; see section 4.3.3.3 of ISO 22734 and CSA/ANSI B22734.

Public Input No. 138-NFPA 2-2023 [Section No. 13.3.2.5]

13.3.2.5 – Vent terminations

Vent terminations from hydrogen generation systems shall be in accordance with Section 6.17.

Statement of Problem and Substantiation for Public Input

Added title to subsection for clarity.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 139-NFPA 2-2023 [New Section after 13.3.2.5]	

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 22:39:51 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-20-NFPA 2-2024
Statement: Electrolyzers produce oxygen in addition to hydrogen. They also may use inert gases. Requirements for vent terminations for these gases is needed to prevent hazards from being created from improper venting.

Public Input No. 144-NFPA 2-2023 [Section No. 13.4.1]

13.4.1* General.

Reforming-based hydrogen generators shall be listed or approved to CSA/ANSI FC 5, Hydrogen generators using fuel processing technologies — Part 1: Safety (Adopted ISO 16110-1 , ~~*Hydrogen Generators Using Fuel Processing Technologies – Part 1: Safety*~~ . :2007, first edition, 2007-03-15, with U.S. deviations) .

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

The U.S. adoption of ISO 16110-1, CSA/ANSI FC 5, was published in 2007.
Reference should have been updated in a previous edition.
(Chapter 13 TG forgot to enter a PI for this in the previous editions.)

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13 TG.
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 20 10:05:41 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-16-NFPA 2-2024
Statement: The U.S. adoption of ISO 16110-1, CSA/ANSI FC 5, was published in 2007. The intent was always to replace the ISO standard with the CSA/ANSI standard when it became available. The adoption of ISO 16110-1 as CSA/ANSI FC 5 has been complete for several years; this Annex A information is no longer needed.

Public Input No. 24-NFPA 2-2023 [Section No. 13.4.1]

13.4.1* General.

Reforming-based hydrogen generators shall be listed or approved to CSA/ANSI FC 5, *Hydrogen generators using fuel processing technologies - Part 1: Safety, or* ISO 16110-1, *Hydrogen Generators Using Fuel Processing Technologies – Part 1: Safety*.

Statement of Problem and Substantiation for Public Input

The 2021 edition of CSA/ANSI FC 5, Hydrogen generators using fuel processing technologies – Part 1: Safety, is an adoption with U.S. deviations of the identically titled ISO 16110-1 and is a suitable listing standard reference.

Submitter Information Verification

Submitter Full Name: Mark Duda
Organization: CSA Group
Street Address:
City:
State:
Zip:
Submittal Date: Tue Aug 15 11:06:45 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-16-NFPA 2-2024
Statement: The U.S. adoption of ISO 16110-1, CSA/ANSI FC 5, was published in 2007. The intent was always to replace the ISO standard with the CSA/ANSI standard when it became available. The adoption of ISO 16110-1 as CSA/ANSI FC 5 has been complete for several years; this Annex A information is no longer needed.

Public Input No. 145-NFPA 2-2023 [Section No. 13.5.3.1 [Excluding any Sub-Sections]]

~~Gasification~~ For gasification systems ~~contain~~ containing conditioning equipment to cool and scrub the gas prior to delivery as a fuel; the conditioning equipment shall comply with 13.5.3.1.1 and 13.5.3.1.2.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

This is an editorial change to fix a grammatical error and clarify that this requirement only applies to gasification systems that include conditioning equipment.

Note: In addition to the edits at the beginning of the sentence made by the TG, I changed "contain" to "containing".

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13 TG.
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 20 10:16:38 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-22-NFPA 2-2024
Statement: This is an editorial change to fix a grammatical error and clarify that this requirement only applies to gasification systems that include conditioning equipment.

Public Input No. 146-NFPA 2-2023 [Section No. 13.5.3.10.3.2]

13.5.3.10.3.2

Ultraviolet/infrared (UV/IR) or Multi-spectrum Infrared (MIR) flame detection shall be provided in the vicinity of the gasifier vessel and all downstream equipment in which the gas temperature exceeds 80 percent of the lowest autoignition temperature of a contained constituent that exceeds 3 percent of the gas mix by volume.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

MIR detectors are a newer technology that can be considered as an alternative to the traditional UV/IR detectors.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13 TG.
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 20 10:24:12 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-17-NFPA 2-2024
Statement: Hydrogen flame detection is not limited to UVIR technology and has been expanded to include all types of fire detection. Multispectrum infrared detectors are also capable of detecting hydrogen flames and typically at greater distances. If the detector is listed for hydrogen flame detection by an accredited NRTL, it should be allowed to be used for the protection of hydrogen gasifier units.

Public Input No. 3-NFPA 2-2023 [Section No. 13.5.3.10.3.2]

13.5.3.10.3.2

~~Ultraviolet/infrared (UV/IR) flame~~ Radiant energy-sensing flame detection shall be provided in the vicinity of the gasifier vessel and all downstream equipment in which the gas temperature exceeds 80 percent of the lowest autoignition temperature of a contained constituent that exceeds 3 percent of the gas mix by volume.

Statement of Problem and Substantiation for Public Input

Hydrogen flame detection is not limited to UVIR technology. Multispectrum infrared detectors are also capable of detecting Hydrogen flames and typically at greater distances. If the detector is listed for hydrogen flame detection by an accredited NRTL, it should be allowed to be used for the protection of hydrogen gasifier units.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 4-NFPA 2-2023 [Section No. A.7.3.2.3.1.4(B)]	

Submitter Information Verification

Submitter Full Name: Aaron Paterson
Organization: Detector Electronics
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 05 14:07:50 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-17-NFPA 2-2024

Statement: Hydrogen flame detection is not limited to UVIR technology and has been expanded to include all types of fire detection. Multispectrum infrared detectors are also capable of detecting hydrogen flames and typically at greater distances. If the detector is listed for hydrogen flame detection by an accredited NRTL, it should be allowed to be used for the protection of hydrogen gasifier units.

Public Input No. 224-NFPA 2-2024 [Chapter 14]

Chapter 14 Combustion Applications

14.1

Scope.

~~This chapter shall apply to equipment that uses hydrogen~~

~~as~~

or a hydrogen enriched fuel source for combustion

~~fuel to provide heat used for the processing of materials and related equipment.~~

applications outlined in 14.3.

14.1.1 *

~~Applicability~~

~~**Applicability** The requirements of this chapter shall apply to the use of~~

~~GH~~ 2

GH2 or a hydrogen enriched fuel as part of a manufacturing process using thermal spraying or as a fuel in heating applications.

14.1.1.1 This chapter also shall apply to new installations and to alterations or extensions to existing equipment that introduces hydrogen gas or a hydrogen enriched fuel to the installation.

14.1.1.2

The storage, use, and handling of

~~GH~~ 2

GH2 in any quantity shall also comply with the requirements of Chapters 1 and 4 and the applicable requirements of Chapters 5 through

~~8~~

7.

14.1.1.

~~3~~

~~The requirements of Chapters 4 and 6 through 8 shall be applicable to all hydrogen systems~~

2.1 Where an LH2 source is used to supply the combustion process, the storage and vaporization to GH2 shall be in accordance with Chapter 8.

14.1.1.

~~4~~

3 Use-specific requirements for hydrogen or hydrogen

~~mixtures~~

enriched fuels used

~~as a fuel for thermal spray equipment and for heating applications~~

for the applications in 14.3 shall apply.

14.1.1.

~~5~~

4 Where there is a conflict between a fundamental requirement and a use-specific requirement, the use-specific requirement shall be applicable.

14.2

General. (Reserved)

14.3

Use.

14.3.

~~1 Thermal Spraying Equipment.~~

1 General

14.3.1.1* Electrical Equipment The area containing the equipment identified in 14.3.2, 14.3.3 and 14.3.4 below using hydrogen gas or a hydrogen enriched fuel shall be classified in accordance with Article 500 or Article 505 of *NFPA 70*.

14.3.1.1

~~General.~~

~~Thermal spraying equipment shall meet the requirements of~~

.1 Electrical wiring and equipment shall be in accordance with Articles 500, 501, and 504 of NFPA 70 or with Article 505 of NFPA 70.

14.3.1 . 1.2 For any device electrically connected using conduit, a means shall be provided to prevent leakage though the conduit into the electrical cabinet.

14.3.1.2

~~* Indoor Installations of Thermal Spraying Equipment.~~

~~**Ventilation.** The area containing the equipment identified in 14.3.~~

~~1.~~

~~2~~

~~.1 *~~

~~Thermal spray equipment shall be installed, inspected, and maintained in accordance with the manufacturer's instructions to minimize the potential for leaks of the gas delivery system~~

and 14.3.3 below using hydrogen gas or a hydrogen enriched fuel shall be ventilated in accordance with 6.16 to prevent flammable gas buildup from potential system leaks.

14.3.1.2.

~~2~~

1 *

The

~~area~~

ceiling of rooms in which

~~the thermal spray equipment~~

equipment using hydrogen gas or a hydrogen enriched fuel is installed shall be

~~classified in accordance with Article 500 or Article 505 of *NFPA 70*~~

constructed in a manner to prevent the accumulation of hydrogen gas .

14.3.1.2.2 Venting systems discharging hydrogen to the atmosphere shall be piped to a designated point outside the building in accordance with Section 6 .

~~1~~

~~Electrical equipment shall comply with the requirements of *NFPA 70* for the electrical classification of the area in which it is installed.~~

17.

14.3.1.3 Gas Detection System.

14.3.1.3.1 A hydrogen gas detection system in accordance with 6.13 shall be installed for the room or area where the equipment identified in 14.3.2 and 14.3.3 below using hydrogen gas or a hydrogen enriched fuel is installed.

14.3.1.3.2 The gas detection location shall be determined by a risk assessment considering the effectiveness of the following detection location options:

(1) in the immediate area of open combustion applications,

(2) in the immediate area of potential equipment leak sources

(3) in a location where leaked gas is expected to accumulate

(4) integrated with the ventilation system exhaust

14.3.1.3.3* The gas detection risk assessment shall also define the alarm and action concentration values for the installation.

14.3.1. 4 External Flame Detection

14.3.1. 4.1* External equipment flame detection shall be provided where the equipment identified in 14.3. 2 and 14 .3

~~Ventilation.~~
.3 below using hydrogen gas or a hydrogen enriched fuel is installed .

14.3.1.

~~2.3.1~~

~~The area containing the thermal spray equipment shall be ventilated to prevent flammable gas buildup from potential system leaks.~~

4.1.1 Detection of an external flame shall result shutdown of the system,

14.3.1. 4.1.2* The type, number and location of the flame detection devices shall be determined based on the following considerations:

(1) Detector effectiveness for the gas composition in use

(2) The optical view capability of the detectors,

(3) Restrictions to the device views due to building features or equipment between the detector and potential fire locations

(4) Shielding from sunlight (direct or reflected) that can result in false detection

(5) Selection of detector type

14.3.1. 4.2* Hydrogen fire warning devices and evacuation routes in the event of a fire shall be defined considering the following:

(1) Locations that require personnel in the proximity of equipment using hydrogen gas or a hydrogen enriched fuel where a fire may occur

(2) The evacuation route from such locations shall not pass through other fire risk areas

(3)* Visibility of the device(s) for persons in the fire risk area

(4) The warning device location identifies the appropriate exit path(s) away from the associate fire risk area

14.3.1. 4.3 The flame detection system shall be connected to the fire alarm system required by 6.12.

14.3.1. 5* Emergency Shutoff. The following requirements shall apply to the “low pressure” applications identified in 14.3. 2 and 14 .3.

~~2~~

~~Mechanical exhaust ventilation systems required by Section 6.18 or for operation of the equipment shall be interlocked with the thermal spraying equipment to prevent the flow of gases without the ventilation system operating~~

3 below that are supplied with a gas pressure of 345 kPa (50 psig) or less.

14.3.1.5.1 Two safety shutoff valves shall be provided on the piping used to supply hydrogen or hydrogen enriched fuel to the equipment.

14.3.1.5.1.1 Where there is a separate gas supply to a combustion system pilot flame device, two safety shutoff valves shall be included for the pilot gas supply.

14.3.1.5.2* The two safety shutoff valves shall require a manual reset after the cause of the activation has been resolved .

14.3.1.

~~2.4 * –~~

~~The ceiling of rooms in which thermal spray equipment is installed shall be constructed in a manner to prevent the accumulation of hydrogen gas~~

5.2.1 For pressures up to and including 103 kPa (15 psig).

(A) A listed safety shutoff valve that meets the requirements of ANSI Z21.21, Automatic Valves for Gas Appliances or UL 429, Electrically Operated Valves shall be used.

(B) Where a listed safety shutoff valve is not available for the application, the selected valve shall have a Class VI leakage rating per ANSI FC 70-2, Control Valve Seat Leakage, as declared by valve manufacturer .

14.3.1. 5. 2.

~~5~~

~~Venting systems discharging hydrogen to the atmosphere shall be piped to a designated point outside the building in accordance with Section 6.17 .~~

2 For pressures greater than 103 kPa (15 psig).

(A) A listed safety shutoff valve that meets the requirements of ANSI Z21.21, Automatic Valves for Gas Appliances or UL 429, Electrically Operated Valves, shall be used. Such valves shall be listed for use with hydrogen gas or be certified by the valve manufacturer for use with hydrogen gas or hydrogen enriched gas.

(B) Where a listed safety shutoff valve is not available for the application, a valve certified by the manufacturer for use with hydrogen gas or hydrogen enriched gas or one specified by the equipment manufacturer for the particular fuel shall be used.

(C)* Where a non-listed safety shutoff valve is used, it shall have a Class VI leakage rating per ANSI FC 70-2, Control Valve Seat Leakage, as declared by valve manufacturer .

14.3.1.5.3* At least one safety shutoff valve shall be located external to the equipment chamber, separate dedicated enclosure or building.

14.3.1.5.4* Valve seat leakage testing of safety shutoff valves and valve proving systems shall be performed in accordance with the manufacturer's instructions. (**86:** 7.4.10)

14.3.1.

~~2.6 Gas Detection System.~~
6 Pre-Mixed Air-Fuel Gas Mixtures.

14.3.1. 6.1* Where a low pressure pre-mixed air-fuel gas (hydrogen or hydrogen enriched fuel) mixture is provided to the equipment identified in 14.3. 2 and 14 . 3.3 below, a flame arrestor shall be provided in piping systems that distribute the mixture.

14.3.1. 6.

~~1 * –~~

~~A hydrogen gas detection system shall be installed in the room or area where thermal spray equipment utilizing hydrogen gas is installed.~~

~~**14.3.1.2.6.2** –~~

~~Activation of the gas detection system~~

2 The flame arrestor shall be installed at the equipment burner inlet(s), and the manufacturer's installation guidelines shall be followed.

14.3.1.6.3 A separate, manually operated gas valve shall be provided at the inlet to the air gas mixer for shutting off the flow of fuel to the mixer after a flashback has occurred.

14.3.1.6.4 The valve(s) required by 14.3.1.6.3 shall not be reopened after a flashback has occurred until the flame arrestor has cooled sufficiently to prevent reignition of the flammable mixture and has been properly reset.

14.3.1.6.5 * A safety blowout shall be installed in accordance with the manufacturer's instructions near the outlet of the mixing equipment that produces the flammable air–fuel gas mixture at a pressure greater than 0.5 kPa (2 in. w.c.).

14.3.2 Open Combustion Applications
14.3.2.1 Thermal Spraying Equipment.

14.3.2.1.1 General. Thermal spraying equipment shall meet the requirements of 14.3.1.

14.3.2.1.2 * Indoor Installations of Thermal Spraying Equipment.

14.3.2.1.2.1 * Thermal spray equipment shall be installed, inspected, and maintained in accordance with the manufacturer's instructions to minimize the potential for leaks of the gas delivery system.
14.3.2.1.3 Gas Detection System. Activation of the gas detection system at the alarm concentration determined by the risk assessment in accordance with 14.3.1.3 , shall result in the following:

(1) The thermal spray system shall be prevented from starting

~~if hydrogen is detected at a concentration exceeding 25 percent of the lower flammable limit (LFL).~~

- ~~The thermal spray system shall be shut down upon detection of hydrogen during operation at a concentration exceeding 25 percent of the LFL.~~

~~**14.3.1.2.7** – Emergency Shutoff.~~

~~**14.3.1.2.7.1** –~~

~~Automatic emergency shutoff valves shall be provided on the piping used to supply hydrogen gas to the thermal spraying equipment.~~

~~14.3.1.2.7.2~~ ~~–~~

~~Activation of the valves shall shut off the flow of hydrogen~~

~~.~~

(2) The thermal spray system shall be shut down.

14.3.2.1.4 Emergency Shutoff.

14.3.2.1.4.1 The two safety shutoff valves specified in 14.3.1.5 shall shut off the flow of hydrogen gas or hydrogen enriched fuel in the event of the following:

(1) Loss of ventilation systems required by 14.3.1.2.

(2) Detection of hydrogen at a concentration exceeding the action concentration determined by the risk assessment in accordance with 14.3.1.3.

(3) Activation of emergency stop functions specified by the equipment manufacturer.

14.3.2.2 Outdoor Installations of Thermal Spray Equipment. (Reserved)

14.3.3 Atmospheric Combustion Applications

14.3.3.1 Boilers and Combustion Systems

14.3.3.1.1 General. Boilers and Combustion System installations using hydrogen gas or a hydrogen enriched fuel for heating shall comply with NFPA 85 and meet the requirements of 14.3.3.1.

14.3.3.1.2* Indoor Installations of Boilers and Combustion Systems .

14.3.3.1.2.1* Boilers and Heat Recovery Steam Generator (HRSG) Duct Burner Systems shall be installed, inspected, and maintained in accordance with the manufacturer's instructions to minimize the potential for leaks of the gas delivery system.

14.3.3.1.2.2 Gas Detection System for the room or area. Activation of the gas detection system at the alarm concentration determined by the risk assessment in accordance with 14.3.1.3 shall result in the following:

(1) Boiler and HRSG Duct Burner Systems shall be prevented from starting.

(2) If running, Boiler and HRSG Duct Burner Systems shall be shut down.

14.3.3.1.2.3 Emergency Shutoff. The two safety shutoff valves specified in 14.3.1.5 shall shut off the flow of hydrogen gas or hydrogen enriched fuel in the event of the following:

(1) Loss of ventilation systems required by 14.3.1.2

(2) Detection of hydrogen at a concentration exceeding the action concentration determined by the risk assessment in accordance with 14.3.1.3.

(3) Activation of emergency stop functions specified by the equipment manufacturer

14.3.3.1.3 Outdoor Installations of Boilers and Combustion Systems.

(Reserved)

14.3.3. 2 Ovens and Furnaces

14.3.3.2.1 General. Ovens and Furnace installations using hydrogen gas or a hydrogen enriched fuel shall comply with NFPA 86 and meet the requirements of 14.3.3.2.

14.3.3.2.2 Indoor Installations of Ovens and Furnaces.

14.3.3.2.2.1 Ovens and Furnaces using hydrogen gas or a hydrogen enriched fuel shall be installed, inspected, and maintained in accordance with the manufacturer's instructions to

minimize the potential for leaks of the gas delivery system.

14.3.3.2.2.2 Gas Detection System for the room or area. Activation of the gas detection system at the alarm concentration determined by the risk assessment in accordance with 14.3.1.3 shall result in the following:

(1) Ovens and Furnaces shall be prevented from starting.

(2) Ovens and Furnaces shall be shut down.

14.3.3.2.2.3*

Emergency Shutoff. The two safety shutoff valves specified in 14.3.1.5 shall shut off the flow of hydrogen gas or hydrogen enriched fuel in the event of the following:

(1) Loss of ventilation systems required by 14.3.1.2

(2) Detection of hydrogen at a concentration exceeding the action concentration determined by the risk assessment in accordance with 14.3.1.3.

(3) Activation of emergency stop functions specified by the equipment manufacturer.

14.3.3.2.3 Outdoor Installations of Ovens and Furnaces.

(Reserved)

14.3.3.3 Fluid Heater Systems

14.3.3.3.1 General. Fluid Heater system installations employing hydrogen or a hydrogen enriched fuel as a heating fuel shall comply with NFPA 87 and meet the requirements of 14.3.3.3.

14.3.3.3.2* Indoor Installations of Fluid Heater Systems.

14.3.3.3.2.1* Fluid Heater systems shall be installed, inspected, and maintained in accordance with NFPA 87 and the manufacturer's instructions to minimize the potential for leaks of the gas delivery system.

14.3.3.3.2.2 Gas Detection System for the room or area. Activation of the gas detection system at the alarm concentration determined by the risk assessment in accordance with 14.3.1.3 shall result in the following:

(1) The heating system burners and pilots shall be prevented from starting.

(2) The heating system burners and pilots shall be shut down.

14.3.3.3.2.3* Emergency Shutoff. The two safety shutoff valves specified in 14.3.1.5 shall shut off the flow of hydrogen gas or hydrogen enriched fuel in the event of the following:

(1) Loss of ventilation systems required by 14.3.1.2

~~.3.2~~

(2) Detection of hydrogen at a concentration exceeding

~~25 percent of the LFL~~

the action concentration determined by the risk assessment in accordance with 14.3.1.3.

(3) Activation of emergency stop functions

~~provided with~~

specified by the

~~manufacturer's~~

equipment manufacturer.

14.3.

~~1~~
3 .3

.3 Outdoor Installations of

~~Thermal Spray Equipment. (Reserved)~~
Fluid Heater Systems.

(Reserved)

14.3.4 * High Pressure Combustion Applications These are combustion applications that use hydrogen or hydrogen enriched fuel at greater than 345 kPa (50 psig). The following applications are considered in this category:

(1) Combustion Engines with a gaseous fuel injection system at greater than 345 kPa (50 psig)

(2) Gas Turbines

14.3.4.1* General The installation and operation of Combustion Engines and Gas Turbines shall be in accordance with NFPA 37 and meet the requirements of 14.3.1.1.

14.3.4.2 Gas Supply The supply of a Hydrogen Enriched Fuel can take two forms:

(1) Pipeline supplied premixed fuel

(2) Locally mixed fuel

14.3.4.2.1 Hydrogen Mixing Where the Hydrogen Enriched Fuel mixing is provided locally, the mixing function shall comply with the manufacturer's requirements related to:

(1) Maximum hydrogen content in the mixture

(2) Shutdown sequence for abnormal or emergency operating conditions

14.3.4.2.2 Emergency Shutoff In addition to the two Automatic Safety Shutoff Valve (ASSV) and associated vent valve arrangement required by NFPA 37 for a combustion engine or gas turbine, the hydrogen or hydrogen enriched fuel supply shall comply with the following:

(1) The ASSVs shall be in accordance with 14.3.1.5.2.2

(2) A vent valve shall be located between the two ASSVs

(3) One of the two ASSVs required by NFPA 37 for an engine other than a Gas turbine shall be located external to the engine package and any associated building

(4) Automatic vent valves shall be provided between all shutoff valves starting downstream of the second ASSV

(5) The gas train shall be provided with an inert purge function to remove the residual hydrogen or hydrogen enriched fuel downstream of the second ASSV

(6) The vent(s) for the hydrogen or hydrogen enriched fuel shall be in accordance with 7.1.16.

Additional Proposed Changes

File Name	Description	Approved

Chapter_14_revised_input_for_TerraView_submission.docx	This is a change tracking on mark-up of Chapter 14 showing all changes made

Statement of Problem and Substantiation for Public Input

Various combustion process equipment is being shifted from natural gas to blends of natural gas and hydrogen as part of the global shift to hydrogen fuel. These blends range from 5% to 95% plus hydrogen. The most common blend seen to date is 20% hydrogen enriched pipeline natural gas blend in Europe; however, mixing systems have been proposed to increase the use of hydrogen in the near future. This led directly to the formation of the Chapter 14 Task group to capture the known industrial processes on this path and provide the appropriate guidance within the chapter.

In the development of the expanded Chapter 14, the Task Group identified NFPA 37, NFPA 85, NFPA 86 and NFPA 87 to be the applicable Codes and Standards for the combustion process equipment affected by the introduction of hydrogen enriched fuels. Due to the extent and complexity of the changes, this PI is being submitted as a complete Chapter replacement and a marked up Word document with commentary regarding the changes is also being provided. The Word Document includes both the mandatory Chapter and Annex text.

This PI is submitted by Lawrence Danner, CSP on behalf of the Chapter 14 Task Group.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 221-NFPA 2-2024 [Section No. 1.3.3]	
Public Input No. 222-NFPA 2-2024 [New Section after 3.3.121]	
Public Input No. 223-NFPA 2-2024 [New Section after 3.3.215]	
Public Input No. 225-NFPA 2-2024 [Sections A.14.1.1, A.14.3.1.2, A.14.3.1.2.1, A.14.3.1.2.2, ...]	
Public Input No. 226-NFPA 2-2024 [New Section after A.3.3.120.2]	

Submitter Information Verification

Submitter Full Name: Larry Danner
Organization: GE Power
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 02 11:20:03 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: CI-133-NFPA 2-2024

Statement: Hydrogen enriched fuel sources for combustion are becoming more prominent in industrial applications. The rewrite of Chapter 14 is being developed to keep NFPA 2 relevant with the industry. However, the committee requires more time to ensure the revisions being proposed are adequate and align with the NFPA manual of style. It is encouraged that the public also provide comments concerning this rewrite of Chapter 14.

Important Notice: This document has been provided for NFPA task group use only. This document is the copyright property of the National Fire Protection Association (NFPA), Copyright © 2023 NFPA, and may not be used for any other purpose or distributed to any other persons or parties outside of the task group.

Chapter 14 Combustion Applications

14.1 Scope. This chapter shall apply to equipment that uses hydrogen or a hydrogen enriched fuel source for combustion applications outlined in 14.3.

14.1.1 * Applicability The requirements of this chapter shall apply to the use of GH2 or a hydrogen enriched fuel as part of a manufacturing process using thermal spraying or as a fuel in heating applications.

> **A.14.1.1** Examples of the use of hydrogen used as a fuel involving flame, include, but would not be limited to, combustion of the gas in a torch used in welding or heating operations where the gas is used to provide a flame and accompanied by a reducing atmosphere. The melting of quartz or glass frequently involves the use of hydrogen combustion operations.
>
> Several European countries are pre-mixing hydrogen up to 20% concentration in the distribution pipelines. Although this is outside the scope of NFPA 2, it is worth noting for awareness.
>
> There is a move to start mixing hydrogen into the fuel supply for industrial Internal Combustion Engines and Gas Turbines. In Europe, this will be provided by way of the pipeline premixed fuel and the vision is for additional hydrogen to be added from a "local" source, up to 100% hydrogen, as hydrogen availability increases. For Gas Turbines, this path was formalized in January 2020 by the European Turbine Network (ETN Global) Hydrogen Working Group in their report "The Path Towards a Zero-Carbon Gas Turbine" which is available at https://etn.global/news-and-events/news/hydrogen-gas-turbines-report/. With this direction in mind, a Task Group was formed to develop initial guidance for the use of "Hydrogen Enriched Fuels" in the 2024 edition of NFPA 37.
>
> The provisions for premixed hydrogen in pipelines will also affect all other gas consumers such as Boilers and Combustion Systems (NFPA 85), Ovens and Furnaces (NFPA 86), and Fluid Heaters (NFPA 87)

14.1.1.1 This chapter also shall apply to new installations and to alterations or extensions to existing equipment that introduces hydrogen gas or a hydrogen enriched fuel to the installation.

14.1.1.2 The storage, use, and handling of GH2 in any quantity shall also comply with the requirements of Chapters 1 and 4 and the applicable requirements of Chapters 5 through 7.

14.1.1.2.1 Where an LH2 source is used to supply the combustion process, the storage and vaporization to GH2 shall be in accordance with Chapter 8.

14.1.1.3 Use-specific requirements for hydrogen or hydrogen enriched fuels used for the applications in 14.3 shall apply.

14.1.1.4 Where there is a conflict between a fundamental requirement and a use-specific requirement, the use-specific requirement shall be applicable.

14.2 General. (Reserved)

14.3 Use.

14.3.1 General

For NFPA Task Group Use Only

Important Notice: This document has been provided for NFPA task group use only. This document is the copyright property of the National Fire Protection Association (NFPA), Copyright © 2023 NFPA, and may not be used for any other purpose or distributed to any other persons or parties outside of the task group.

14.3.1.1* Electrical Equipment The area containing the equipment identified in 14.3.2, 14.3.3 and 14.3.4 below using hydrogen gas or a hydrogen enriched fuel shall be classified in accordance with Article 500 or Article 505 of *NFPA 70*.

A.14.3.1.1 NFPA 497 provides guidance on the classification of areas.

14.3.1.1.1 Electrical wiring and equipment shall be in accordance with Articles 500, 501, and 504 of NFPA 70 or with Article 505 of NFPA 70.

14.3.1.1.2 For any device electrically connected using conduit, a means shall be provided to prevent leakage though the conduit into the electrical cabinet.

A. 14.3.1.1.2 The higher the pressure, the greater the risk of hydrogen leaking through O-rings and other seals, which are leak tight when tested with air or natural gas. Examples of leak prevention would be the use of conduit plugs. This requirement would not apply to wiring methods that do not use conduit, cable such as SO / SOOW because gas does not freely pass through such cable.

14.3.1.2 Ventilation. The area containing the equipment identified in 14.3.2 and 14.3.3 below using hydrogen gas or a hydrogen enriched fuel shall be ventilated in accordance with 6.16 to prevent flammable gas buildup from potential system leaks.

14.3.1.2.1* The ceiling of rooms in which equipment using hydrogen gas or a hydrogen enriched fuel is installed shall be constructed in a manner to prevent the accumulation of hydrogen gas.

A.14.3.1.2.1 Features such as solid beams that form a tight fit with the roof deck should be avoided. The intakes for the ventilation system should be located at high points in the ceiling to prevent the trapping of hydrogen in the thermal spraying area.

14.3.1.2.2 Venting systems discharging hydrogen to the atmosphere shall be piped to a designated point outside the building in accordance with Section 6.17.

14.3.1.3 Gas Detection System.

14.3.1.3.1 A hydrogen gas detection system in accordance with 6.13 shall be installed for the room or area where the equipment identified in 14.3.2 and 14.3.3 below using hydrogen gas or a hydrogen enriched fuel is installed.

14.3.1.3.2 The gas detection location shall be determined by a risk assessment considering the effectiveness of the following detection location options:

(1) in the immediate area of open combustion applications,

(2) in the immediate area of potential equipment leak sources

(3) in a location where leaked gas is expected to accumulate

(4) integrated with the ventilation system exhaust

14.3.1.3.3* The gas detection risk assessment shall also define the alarm and action concentration values for the installation.

A.14.3.1.3.3 The maximum gas concentration value for action should be no higher than 25% of the Lower Flammability Limit.

14.3.1.4 External Flame Detection

For NFPA Task Group Use Only

Important Notice: This document has been provided for NFPA task group use only. This document is the copyright property of the National Fire Protection Association (NFPA), Copyright © 2023 NFPA, and may not be used for any other purpose or distributed to any other persons or parties outside of the task group.

14.3.1.4.1* External equipment flame detection shall be provided where the equipment identified in 14.3.2 and 14.3.3 below using hydrogen gas or a hydrogen enriched fuel is installed.

> **A.14.3.1.4.1** If ignited, external leakage of hydrogen or hydrogen enriched fuels from the piping and gas control system supplying the equipment can result in an invisible flame and risk of personnel injury.

14.3.1.4.1.1 Detection of an external flame shall result shutdown of the system,

14.3.1.4.1.2* The type, number and location of the flame detection devices shall be determined based on the following considerations:

> **A.14.3.1.4.1.2** The historical detection technology for hydrogen flames is Ultraviolet (UV) or Ultraviolet/Infrared (UV/IR). These systems are susceptible to "false detection" due to sun light, either direct or reflected, and other sources such as welding and activities that result in sparks. In recent years, a Multi-Spectrum IR (MIR) technology has been developed that reduces the potential for false alarms. Additionally, detectors that are specific to the fuel being burned (e.g., natural gas, hydrogen, etc.) are available and some detectors are capable of selectively detecting fires from various fuels.

(1) Detector effectiveness for the gas composition in use

(2) The optical view capability of the detectors,

(3) Restrictions to the device views due to building features or equipment between the detector and potential fire locations

(4) Shielding from sunlight (direct or reflected) that can result in false detection

(5) Selection of detector type

14.3.1.4.2* Hydrogen fire warning devices and evacuation routes in the event of a fire shall be defined considering the following:

> **A.14.3.1.4.2** Combination visual and aural warning devices are essential. The local warning devices are independent from other fire and hazard warning devices (e.g., general fire alarm, toxic gas, etc.) and the visual and aural signals must be distinct from the other local hazard warning devices to ensure no confusion as to the hazard that is being highlighted.

(1) Locations that require personnel in the proximity of equipment using hydrogen gas or a hydrogen enriched fuel where a fire may occur

(2) The evacuation route from such locations shall not pass through other fire risk areas

(3)* Visibility of the device(s) for persons in the fire risk area

> **A.14.3.1.4.2(3)** Multiple devices along the exit path may be required

(4) The warning device location identifies the appropriate exit path(s) away from the associate fire risk area

14.3.1.4.3 The flame detection system shall be connected to the fire alarm system required by 6.12.

14.3.1.5* Emergency Shutoff. The following requirements shall apply to the "low pressure" applications identified in 14.3.2 and 14.3.3 below that are supplied with a gas pressure of 345 kPa (50 psig) or less.

For NFPA Task Group Use Only

Important Notice: This document has been provided for NFPA task group use only. This document is the copyright property of the National Fire Protection Association (NFPA), Copyright © 2023 NFPA, and may not be used for any other purpose or distributed to any other persons or parties outside of the task group.

A.14.3.1.5 Given the flammability characteristics of hydrogen versus natural gas with respect to the gas supply pressure, the 345 kPa (50 psig) low pressure limit defined in NFPA 54, 1.1.1.1(C) is used for the equipment identified in this chapter. Where the fuel supply is greater than 345 kPa (50 psig) the specific requirements for Combustion Engines and Gas Turbines defined in NFPA 37 as modified in 14.3.3 are applicable

14.3.1.5.1 Two safety shutoff valves shall be provided on the piping used to supply hydrogen or hydrogen enriched fuel to the equipment.

14.3.1.5.1.1 Where there is a separate gas supply to a combustion system pilot flame device, two safety shutoff valves shall be included for the pilot gas supply.

14.3.1.5.2* The two safety shutoff valves shall require a manual reset after the cause of the activation has been resolved.

A.14.3.1.5.1.2 The reset may be either a physical reset of the valve actuation or clearing of the “fault” in the control system that returns the valve to the normal operation state.

14.3.1.5.2.1 For pressures up to and including 103 kPa (15 psig).

(A) A listed safety shutoff valve that meets the requirements of ANSI Z21.21, Automatic Valves for Gas Appliances or UL 429, Electrically Operated Valves shall be used.

(B) Where a listed safety shutoff valve is not available for the application, the selected valve shall have a Class VI leakage rating per ANSI FC 70-2, Control Valve Seat Leakage, as declared by valve manufacturer.

A.14.3.1.5.2.1(B) It is recommended that the valve manufacturer consider independent testing laboratory verification and certification of the valve leakage using 10% minimum helium – nitrogen blend.

14.3.1.5.2.2 For pressures greater than 103 kPa (15 psig).

(A) A listed safety shutoff valve that meets the requirements of ANSI Z21.21, Automatic Valves for Gas Appliances or UL 429, Electrically Operated Valves, shall be used. Such valves shall be listed for use with hydrogen gas or be certified by the valve manufacturer for use with hydrogen gas or hydrogen enriched gas.

(B) Where a listed safety shutoff valve is not available for the application, a valve certified by the manufacturer for use with hydrogen gas or hydrogen enriched gas or one specified by the equipment manufacturer for the particular fuel shall be used.

(C)* Where a non-listed safety shutoff valve is used, it shall have a Class VI leakage rating per ANSI FC 70-2, Control Valve Seat Leakage, as declared by valve manufacturer.

A.14.3.1.5.2.2(C) It is recommended that the valve manufacturer consider independent testing laboratory verification and certification of the valve leakage using 10% minimum helium – nitrogen blend.

14.3.1.5.3* At least one safety shutoff valve shall be located external to the equipment chamber, separate dedicated enclosure or building.

A.14.3.1.5.3 A “separate dedicated enclosure” is a structure that has no separate rooms and only the hydrogen consuming equipment is located within the enclosure or building.

14.3.1.5.4* Valve seat leakage testing of safety shutoff valves and valve proving systems shall be performed in accordance with the manufacturer's instructions. (**86:** 7.4.10)

For NFPA Task Group Use Only

Important Notice: This document has been provided for NFPA task group use only. This document is the copyright property of the National Fire Protection Association (NFPA), Copyright © 2023 NFPA, and may not be used for any other purpose or distributed to any other persons or parties outside of the task group.

A.14.3.1.5.4 see NFPA 86 Annex section A.7.4.10 for additional guidance.

14.3.1.6 Pre-Mixed Air-Fuel Gas Mixtures.

14.3.1.6.1* Where a low pressure pre-mixed air-fuel gas (hydrogen or hydrogen enriched fuel) mixture is provided to the equipment identified in 14.3.2 and 14.3.3 below, a flame arrestor shall be provided in piping systems that distribute the mixture.

A.14.3.1.6.1 Two basic configurations for the flame arrestor are recognized. One is to provide a separate flame arrestor at each burner, the other is to provide a flame arrestor at each group of burners. The single a flame arrestor for a group of burners is more practical if a system consists of many closely spaced burners.

14.3.1.6.2 The flame arrestor shall be installed at the equipment burner inlet(s), and the manufacturer's installation guidelines shall be followed.

14.3.1.6.3 A separate, manually operated gas valve shall be provided at the inlet to the air gas mixer for shutting off the flow of fuel to the mixer after a flashback has occurred.

14.3.1.6.4 The valve(s) required by 14.3.1.6.3 shall not be reopened after a flashback has occurred until the flame arrestor has cooled sufficiently to prevent reignition of the flammable mixture and has been properly reset.

14.3.1.6.5* A safety blowout shall be installed in accordance with the manufacturer's instructions near the outlet of the mixing equipment that produces the flammable air–fuel gas mixture at a pressure greater than 0.5 kPa (2 in. w.c.).

A.14.3.1.6.5 It is recommended to include a safety blowout regardless of the mixture pressure. Acceptable safety blowouts are available from some manufacturers of air–fuel mixing machines. They incorporate all the following components and design features:

(1) Flame arrester

(2) Blowout disk

(3) Provision for automatically shutting off the supply of air–gas mixture to the burners in the event of a flashback passing through an automatic fire check

14.3.2 Open Combustion Applications

14.3.2.1 Thermal Spraying Equipment.

14.3.2.1.1 General. Thermal spraying equipment shall meet the requirements of 14.3.1.

14.3.2.1.2 * Indoor Installations of Thermal Spraying Equipment.

A.14.3.2.1.2 Thermal spraying is typically conducted with robotic equipment in isolated chambers or otherwise protected areas to isolate persons from hazards such as noise, intense ultraviolet light, process gases, and vapors. The equipment includes multiple flexible piping or hoses, which pass through the chamber walls to deliver the gas from a control source to the process device or gun. The flexible portions of the fuel delivery system represent potential leak sources.

NFPA 497 provides guidance on the classification of areas.

14.3.2.1.2.1 * Thermal spray equipment shall be installed, inspected, and maintained in accordance with the manufacturer's instructions to minimize the potential for leaks of the gas delivery system.

For NFPA Task Group Use Only

Important Notice: This document has been provided for NFPA task group use only. This document is the copyright property of the National Fire Protection Association (NFPA), Copyright © 2023 NFPA, and may not be used for any other purpose or distributed to any other persons or parties outside of the task group.

A.14.3.2.1.2.1.1 System preventive maintenance typically includes regular leak checks and the replacement of hoses in accordance with the manufacturer's recommendations. An increase in the frequency might be warranted based on maintenance experience.

14.3.2.1.3 Gas Detection System. Activation of the gas detection system at the alarm concentration determined by the risk assessment in accordance with 14.3.1.3 shall result in the following:

(1) The thermal spray system shall be prevented from starting.

(2) The thermal spray system shall be shut down.

14.3.2.1.4 Emergency Shutoff.

14.3.2.1.4.1 The two safety shutoff valves specified in 14.3.1.5 shall shut off the flow of hydrogen gas or hydrogen enriched fuel in the event of the following:

(1) Loss of ventilation systems required by 14.3.1.2.

(2) Detection of hydrogen at a concentration exceeding the action concentration determined by the risk assessment in accordance with 14.3.1.3.

(3) Activation of emergency stop functions specified by the equipment manufacturer.

14.3.2.2 Outdoor Installations of Thermal Spray Equipment. (Reserved)

14.3.3 Atmospheric Combustion Applications

14.3.3.1 Boilers and Combustion Systems

14.3.3.1.1 General. Boilers and Combustion System installations using hydrogen gas or a hydrogen enriched fuel for heating shall comply with NFPA 85 and meet the requirements of 14.3.3.1.

14.3.3.1.2* Indoor Installations of Boilers and Combustion Systems.

A14.3.3.1.2 The categories of equipment identified in NFPA 85 that may use a gaseous fuel, to include hydrogen or a hydrogen enriched fuel, are:

(1) Single Burner Boilers

(2) Multiple Burner Boilers

(3) Warm-Up Burners and Lances for Fluidized Bed Boilers

(4) Duct Burners included in a Heat Recovery Steam Generator

(5) An Auxiliary Boiler associated with a Stoker

This guidance can also be applied to the equipment covered by ASME/CSD-1 Controls and Safety Devices for Automatically Fired Boilers.

14.3.3.1.2.1* Boilers and Heat Recovery Steam Generator (HRSG) Duct Burner Systems shall be installed, inspected, and maintained in accordance with the manufacturer's instructions to minimize the potential for leaks of the gas delivery system.

A.14.3.3.1.2.1 System preventive maintenance typically includes regular leak checks and the replacement of hoses in accordance with the manufacturer's recommendations.

For NFPA Task Group Use Only

Important Notice: This document has been provided for NFPA task group use only. This document is the copyright property of the National Fire Protection Association (NFPA), Copyright © 2023 NFPA, and may not be used for any other purpose or distributed to any other persons or parties outside of the task group.

An increase in the frequency might be warranted based on maintenance experience. Additional guidance for leak checks is provided a 14.3.1.5.4.

14.3.3.1.2.2 Gas Detection System for the room or area. Activation of the gas detection system at the alarm concentration determined by the risk assessment in accordance with 14.3.1.3 shall result in the following:

(1) Boiler and HRSG Duct Burner Systems shall be prevented from starting.

(2) If running, Boiler and HRSG Duct Burner Systems shall be shut down.

14.3.3.1.2.3 Emergency Shutoff. The two safety shutoff valves specified in 14.3.1.5 shall shut off the flow of hydrogen gas or hydrogen enriched fuel in the event of the following:

(1) Loss of ventilation systems required by 14.3.1.2

(2) Detection of hydrogen at a concentration exceeding the action concentration determined by the risk assessment in accordance with 14.3.1.3.

(3) Activation of emergency stop functions specified by the equipment manufacturer

14.3.3.1.3 Outdoor Installations of Boilers and Combustion Systems.

(Reserved)

14.3.3.2 Ovens and Furnaces

14.3.3.2.1 General. Ovens and Furnace installations using hydrogen gas or a hydrogen enriched fuel shall comply with NFPA 86 and meet the requirements of 14.3.3.2.

14.3.3.2.2 Indoor Installations of Ovens and Furnaces.

14.3.3.2.2.1 Ovens and Furnaces using hydrogen gas or a hydrogen enriched fuel shall be installed, inspected, and maintained in accordance with the manufacturer's instructions to minimize the potential for leaks of the gas delivery system.

A.14.3.3.2.2.1 System preventive maintenance typically includes regular leak checks and the replacement of hoses in accordance with the manufacturer's recommendations. An increase in the frequency might be warranted based on maintenance experience.

14.3.3.2.2.2 Gas Detection System for the room or area. Activation of the gas detection system at the alarm concentration determined by the risk assessment in accordance with 14.3.1.3 shall result in the following:

(1) Ovens and Furnaces shall be prevented from starting.

(2) Ovens and Furnaces shall be shut down.

14.3.3.2.2.3*

Emergency Shutoff. The two safety shutoff valves specified in 14.3.1.5 shall shut off the flow of hydrogen gas or hydrogen enriched fuel in the event of the following:

(1) Loss of ventilation systems required by 14.3.1.2

(2) Detection of hydrogen at a concentration exceeding the action concentration determined by the risk assessment in accordance with 14.3.1.3.

(3) Activation of emergency stop functions specified by the equipment manufacturer.

A.14.3.3.2.2.3 NFPA 86 permits a single safety shutoff valve for radiant tube-fired burner systems based on an explosion resistance validation of the assembly. The

For NFPA Task Group Use Only

Important Notice: This document has been provided for NFPA task group use only. This document is the copyright property of the National Fire Protection Association (NFPA), Copyright © 2023 NFPA, and may not be used for any other purpose or distributed to any other persons or parties outside of the task group.

explosion pressure from a hydrogen or hydrogen enriched fuel can be significantly greater that for other fuels, and the validation must consider the fuel being used for the installation.

14.3.3.2.3 Outdoor Installations of Ovens and Furnaces.

(Reserved)

14.3.3.3 Fluid Heater Systems

14.3.3.3.1 General. Fluid Heater system installations employing hydrogen or a hydrogen enriched fuel as a heating fuel shall comply with NFPA 87 and meet the requirements of 14.3.3.3.

14.3.3.3.2* Indoor Installations of Fluid Heater Systems.

14.3.3.3.2.1* Fluid Heater systems shall be installed, inspected, and maintained in accordance with NFPA 87 and the manufacturer's instructions to minimize the potential for leaks of the gas delivery system.

A.14.3.3.3.2.1 System preventive maintenance typically includes regular leak checks and the replacement of hoses in accordance with the manufacturer's recommendations. An increase in the frequency might be warranted based on maintenance experience. NFPA 87 Chapter 7 provides specific guidance for system maintenance.

14.3.3.3.2.2 Gas Detection System for the room or area. Activation of the gas detection system at the alarm concentration determined by the risk assessment in accordance with 14.3.1.3 shall result in the following:

(1) The heating system burners and pilots shall be prevented from starting.

(2) The heating system burners and pilots shall be shut down.

14.3.3.3.2.3* Emergency Shutoff. The two safety shutoff valves specified in 14.3.1.5 shall shut off the flow of hydrogen gas or hydrogen enriched fuel in the event of the following:

(1) Loss of ventilation systems required by 14.3.1.2

(2) Detection of hydrogen at a concentration exceeding the action concentration determined by the risk assessment in accordance with 14.3.1.3.

(3) Activation of emergency stop functions specified by the equipment manufacturer.

14.3.3.3.3 Outdoor Installations of Fluid Heater Systems.

(Reserved)

14.3.4* High Pressure Combustion Applications These are combustion applications that use hydrogen or hydrogen enriched fuel at greater than 345 kPa (50 psig). The following applications are considered in this category:

(1) Combustion Engines with a gaseous fuel injection system at greater than 345 kPa (50 psig)

(2) Gas Turbines

A.14.3.4

a) Reciprocating engines have demonstrated operation at 100% hydrogen

b) Today's gas turbines are fully capable of operating on 20% hydrogen

For NFPA Task Group Use Only

Important Notice: This document has been provided for NFPA task group use only. This document is the copyright property of the National Fire Protection Association (NFPA), Copyright © 2023 NFPA, and may not be used for any other purpose or distributed to any other persons or parties outside of the task group.

c) Gas turbines have demonstrated reliable operation at hydrogen concentrations of 50% and greater using “Syngas”, Refinery Gas and Coke Oven Gas; these uses have been limited primarily to industrial settings that, in general, fall into the “petrochemical plant” category.

d) The gas turbine industry has committed to achieving the ability to run on 100% hydrogen by 2030

14.3.4.1* General The installation and operation of Combustion Engines and Gas Turbines shall be in accordance with NFPA 37 and meet the requirements of 14.3.1.1.

A.14.3.4.1 NFPA 37 provides detailed information and requirements related to:

(1) Ventilation of system enclosures

(2) Gas detection and emergency action

(3) Fire detection and suppression

14.3.4.2 Gas Supply The supply of a Hydrogen Enriched Fuel can take two forms:

(1) Pipeline supplied premixed fuel

(2) Locally mixed fuel

14.3.4.2.1 Hydrogen Mixing Where the Hydrogen Enriched Fuel mixing is provided locally, the mixing function shall comply with the manufacturer’s requirements related to:

(1) Maximum hydrogen content in the mixture

(2) Shutdown sequence for abnormal or emergency operating conditions

14.3.4.2.2 Emergency Shutoff In addition to the two Automatic Safety Shutoff Valve (ASSV) and associated vent valve arrangement required by NFPA 37 for a combustion engine or gas turbine, the hydrogen or hydrogen enriched fuel supply shall comply with the following:

(1) The ASSVs shall be in accordance with 14.3.1.5.2.2

(2) A vent valve shall be located between the two ASSVs

(3) One of the two ASSVs required by NFPA 37 for an engine other than a Gas turbine shall be located external to the engine package and any associated building

(4) Automatic vent valves shall be provided between all shutoff valves starting downstream of the second ASSV

(5) The gas train shall be provided with an inert purge function to remove the residual hydrogen or hydrogen enriched fuel downstream of the second ASSV

(6) The vent(s) for the hydrogen or hydrogen enriched fuel shall be in accordance with 7.1.16.

For NFPA Task Group Use Only

Public Input No. 97-NFPA 2-2023 [Section No. 18.1.2]

18.1.2

This chapter ~~does not~~ shall apply to buildings and structures used for service and repair operations in connection ~~with self-propelled vehicles that store~~ with vehicles in which LH_2 ~~onboard~~ is used .

Statement of Problem and Substantiation for Public Input

The intent is to update NFPA 2 to include vehicles with liquid hydrogen storage systems to repair garages. Commercial vehicles, including heavy duty trucks, will include liquid hydrogen storage systems and the codes need to evolve and include this to support technology advancement and local permitting of projects to ensure safe operation.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 98-NFPA 2-2023 [Section No. 18.2.3]	Additional related update
Public Input No. 99-NFPA 2-2023 [Section No. 18.2.1]	
Public Input No. 100-NFPA 2-2023 [Section No. 18.2.2]	
Public Input No. 101-NFPA 2-2023 [Section No. 18.2.5.1.2]	
Public Input No. 102-NFPA 2-2023 [Section No. 18.2.5.1.3]	
Public Input No. 103-NFPA 2-2023 [New Section after 18.3.2.10]	
Public Input No. 104-NFPA 2-2023 [Section No. 18.3.7.2]	

Submitter Information Verification

Submitter Full Name: Kevin Slusser
Organization: Daimler Truck North America
Street Address:
City:
State:
Zip:
Submittal Date: Mon Dec 11 14:24:41 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The scope of the chapter is compressed gas with gaseous hydrogen and changing the scope of the chapter to add liquid requires further justification and technical substantiation in the context of the chapter.

Public Input No. 99-NFPA 2-2023 [Section No. 18.2.1]

18.2.1

This chapter shall apply to service and repair operations in connection with self-propelled vehicles powered by GH_2 and LH_2.

Statement of Problem and Substantiation for Public Input

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 98-NFPA 2-2023 [Section No. 18.2.3]	
Public Input No. 97-NFPA 2-2023 [Section No. 18.1.2]	
Public Input No. 100-NFPA 2-2023 [Section No. 18.2.2]	
Public Input No. 101-NFPA 2-2023 [Section No. 18.2.5.1.2]	
Public Input No. 102-NFPA 2-2023 [Section No. 18.2.5.1.3]	
Public Input No. 103-NFPA 2-2023 [New Section after 18.3.2.10]	
Public Input No. 104-NFPA 2-2023 [Section No. 18.3.7.2]	

Submitter Information Verification

Submitter Full Name: Kevin Slusser
Organization: Daimler Truck North America
Street Address:
City:
State:
Zip:
Submittal Date: Mon Dec 11 14:44:15 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The scope of the chapter is compressed gas with gaseous hydrogen and changing the scope of the chapter to add liquid requires further justification and technical substantiation in the context of the chapter.

Public Input No. 100-NFPA 2-2023 [Section No. 18.2.2]

18.2.2

The storage, use, and handling of GH_2 in any quantity shall comply with the requirements of Chapters 1 and 4 and the applicable requirements of Chapters 5 through 7.

The storage, use, and handling of LH_2 in any quantity shall comply with the requirements of Chapters 1 and 4 and the applicable requirements of Chapters 5, 6 and 8.

Statement of Problem and Substantiation for Public Input

The intent is to update NFPA 2 to include vehicles with liquid hydrogen storage systems to repair garages. Commercial vehicles, including heavy duty trucks, will include liquid hydrogen storage systems and the codes need to evolve and include this to support technology advancement and local permitting of projects to ensure safe operation.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 97-NFPA 2-2023 [Section No. 18.1.2]	
Public Input No. 98-NFPA 2-2023 [Section No. 18.2.3]	
Public Input No. 99-NFPA 2-2023 [Section No. 18.2.1]	
Public Input No. 101-NFPA 2-2023 [Section No. 18.2.5.1.2]	
Public Input No. 102-NFPA 2-2023 [Section No. 18.2.5.1.3]	
Public Input No. 103-NFPA 2-2023 [New Section after 18.3.2.10]	
Public Input No. 104-NFPA 2-2023 [Section No. 18.3.7.2]	

Submitter Information Verification

Submitter Full Name: Kevin Slusser
Organization: Daimler Truck North America
Street Address:
City:
State:
Zip:
Submittal Date: Mon Dec 11 14:45:49 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The scope of the chapter is compressed gas with gaseous hydrogen and changing the scope of the chapter to add liquid requires further justification and technical substantiation in the context of the chapter.

Public Input No. 98-NFPA 2-2023 [Section No. 18.2.3]

18.2.3

Dispensing of GH_2 shall comply with Chapter 10.

Dispensing of LH_2 shall comply with Chapter 11.

Statement of Problem and Substantiation for Public Input

The current version of this code does not include liquid hydrogen fueled vehicles. Commercial vehicles, including heavy duty trucks, are beginning to use liquid hydrogen storage systems and will require addition to this code to support safe deployment of the technology and enable local permitting for use.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 97-NFPA 2-2023 [Section No. 18.1.2]	
Public Input No. 99-NFPA 2-2023 [Section No. 18.2.1]	
Public Input No. 100-NFPA 2-2023 [Section No. 18.2.2]	
Public Input No. 101-NFPA 2-2023 [Section No. 18.2.5.1.2]	
Public Input No. 102-NFPA 2-2023 [Section No. 18.2.5.1.3]	
Public Input No. 103-NFPA 2-2023 [New Section after 18.3.2.10]	
Public Input No. 104-NFPA 2-2023 [Section No. 18.3.7.2]	

Submitter Information Verification

Submitter Full Name: Kevin Slusser
Organization: Daimler Truck North America
Street Address:
City:
State:
Zip:
Submittal Date: Mon Dec 11 14:35:16 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The scope of the chapter is compressed gas with gaseous hydrogen and changing the scope of the chapter to add liquid requires further justification and technical substantiation in the context of the chapter.

Public Input No. 101-NFPA 2-2023 [Section No. 18.2.5.1.2]

18.2.5.1.2

Repairs that would be required to be performed in a major repair garage shall be permitted to be performed in a minor repair garage if the vehicle is defueled in accordance with 18.3.2 to less than 400 scf (11.4 Nm^3) ~~and~~ if GH_2 or 39.7 gal (150 L) if LH_2 and the fuel supply container is sealed and not damaged.

Statement of Problem and Substantiation for Public Input

The intent is to update NFPA 2 to include vehicles with liquid hydrogen storage systems to repair garages. Commercial vehicles, including heavy duty trucks, will include liquid hydrogen storage systems and the codes need to evolve and include this to support technology advancement and local permitting of projects to ensure safe operation.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 97-NFPA 2-2023 [Section No. 18.1.2]	
Public Input No. 98-NFPA 2-2023 [Section No. 18.2.3]	
Public Input No. 99-NFPA 2-2023 [Section No. 18.2.1]	
Public Input No. 100-NFPA 2-2023 [Section No. 18.2.2]	
Public Input No. 102-NFPA 2-2023 [Section No. 18.2.5.1.3]	
Public Input No. 103-NFPA 2-2023 [New Section after 18.3.2.10]	
Public Input No. 104-NFPA 2-2023 [Section No. 18.3.7.2]	

Submitter Information Verification

Submitter Full Name: Kevin Slusser
Organization: Daimler Truck North America
Street Address:
City:
State:
Zip:
Submittal Date: Mon Dec 11 14:48:24 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The scope of the chapter is compressed gas with gaseous hydrogen and changing the scope of the chapter to add liquid requires further justification and technical substantiation in the context of the chapter.

Public Input No. 167-NFPA 2-2023 [Section No. 18.2.5.1.2]

18.2.5.1.2

Repairs that would be required to be performed in a major repair garage shall be permitted to be performed in a minor repair garage if the vehicle is defueled in accordance with 18.3.2 to less than ~~400 scf~~ 1000 scf (~~11~~ 28 ~~.4 Nm~~ 5 Nm ^{3}) and the fuel supply container is sealed and not damaged.

Statement of Problem and Substantiation for Public Input

The medium-/heavy-duty vehicles can contain over 40,000 scf of hydrogen in much larger fuel supply containers. The original volume of 400 scf could lead to low pressures in the container which could damage the liner or allow air to leak. The increase to less than1000 scf allows for increased pressure in the system. Although fuel supply containers are not considered part of the maximum allowable quantity, for reference the MAQ for flammable gases is 1000 scf.

This public input is submitted on behalf of the NFPA2 Fueling Task Group.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 168-NFPA 2-2023 [New Section after A.18.3.2.6]	Annex Material
Public Input No. 168-NFPA 2-2023 [New Section after A.18.3.2.6]	

Submitter Information Verification

Submitter Full Name: Spencer Quong
Organization: Quong & Associates Inc.
Affiliation: Toyota
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 21 17:44:32 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The proposed increase would allow major repairs in a minor garage without requiring a major repair garage and its related safety features, and there is no current justification to allow this increase. This would also need to be correlated with the relevant fire codes.

Public Input No. 102-NFPA 2-2023 [Section No. 18.2.5.1.3]

18.2.5.1.3

Movement of the fuel supply container or a subassembly upon which the fuel supply container remains mounted to allow access to other parts of the vehicle that are not a portion of the fuel system shall be permitted to be performed in a minor repair garage if it is defueled to less than 400 scf (11.4Nm^3) if GH_2 or 39.7 gal (150 L) if LH_2 and the fuel supply container is sealed and not damaged.

Statement of Problem and Substantiation for Public Input

The intent is to update NFPA 2 to include vehicles with liquid hydrogen storage systems to repair garages. Commercial vehicles, including heavy duty trucks, will include liquid hydrogen storage systems and the codes need to evolve and include this to support technology advancement and local permitting of projects to ensure safe operation.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 97-NFPA 2-2023 [Section No. 18.1.2]	
Public Input No. 98-NFPA 2-2023 [Section No. 18.2.3]	
Public Input No. 99-NFPA 2-2023 [Section No. 18.2.1]	
Public Input No. 100-NFPA 2-2023 [Section No. 18.2.2]	
Public Input No. 101-NFPA 2-2023 [Section No. 18.2.5.1.2]	
Public Input No. 103-NFPA 2-2023 [New Section after 18.3.2.10]	
Public Input No. 104-NFPA 2-2023 [Section No. 18.3.7.2]	

Submitter Information Verification

Submitter Full Name: Kevin Slusser
Organization: Daimler Truck North America
Street Address:
City:
State:
Zip:
Submittal Date: Mon Dec 11 14:50:37 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The scope of the chapter is compressed gas with gaseous hydrogen and changing the scope of the chapter to add liquid requires further justification and technical substantiation in the context of the chapter.

Public Input No. 103-NFPA 2-2023 [New Section after 18.3.2.10]

TITLE OF NEW CONTENT

18.3.2.10.1 Boil off venting from LH 2 storage tanks shall be either catalytically oxidized prior to release into the repair garage by vehicular on-board system or the vehicle vent pipe(s) shall be connected to repair garage vent pipe(s) according to 6.17.

Boil off venting systems used for LH 2 vehicles according to 6.17 shall include provisions to prevent backflow of hydrogen vapors out of unused vents back into the repair garage.

Statement of Problem and Substantiation for Public Input

The intent is to update NFPA 2 to include vehicles with liquid hydrogen storage systems to repair garages. Commercial vehicles, including heavy duty trucks, will include liquid hydrogen storage systems and the codes need to evolve and include this to support technology advancement and local permitting of projects to ensure safe operation.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 97-NFPA 2-2023 [Section No. 18.1.2]	
Public Input No. 98-NFPA 2-2023 [Section No. 18.2.3]	
Public Input No. 99-NFPA 2-2023 [Section No. 18.2.1]	
Public Input No. 100-NFPA 2-2023 [Section No. 18.2.2]	
Public Input No. 101-NFPA 2-2023 [Section No. 18.2.5.1.2]	
Public Input No. 102-NFPA 2-2023 [Section No. 18.2.5.1.3]	
Public Input No. 104-NFPA 2-2023 [Section No. 18.3.7.2]	

Submitter Information Verification

Submitter Full Name: Kevin Slusser
Organization: Daimler Truck North America
Street Address:
City:
State:
Zip:
Submittal Date: Mon Dec 11 14:53:17 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The scope of the chapter is compressed gas with gaseous hydrogen and changing the scope of the chapter to add liquid requires further justification and technical substantiation in the context of the chapter.

Public Input No. 208-NFPA 2-2023 [Section No. 18.3.5.1]

~~18.3.5.1~~ –

~~Where approved by the AHJ, natural ventilation shall be allowed in lieu of a mechanical exhaust ventilation system.~~

Statement of Problem and Substantiation for Public Input

Substantiation: This section is not needed. 18.3.5.2 already points to section 6.18 which is all that is needed. Pointing to 6.18 is better because as 6.18 evolves the need to locate and update repeated requirements like this is avoided.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 16:09:07 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: Natural ventilation is adequate for some applications. For example, repair facilities with a roof or a canopy with limited walls, that are effectively outdoors, where natural ventilation is adequate.

Public Input No. 104-NFPA 2-2023 [Section No. 18.3.7.2]

18.3.7.2

Except as otherwise provided by this code, the storage and handling of hydrogen shall be in accordance with Chapters 6 ~~and 7~~ through 8 .

Statement of Problem and Substantiation for Public Input

The intent is to update NFPA 2 to include vehicles with liquid hydrogen storage systems to repair garages. Commercial vehicles, including heavy duty trucks, will include liquid hydrogen storage systems and the codes need to evolve and include this to support technology advancement and local permitting of projects to ensure safe operation.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 97-NFPA 2-2023 [Section No. 18.1.2]	
Public Input No. 98-NFPA 2-2023 [Section No. 18.2.3]	
Public Input No. 99-NFPA 2-2023 [Section No. 18.2.1]	
Public Input No. 100-NFPA 2-2023 [Section No. 18.2.2]	
Public Input No. 101-NFPA 2-2023 [Section No. 18.2.5.1.2]	
Public Input No. 102-NFPA 2-2023 [Section No. 18.2.5.1.3]	
Public Input No. 103-NFPA 2-2023 [New Section after 18.3.2.10]	

Submitter Information Verification

Submitter Full Name: Kevin Slusser
Organization: Daimler Truck North America
Street Address:
City:
State:
Zip:
Submittal Date: Mon Dec 11 14:56:19 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The scope of the chapter is compressed gas with gaseous hydrogen and changing the scope of the chapter to add liquid requires further justification and technical substantiation in the context of the chapter.

Public Input No. 204-NFPA 2-2023 [Section No. 19.3.1]

19.3.1

Indoor ~~occupancy~~ use for ~~HPIT usage~~ HPITs shall ~~including~~ include parking.

Statement of Problem and Substantiation for Public Input

Substantiation: The term occupancy is confusing as used here and could refer to occupancy classifications defined by the building code with an allowable use. Parking is an allowable use and the proposed text makes that more clear. The typical occupancy where HPITs are used is Storage but could also include others such a Factory/Industrial.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 15:57:58 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-175-NFPA 2-2024
Statement: The term occupancy is confusing as previously used here and could refer to occupancy classifications defined by the building code with an allowable use. Parking is an allowable use and the proposed text makes that more clear. The typical occupancy where HPITs are used is Storage but could also include others such a Factory/Industrial.

Public Input No. 205-NFPA 2-2023 [New Section after 19.3.2]

(new section) 19.3.3. Hydrogen in a fuel supply container or power module of an HPIT shall be included in the building MAQ when removed from the HPIT . ..

Statement of Problem and Substantiation for Public Input

Substantiation: This clarifies the code intent and prevents abuse which could lead to large fires.
The IFC has long exempted the fuel used in forklifts used indoors from MAQ tallying. But the exemption only applies when the fuel container is installed on the forklift. For example, the fuel in a removable propane tank on a propane powered forklift is exempt from MAQ when the propane tank is installed on a forklift but not when it is removed. Propane fuel tanks are included in the MAQ when they are not installed on the forklift. Since this is mostly unworkable for most warehouses, full or empty propane tanks are usually stored outdoors. The propane tanks are protected from collision damage when installed on a forklift and are unlikely to be stacked vertically. Nobody stacks forklifts and it is not worth talking about.

This same concept needs to extend to HPITs in NFPA 2. When the hydrogen fuel is installed in the HPIT, there is collision protection offered by the HPIT itself such that most impacts would not involve the hydrogen fuel tank directly. Similarly, a fire involving an HPIT is possible (just like with a propane forklift, but the likelihood of than fire involving the fuel of more than one HPIT is remote. An acceptable risk, just like propone units.
One difference is that HPITs commonly have power modules with an integral hydrogen storage tank and fuel cell power supply. These modules can be removed from an HPIT relatively easily. Perhaps to perform repairs or swap a defective module for a replacement. When removed from the HPIT, the collision protection offered by the HPIT itself does not apply. In addition, these modules are commonly stored on pallets for relocation and handling. MAQ limitations need to apply to these modules when they are not inserted into an HPIT similar to how propane cylinders are handled. If the power modules are stacked for storage, such as in a rack, the vertical orientation can lead to a massive vertically propagating fire due to combustibles in the power module causing heating of the hydrogen tank and its eventual release. Loose HPIT power modules with integral hydrogen containers could cause a propagating fire and should not be exempt from MAQ considerations.

Applying MAQ requirements assures that this flammable gas hazard is properly addressed.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 16:00:16 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-204-NFPA 2-2024

Statement: Other fire code documents (such as the IFC) exempt the fuel used in forklifts, used indoors, from MAQ tallying. However, the exemption only applies when the fuel container is installed on the forklift. For example, the fuel in a removable propane tank on a propane powered forklift is exempt from MAQ when the propane tank is installed on a forklift but not when it is removed. Propane fuel tanks are included in the MAQ when they are not installed on the forklift. Since this is mostly unworkable for most warehouses, full or empty propane tanks are usually stored outdoors. The propane tanks are protected from collision damage when installed on a forklift and are unlikely to be stacked vertically.

When the hydrogen fuel is installed in the HPIT, there is collision protection offered by the HPIT itself such that most impacts would not involve the hydrogen fuel tank directly. Similarly, a fire involving an HPIT is possible (just like with a propane forklift) but the likelihood of the fire involving the fuel of more than one HPIT is remote.

One difference is that HPITs commonly have power modules with an integral hydrogen storage tank and fuel cell power supply. These modules can be removed from an HPIT relatively easily. When removed from the HPIT, the collision protection offered by the HPIT itself does not apply. In addition, these modules are commonly stored on pallets for relocation and handling. MAQ limitations should apply to these modules when they are not inserted into an HPIT similar to how propane cylinders are handled. If the power modules are stacked for storage, such as in a rack, the vertical orientation can lead to a massive vertically propagating fire due to combustibles in the power module causing heating of the hydrogen tank and its eventual release. Loose HPIT power modules with integral hydrogen containers could cause a propagating fire and should not be exempt from MAQ considerations.

Applying MAQ requirements assures that this flammable gas hazard is properly addressed.

Public Input No. 206-NFPA 2-2023 [Section No. 19.5]

19.5 Maintenance, Service, and Repairs.

Maintenance, service, and repairs of HPITS shall be performed in facilities that comply with Section 18.~~5~~ 6 .

Statement of Problem and Substantiation for Public Input

Point to the correct section number.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 16:03:49 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-205-NFPA 2-2024
Statement: This revision corrects a cross-reference to the correct section number.

Public Input No. 106-NFPA 2-2023 [Section No. A.3.3.51.2]

A.3.3.51.2 Explosion Control.

Explosion control is provided to prevent formation of flammable mixtures, prevent ignition, protect against deflagration, and prevent detonation conditions from developing when there is the potential to exceed 1 percent hydrogen concentration in enclosures.

NFPA 69 provides guidance on the use of suppression, ventilation systems, and the limiting of oxidants as a means to prevent the occurrence of an explosion.

NFPA 68 provides guidance on the use of deflagration venting systems in buildings and other enclosures. The primary purpose of a venting system is to relieve the overpressure produced in an explosion to limit the potential damage to the building where the explosion occurs. Although some structural damage can be anticipated, the use of relief venting is expected to prevent massive building failure and collapse. In cases where detonation is probable, venting is often used in conjunction with barricade construction where the pressure-resistant portions of the building have been constructed to resist the pressures anticipated should an explosive event occur. Design of barricade systems is highly specialized and the subject of military standards applicable to the subject. ~~NFPA 69 provides guidance on the use of suppression, ventilation systems, and the limiting of oxidants as a means to prevent the occurrence of an explosion.~~ When relief vents are to be used as a means to provide explosion relief, the fundamental requirements of the adopted building code for structural elements, including snow, wind, and seismic events, should be considered. In some instances, the requirements for wind resistance can impose more rigorous requirements on the relief vents than required by the engineering analysis used to determine the relief pressure. In such cases, users must demonstrate that the relief vents will not become airborne or release in such a manner as to create secondary hazards within or external to the building in which they are installed. Specific designs might require approval by the AHJ.

Statement of Problem and Substantiation for Public Input

The explosion control task group added the new first line and moved mention of NFPA 69 ahead of all discussion of NFPA 68

the chapter 9 submission (PCxxx) will include this content a A.9.1

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 169-NFPA 2-2023 [Section No. 3.3.81]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control TG
Street Address:
City:
State:
Zip:

Submittal Date: Wed Dec 13 13:58:03 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-28-NFPA 2-2024

Statement: The sentence pointing to NFPA 69 is moved to the beginning of the annex material to to clarify the intent of prevention first and protection as a secondary layer . Further annex material has been added to explain the hazards explosion control is protecting against. The definition is moving out from under control to be listed alphabetically.

Public Input No. 215-NFPA 2-2023 [Section No. A.3.3.51.2]

~~**A.3.3.51.2** – Explosion Control. –~~

~~NFPA 68 provides guidance on the use of deflagration venting systems in buildings and other enclosures. The primary purpose of a venting system is to relieve the overpressure produced in an explosion to limit the potential damage to the building where the explosion occurs. Although some structural damage can be anticipated, the use of relief venting is expected to prevent massive building failure and collapse. In cases where detonation is probable, venting is often used in conjunction with barricade construction where the pressure-resistant portions of the building have been constructed to resist the pressures anticipated should an explosive event occur. Design of barricade systems is highly specialized and the subject of military standards applicable to the subject. NFPA 69 provides guidance on the use of suppression, ventilation systems, and the limiting of oxidants as a means to prevent the occurrence of an explosion. When relief vents are to be used as a means to provide explosion relief, the fundamental requirements of the adopted building code for structural elements, including snow, wind, and seismic events, should be considered. In some instances, the requirements for wind resistance can impose more rigorous requirements on the relief vents than required by the engineering analysis used to determine the relief pressure. In such cases, users must demonstrate that the relief vents will not become airborne or release in such a manner as to create secondary hazards within or external to the building in which they are installed. Specific designs might require approval by the AHJ.~~

Statement of Problem and Substantiation for Public Input

remove this annex note from the "old" location

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 107-NFPA 2-2023 [Section No. 3.3.51.2]	revise definition
Public Input No. 169-NFPA 2-2023 [Section No. 3.3.81]	move new definition
Public Input No. 170-NFPA 2-2023 [Section No. 3.3.51.2]	point 3.3.51.2 to 3.3.81
Public Input No. 169-NFPA 2-2023 [Section No. 3.3.81]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 27 14:00:51 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-28-NFPA 2-2024

Statement: The sentence pointing to NFPA 69 is moved to the beginning of the annex material to to clarify the intent of prevention first and protection as a secondary layer . Further annex material has been added to explain the hazards explosion control is protecting against. The definition is moving out from under control to be listed alphabetically.

Public Input No. 64-NFPA 2-2023 [New Section after A.3.3.64]

TITLE OF NEW CONTENT

A.3.3.69. Emergency Shutdown Device (ESD).

Emergency Shutdown Devices (ESDs) may be any of the following devices that will "trip" the Emergency Shutdown System (ESS) to shut down the system into a safe mode:

1. A manually operated red pushbutton switch with a yellow background in compliance with NFPA-79,

2. A low pressure switch measuring hydrogen compressor suction pressure,

3. An UV/IR or hydrogen detector,

4. Or any other safety related input device that has a switch for electrical conductivity of signal or other means of connection to the ESS.

Most hydrogen Fueling station modules will include a separate ESS to stop the process of the module (production, compression, dispensing) in the event of an ESS activation.

Each hydrogen fueling station site will typically have all operating modules connected to a site-wide Emergency Shutdown System.

Statement of Problem and Substantiation for Public Input

The confusing use of the terms ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV. The harmonized definitions are show below:
Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.
Emergency Shutoff Valve (ESV)* -- A designated valve designed to shut off the flow of fluid in the event of an emergency

This is one of a series of leftover PCs that came out of the previous cycle HEE TG that were too late for the first draft

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 57-NFPA 2-2023 [Section No. 3.3.69]	
Public Input No. 58-NFPA 2-2023 [Sections 3.3.69, 3.3.70]	
Public Input No. 59-NFPA 2-2023 [New Section after 3.3.69]	
Public Input No. 60-NFPA 2-2023 [Section No. 3.3.63.1]	
Public Input No. 61-NFPA 2-2023 [Section No. 3.3.252]	
Public Input No. 62-NFPA 2-2023 [Section No. 8.3.1.2.8.3]	
Public Input No. 63-NFPA 2-2023 [Section No. 8.3.1.2.9]	

Submitter Information Verification

Submitter Full Name:	Robert Boyd
Organization:	Boyd Hydrogen LLC
Affiliation:	This is one of a series of leftover PCs that came out of the previous cycle HEE TG that were too late for the first draft
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Mon Oct 23 14:33:27 EDT 2023
Committee:	HYD-AAA

Committee Statement

Resolution: FR-94-NFPA 2-2024

Statement: This revision harmonizes the use of these terms with what is defined in CSA-HGV-4.1 Hydrogen Dispensers, and CSA-HGV-4.9 Hydrogen Fueling Stations.

Public Input No. 87-NFPA 2-2023 [New Section after A.3.3.64]

TITLE OF NEW CONTENT

A.3.3.69. Emergency Shutdown Devices (ESDs)

Emergency Shutdown Devices (ESDs) may be any of the following devices that will “trip” the Emergency Shutdown System (ESS) to shut down the system into a safe mode:

1. A manually operated Red push button switch with a yellow background in compliance with NFPA-79,

2. A low pressure switch measuring hydrogen compressor suction pressure,

3. An UV/IR or hydrogen detector

4. Any other safety related input device that has a switch for electrical conductivity of signal or other means of connection to the ESS.

Most hydrogen Fueling station modules will include a separate ESS to stop the process of the module (production, compression, dispensing) in the event of an ESS activation.

Each hydrogen fueling station site will typically have all operating modules connected to a site-wide Emergency Shutdown System.

Additional Proposed Changes

File Name	Description	Approved
PC_No._87_Rejected_but_Held.pdf	NFPA 2 PC No. 87 Rejected but held	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as "Rejected but Held" in Public Comment No. 87 of A2022 Second Draft Report for NFPA 2 and per Regs. at 4.4.8.3.1 and needs to be reconsidered by the TC for the next edition of the document.

PI-230 proposed changing the location of the ESD on an HEE and the HEE task group has proposed a revised requirement.

In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this is on of a series of public comments that will provide consistency in the definitions and use of the terms ESS an ESD trough out the document.

This proposal also harmonizes the use of these term in CSA-HGV-4.1 and CSA-HGV-4.6.

Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Submitter Information Verification

Submitter Full Name:
Organization: Holds
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 06 09:38:17 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-94-NFPA 2-2024

Statement: This revision harmonizes the use of these terms with what is defined in CSA-HGV-4.1 Hydrogen Dispensers, and CSA-HGV-4.9 Hydrogen Fueling Stations.

Public Comment No. 87-NFPA 2-2021 [New Section after A.3.3.64]

A.3.3.69. Emergency Shutdown Devices (ESDs)

Emergency Shutdown Devices (ESDs) may be any of the following devices that will “trip” the Emergency Shutdown System (ESS) to shut down the system into a safe mode:

1. A manually operated Red pushbutton switch with a yellow background in compliance with NFPA-79,

2. A low pressure switch measuring hydrogen compressor suction pressure,

3. An UV/IR or hydrogen detector

4. Any other safety related input device that has a switch for electrical conductivity of signal or other means of connection to the ESS.

Most hydrogen Fueling station modules will include a separate ESS to stop the process of the module (production, compression, dispensing) in the event of an ESS activation.

Each hydrogen fueling station site will typically have all operating modules connected to a site-wide Emergency Shutdown System.

Additional Proposed Changes

File Name	Description	Approved
ESD-ESS_-_Rev5.pdf	Clarification of ESS and ESD and definition of ESS in NFPA-2	

Statement of Problem and Substantiation for Public Comment

PI-230 proposed changing the location of the ESD on an HEE and the HEE task group has proposed a revised requirement.

In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this is on of a series of public comments that will provide consistency in the definitions and use of the terms ESS an ESD trough out the document.

This proposal also harmonizes the use of these term in CSA-HGV-4.1 and CSA-HGV-4.6.

Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Related Item

• PI-230

Submitter Information Verification

Submitter Full Name: Robert Boyd

Organization: Boyd Hydrogen LLC

Affiliation:	This proposal was developed during parallel discussions by members of the NFPA-2-HEE Task Group
Street Address:	
City:	
State:	
Zip:	
Submittal Date:	Wed Jun 02 19:07:08 EDT 2021
Committee:	HYD-AAA

Committee Statement

Committee Action:	Rejected but held
Resolution:	The proposed revisions were not discussed during the First Draft meeting and are considered to be new material which cannot be acted upon at the Second Draft meeting.

Clarification of ESS and ESD and definition of ESS in NFPA-2

PI-230 proposed changing the location of the ESD on an HEE and the HEE task force will be proposing a revised requirement. In the review of NFPA-2 we found inconsistency with the use of ESD and ESS and this series of public comments will provide consistency in the definitions and use of the terms ESS an ESD trough out the document. This series of Public Comments also harmonizes the use of these terms with what is defined in CSA-HGV-4.1 *Hydrogen Dispensers,* and CSA-HGV-4.9 *Hydrogen Fueling Stations*

This document supports public comments: PC-79 , PC-80, PC-81, PC-82, PC-83, PC-84, PC-87 and PC-90

Problem Statement

The confusing use of the term ESD and ESD system (Emergency Shutdown System ESS) can be clarified by defining ESS and ESD clearly. Emergency response and safety is paramount, and it is good practice to have all of these definitions together in 3.3.69 ESD , 3.3.70 ESS and 3.3.71 ESV.

The harmonized definitions are show below:

Emergency shutdown device (ESD)* — a device that activates the emergency shutdown system (ESS).
Emergency shutdown system (ESS)* — the system that responds to ESD activation.

Annex notes (new)

A.3.3.69. Emergency Shutdown Device (ESD).

Emergency Shutdown Devices (ESDs) may be any of the following devices that will "trip" the Emergency Shutdown System (ESS) to shut down the system into a safe mode:

1. A manually operated red pushbutton switch with a yellow background in compliance with NFPA-79,
2. A low pressure switch measuring hydrogen compressor suction pressure,
3. An UV/IR or hydrogen detector,
4. Or any other safety related input device that has a switch for electrical conductivity of signal or other means of connection to the ESS.

Most hydrogen Fueling station modules will include a separate ESS to stop the process of the module (production, compression, dispensing) in the event of an ESS activation.

Each hydrogen fueling station site will typically have all operating modules connected to a site-wide Emergency Shutdown System.

Emergency Shutdown System (ESS): The ESS responds to any activation of an ESD and shuts down the system safely.

Actions to take in NFPA-2

- Delete 3.3.63.1 (ESD definition, extract from NFPA 52)
- Modify 3.3.69 (ESD- use definition from ANSI/CSA HGV 4.1)

- Add new section after 3.3.69 (ESS-use definition from ANSI/CSA HGV 4.1) – this will go between ESD and Emergency Shutoff Valve
- Modify 3.3.70 Emergency Shutoff Valve drop link to see 3.3.250.1 and adopt current language: A designated valve designed to shut off the flow of liquids or gases

The following shows how the use of ESD and ESS need to be cleaned up and how important it is to define ESS

- 8.3.1.2.8.3 – propose to change "ESD" to "ESS" and "ESD system" change to "ESS"
  - Proposed language: "When an emergency shutdown is required, activation of the ESS shall shut down operation of all pumps and compressors. 55:11.2.8.3
- 8.3.1.2.9- propose to add acronym (ESS)
- 8.3.1.2.9.2- propose to change "system" to "device:
  - Proposed language: "An emergency shutdown device (ESD) shall be provided at the bulk source to stop the flow of liquid and gas into the use line when actuated."
- 8.3.2.1.9.4- Proposed language: "Reactivation of the ESS after activation shall require that the ESS be manually reset."
-
- 8.3.1.2.9.5- Proposed language: "The ESD manual activation shall be identified by means of a sign."
- 11.3.1.8: change "(ESD)" to "(ESS)". Revise language

This proposal was developed during parallel discussions by members of the NFPA-2-HEE Task Group

The following change was developed after a further review of NFPA-2 first draft are shown below:

8.3.1.2.8.3 Emergency Shutdown System Operation.
When an emergency shutdown (ESD) is required, activation of the **Emergency Shutdown System (ESS)** ~~**ESD** system~~ shall shut down operation of all pumps and compressors. [~~**55:**11.2.8.3~~]

Public Input No. 11-NFPA 2-2023 [Section No. A.3.3.106.6]

A.3.3.106.6 Inert Gas.

Inert gases do not react readily with other materials under normal temperatures and pressures. For example, nitrogen combines with some of the more active metals such as lithium and magnesium to form nitrides, and at high temperatures it will also combine with hydrogen, oxygen, and other elements. The gases neon, krypton, and xenon are considered rare due to their scarcity. Although these gases are commonly referred to as inert gases, the formation of compounds is possible. For example, xenon combines with fluorine, to form various fluorides and with oxygen to form oxides; the compounds formed are crystalline solids. Radon is inert under the definition provided, but because it is radioactive, it is not considered inert for the purposes of ~~NFPA 55~~ NFPA 2 .

Statement of Problem and Substantiation for Public Input

This material was originally extracted from NFPA 55 but now is resident in NFPA 2, so the reference to NFPA 55 is no longer needed.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Affiliation: NFPA 2/55 hydrogen alignment task group
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 24 14:09:13 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-8-NFPA 2-2024

Statement: The scope of NFPA 2 has been revised to contain all requirements for hydrogen storage, use, and handling. The scope of NFPA 55 has been revised so that it no longer contains requirements for hydrogen storage, use, and handling. The section was originally extracted into NFPA 2 from NFPA 55. NFPA 2 has removed the extract tags so that the language is resident in NFPA 2. The section now applies to NFPA 2 and not to NFPA 55 in this code (NFPA 2), and so the reference has been changed to NFPA 2.

Public Input No. 226-NFPA 2-2024 [New Section after A.3.3.120.2]

TITLE OF NEW CONTENT

A.3.3.X The 25% threshold is based on the minimum public domain guidance (NFPA, IEC, etc.) regarding a hydrogen content in Natural Gas where the flammability properties of the mixture are considered the same as natural gas. The upper limit for a Hydrogen Enriched Fuel is 95% []. **(37:** 3.3.10 **)**

Statement of Problem and Substantiation for Public Input

Various combustion process equipment is being shifted from natural gas to blends of natural gas and hydrogen as part of the global shift to hydrogen fuel. These blends range from 5% to 95% plus hydrogen. The most common blend seen to date is 20% hydrogen enriched pipeline natural gas blend in Europe; however, mixing systems have been proposed to increase the use of hydrogen in the near future. This led directly to the formation of the Chapter 14 Task group to capture the known industrial processes on this path and provide the appropriate guidance within the chapter.

Guidance regarding the hazardous area classification of hydrogen mixtures have indicated those greater than 25% (IEC) or 30% (NFPA) are considered as “hydrogen” for the selection of electrical equipment. It is from that basis that the Task Group agreed to use 25% as the limit hydrogen concentration for inclusion of such mixtures in NFPA 2.

To properly separate these mixtures from the original 95% or greater hydrogen content defined in the original NFPA 2 scope an additional definition that recognizes these mixtures as used in Chapter 14 is essential. For clarity, this discussion was taken on by an NFPA 37 Task Group that developed the definition of “Hydrogen Enriched Fuel” for the 2024 edition and that definition is being proposed for NFPA 2 to ensure consistency.

This PI is submitted by Lawrence Danner, CSP on behalf of the Chapter 14 Task Group.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 221-NFPA 2-2024 [Section No. 1.3.3]	
Public Input No. 222-NFPA 2-2024 [New Section after 3.3.121]	
Public Input No. 223-NFPA 2-2024 [New Section after 3.3.215]	
Public Input No. 224-NFPA 2-2024 [Chapter 14]	
Public Input No. 225-NFPA 2-2024 [Sections A.14.1.1, A.14.3.1.2, A.14.3.1.2.1, A.14.3.1.2.2, ...]	

Submitter Information Verification

Submitter Full Name: Larry Danner
Organization: GE Power
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jan 02 12:01:42 EST 2024

Committee: HYD-AAA

Committee Statement

Resolution: CI-131-NFPA 2-2024

Statement: The industrial applications defined in the Chapter 14 rewrite will be using GH2 – fuel gas mixtures that, within the scope of the chapter, will have a GH2 content of greater than 25% by volume. A specific term for such mixtures was published in the latest edition of NFPA 37 that is consistent with the PI 221 requirements and is proposed here for consistency and clear understanding of the intent as used in Chapter 14.

Public Input No. 13-NFPA 2-2023 [Section No. A.3.3.237.4]

~~**A.3.3.237.4** – Bulk Oxygen System. –~~

~~The bulk oxygen system terminates at the point where oxygen at service pressure first enters the supply line. The oxygen containers are either stationary or movable, and the oxygen is stored as a compressed gas or cryogenic fluid.~~

~~Bulk oxygen systems can be used to supply gas in either its compressed gaseous or liquefied form. Systems that may be used to supply both gaseous and liquid forms are referred to as hybrid systems. The following bulk oxygen systems are typical of those in use:~~

~~(1) When the primary supply of the gas as stored is from a compressed gaseous source that is used in the compressed and gaseous form, the bulk oxygen system is said to be a bulk compressed oxygen gas system.~~

~~(2) When the primary supply of the gas as stored is in a liquid form and the system is designed to transfer only liquid, the system is said to be a bulk liquefied oxygen system.~~

~~(3) When the primary supply of the gas as stored is in a liquid form and the system is designed to transfer or store the gas in a compressed gaseous form, with or without a feature that may also allow the subsequent transfer and use of liquid, the bulk oxygen system is said to be a hybrid bulk oxygen system. For the purposes of the application of the code, a hybrid system is viewed as a bulk liquefied oxygen system.~~

Statement of Problem and Substantiation for Public Input

The defined term is not used in the body or annex notes of NFPA 2.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Affiliation: NFPA 2/55 hydrogen alignment task group
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 24 14:19:13 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-7-NFPA 2-2024
Statement: The scope of NFPA 2 has been revised to contain all requirements for hydrogen storage, use, and handling. The scope of NFPA 55 has been revised so that it no longer contains requirements for hydrogen storage, use, and handling. With the removal of NFPA 55 extract tags from NFPA 2, the defined term is no longer used in the NFPA 2 body or annex notes.

Public Input No. 124-NFPA 2-2023 [Section No. A.6.5.1]

~~A.6.5.1~~ —

~~Any reference to listed or approved equipment in the noted sections of the IFGC is within the context of ASME B31.12, *Hydrogen Piping and Pipelines,* and describes a material or component that conforms to the specifications integral to ASME B31.12.~~

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.
If reference to IFGC is removed from 6.5.1 as proposed, this Annex A information is no longer applicable.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 122-NFPA 2-2023 [Section No. 6.5.1 [Excluding any Sub-Sections]]	This Annex A is explanatory information related to 6.5.1.
Public Input No. 122-NFPA 2-2023 [Section No. 6.5.1 [Excluding any Sub-Sections]]	

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13 TG
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 20:44:22 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-25-NFPA 2-2024

Statement: Piping systems for hydrogen systems should be designed and constructed to minimize the likelihood of a release (leak). Welded connections are generally considered the best way to achieve this, however, they are not always practical.

In addition, many types of hydrogen systems include piping for fluids other than hydrogen. For example, electrolyzer based hydrogen generators include piping for water and reformer-based hydrogen generators often include piping for natural gas.

The Code for Pressure Piping, ASME B31, addresses the design, fabrication, assembly, and testing of piping systems for all types of fluid including hydrogen. ASME B31.12, Hydrogen Piping and Pipelines, addresses piping system for hydrogen in particular.

ASME B31 has been used successfully in hydrogen systems for many decades. And, many product safety standards for hydrogen equipment such as CSA FC 1 for fuel cells and CSA/ANSI B22734 for electrolyzers refer specifically to ASME B31.

For the renumbered 6.5.1.2 is a contradiction between the International Fuel Gas Code (IFGC) and the American Society of Mechanical Engineers (ASME) B31 piping codes in the pressure testing requirements of hydrogen systems for high-pressure applications. The contradiction concerns the acceptable resultant hoop (circumferential) stress from a pneumatic or hydrostatic pressure test. The requirement in the IFGC is limiting and would require a lower test pressure and, in some cases, below the MAWP, where the B31 codes state that no test pressure reduction is required. B31 allows for testing up to the yield. For example, a 1" stainless steel tube has a wall thickness of 0.083". If they follow the IFGC Section 705, it limits the pressure test based on 50% of the hoop stress, resulting in a pressure test at 2507psig.

Meanwhile, the Barlow formula provided by B31 can establish an MAWP of 3100psig. ASME B31 would require a pressure test at 1.1xMAWP.

Public Input No. 194-NFPA 2-2023 [Section No. A.6.9]

~~A.6.9~~ —

~~Under the requirements of 29 CFR 1910.38 established by OSHA regulations, employers must establish an employee alarm system that complies with 29 CFR 1910.165. The requirements of 29 CFR 1910.165 for the employee alarm system include, but are not limited to, systems that are capable of being perceived above ambient noise or light levels by all employees in the affected portions of the workplace. Tactile devices can be used to alert those employees who would not otherwise be able to recognize the audible or visual alarm. The alarm system can be electrically powered or powered by pneumatic or other means. State, local, or other governmental regulations might also establish requirements for employee alarm systems.~~

Statement of Problem and Substantiation for Public Input

Substantiation: NFPA 2 is not an enforcement tool for OSHA and serves occupants and firefighters, not just employees, like OSHA does. OSHA does their own enforcement through a separate series of relatively static (compared to NFPA 2) series of federal laws. OSHA does not need NFPA 2 to serve its mission and vice-versa. NFPA 2 is a dynamic fire code document and needs to focus on hydrogen related fire safety requirements. An emergency alarm system as described in the proposed text, provides a needed fire safety alert to occupants and firefighters of a possible increased fire hazard in rooms containing greater then MAQ amounts of hydrogen. The existing reference to 4.6.1 is not needed. This aligns NFPA 2 with the IFC.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 193-NFPA 2-2023 [Section No. 6.9]	

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 15:09:56 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-142-NFPA 2-2024

Statement: NFPA 2 is not an enforcement tool for OSHA and serves all occupants and firefighters, not just employees, like OSHA does. OSHA does their own enforcement through a separate series of relatively static (compared to NFPA 2) series of federal laws. OSHA does not need NFPA 2 to serve its mission and vice-versa. NFPA 2 is a dynamic fire code document and needs to focus on hydrogen related fire safety requirements. An emergency alarm system as described in the proposed text, provides a needed fire safety alert to occupants and firefighters of a possible increased fire hazard in rooms

containing greater then MAQ amounts of hydrogen. The existing reference to 4.6.1 is not needed. This aligns NFPA 2 with the IFC.

Public Input No. 7-NFPA 2-2023 [Section No. A.6.10.3]

A.6.~~10~~ 11 .~~3~~ — 1 __

The intent of this section is to require a water-based fire extinguishing system to keep vessels containing compressed gases cool in the event of an exposure fire, thereby minimizing the likelihood of a release and associated consequences. Accordingly, alternative fire extinguishing systems, such as dry-chemical or gaseous agent systems, should not be substituted.

Statement of Problem and Substantiation for Public Input

This Annex A comment appears to reference the wrong section of the code.

Submitter Information Verification

Submitter Full Name: William Hoffman
Organization: Black and Veatch
Street Address:
City:
State:
Zip:
Submittal Date: Sat Jul 01 11:14:07 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-143-NFPA 2-2024
Statement: This Annex A section has been relocated to the correct requirement which discusses water-based fire protection systems.

Public Input No. 79-NFPA 2-2023 [New Section after A.7.1.22(9)(a)]

A. 7.1.22.10 HEE Ventilation

En g ineerin g assessment ma y be performed per IEC 60079-10-1, Explosive atmospheres - Part 10-1: Classification of Areas - Explosive Gas atmospheres, to utalize alternaitve ventilation methods.

Additional Proposed Changes

File Name	Description	Approved
PC_No._39_Rejected_but_Held.pdf	NFPA 2 PC No. 39 Rejected but Held	

Statement of Problem and Substantiation for Public Input

NOTE: This Public Input appeared as "Rejected but Held" in Public Comment No. 39 of A2022 Second Draft Report for NFPA 2 and per Regs. at 4.4.8.3.1 and needs to be reconsidered by the TC for the next edition of the document.

The proposed annex material would provide guidance to AHJ's and users of alternative means to meet the requirements in 7.1.22.10. using industry recognized standards such as IEC-60079-10-1. The annex material would also allow use of engineering assessment to apply alternative protection methods as allowed in Clause 1.5.

This topic was discussed in the HEE Task Group but did not have time to reach a final and consensus submission by the Task Group.

Submitter Information Verification

Submitter Full Name: Yiu Lee
Organization: holds@nfpa.org
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 05 14:25:18 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-156-NFPA 2-2024
Statement: The proposed annex material identifies guidance to AHJ's and users on how to assess alternative ventilation methods. The annex material identifies an engineering assessment for alternative protection methods that aligns with section 1.5.

Public Comment No. 39-NFPA 2-2021 [New Section after A.7.1.22.9.2]

A. 7.1.22.10 HEE Ventilation

Engineering assessment may be performed per IEC 60079-10-1, Explosive atmospheres - Part 10-1: Classification of Areas - Explosive Gas atmospheres, to utalize alternaitve ventilation methods.

Statement of Problem and Substantiation for Public Comment

The proposed annex material would provide guidance to AHJ's and users of alternative means to meet the requirements in 7.1.22.10. using industry recognized standards such as IEC-60079-10-1. The annex material would also allow use of engineering assessment to apply alternative protection methods as allowed in Clause 1.5.

This topic was discussed in the HEE Task Group but did not have time to reach a final and consensus submission by the Task Group.

Related Item

• Public Input No 256

Submitter Information Verification

Submitter Full Name: Bryan Gordon
Organization: Ivys Energy Solutions, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jun 02 11:47:02 EDT 2021
Committee: HYD-AAA

Committee Statement

Committee Action: Rejected but held

Resolution: The proposed revision is not on a topic discussed at the First Draft meeting and is considered new material and cannot be acted upon at the Second Draft meeting.

Public Input No. 15-NFPA 2-2023 [Section No. A.7.3.2.3.1.2]

A.7.3.2.3.1.2

Conversions for distance between inch-pound and SI units of measure cannot be consistently performed using typical mathematical conversion factors. The majority of separation distances shown in the SI table have been determined by the application of a risk-informed approach substantiated by statistical evaluation and modeling based on validated models for both ignited and unignited release of hydrogen gas. Where distance has been determined to allow for access or for correlation with the electrical code, the distances were not established through the use of models. Tabular distances in the inch-pound table have been determined by first converting SI units into inch-pound units and then rounding the distance to the nearest 5 ft for ease of application by code enforcers and users. A similar rounding technique has not been applied in the tabular distances shown in the SI table.

The exposures integral to Table 7.3.2.3.1.2(B)(a), Table 7.3.2.3.1.2(B)(b), and Table 7.3.2.3.1.2(B)(c) have been arranged into groups based on similar risks. The estimated leak area was changed from 3 percent to 1 percent of the pipe diameter to evaluate separation distances. The thresholds are applicable to the exposures identified in each group, as follows:

(1) *Group 1 Exposures.* The distances specified are those required to reduce the radiant heat flux level to 500 Btu/hr/ft^2 (1577 W/m^2) at the property line or the distance to a point in the unignited hydrogen jet where the hydrogen content is reduced to a 4 percent mole fraction (volume fraction) of hydrogen, whichever is greater. In all cases, the distance required to achieve a 4 percent mole fraction was the greater distance and was used to establish the requirements.

(2) *Group 2 Exposures.* The distances specified are those required to reduce the radiant heat flux level to 1500 Btu/hr/ft^2 (4732 W/m^2) for persons exposed a maximum of 3 minutes.

(3) *Group 3 Exposures.* The distances specified are those required to reduce the radiant heat flux level to 6340 Btu/hr/ft^2 (20,000 W/m^2) or the visible flame length for combustible materials, or a radiant heat flux level of 8000 Btu/hr/ft^2 (25,237 W/m^2) or the visible flame length for noncombustible equipment. In both cases, the visible flame length was used to establish the requirements.

A 50 percent safety factor was added to all resulting separation distance values.

Table 7.3.2.3.1.2(B)(a) Exposures Group 1(a). Lot lines (property lines) are those property lines between parcels and should not be construed to be the imaginary property lines that are drawn for the purposes of protecting the exterior walls of multiple buildings placed on the same lot or parcel. Railroad easements that are not accessible to the public other than by rail travel can be used as a means of spatial separation, with the required separation being measured between the hydrogen system and the nearest railroad track. It should be noted that in these cases, the addition or relocation of track can result in an encroachment that will necessitate relocation of the hydrogen system at the system user's expense.

Where the property on the other side of a property line is determined to be unbuildable or unoccupiable due to natural features including, but not limited to, waterways, terrain, wetlands, or similar features encroachment by the hydrogen system on the property line can be acceptable with the approval of the authority having jurisdiction. Should the property that is encroached upon become buildable or otherwise occupiable, the hydrogen system location should be reevaluated by the system user and the AHJ notified of the results.

Table 7.3.2.3.1.2(B)(a) Exposure Group 2(a). The exposed persons of concern are non-work-related persons or members of the public who are not involved with servicing the system, because these persons typically are neither trained nor knowledgeable in the operation of the system, but are on the premises. By comparison, service personnel or those involved with servicing the system are trained and engaged in activities related to the system operation including, but not limited to, inspecting, monitoring system inventory, delivering product, maintenance, or similar functions. Administrative controls, engineering controls, or construction features are typically used to restrict persons other than service personnel from being within the zone of potential exposure. The permit holder is responsible for managing and administering the controls to restrict access. Examples of such controls could include painted lines or signs or physical barriers such as a fence.

CGA PS-48, *Clarification of Existing Hydrogen Setback Distances and Development of New Hydrogen Setback Distances in ~~NFPA 55~~ NFPA 2* , provides guidance and clarification on types

of exposures as well as applications of the separation distances.

Statement of Problem and Substantiation for Public Input

CGA PS-48 has been revised and renamed to apply to the hydrogen distances that are in NFPA 2 and are no longer in NFPA 55.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Affiliation: NFPA 2/55 hydrogen alignment task group
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 24 14:29:12 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-118-NFPA 2-2024
Statement: The terminology has changed to align with the definition of Vent System, 3.3.225. The designer needs to consider the plume dispersion in relation to group I exposures. The designer also must consider the radiation effects of a vent stack fire for group II and III exposures.CGA PS-48 has been revised and renamed to apply to the hydrogen distances that are in NFPA 2 and are no longer in NFPA 55. The term storage has been added to several sections to specify what the separation distance is applying to.

Public Input No. 4-NFPA 2-2023 [Section No. A.7.3.2.3.1.4(B)]

A.7.3.2.3.1.4(B)

To determine the acceptability of technologies, processes, products, facilities, materials, and uses attending the design, operation or use of such systems, the AHJ is authorized to require the owner or agent to provide, without charge to the jurisdiction, a technical opinion and report. The model fire prevention codes provide the authority for the AHJ to seek technical assistance from independent third parties with expertise in the matter to be reviewed at the submitter's expense. The AHJ is authorized to require design submittals to be prepared by, and bear the stamp of, a registered design professional or professional engineer.

Active means of control could include a means to detect leakage or fire coupled with automatic system shutdown, such as gas or flame detection. The use of gas or flame detection should consider, but is not limited to, the following:

(1) *Gas Detection.* To utilize gas detection as a means of control, the gas sensor would be placed at a point between the bulk hydrogen compressed gas system and the exposure. Gas detection systems may be limited in their ability to detect the presence of hydrogen in the open. They are most effective if the sensor is located within an enclosed space such as an equipment enclosure. If used, gas detection systems should be either listed or approved.

(2) *Flame Detection.* Flame detection systems may include ~~combination UV/IR detection~~ radiant energy-sensing detection systems and be installed in accordance with the requirements of *NFPA 72.*

Ultraviolet flame detectors typically use a vacuum photodiode Geiger–Muller tube to detect the ultraviolet radiation that is produced by a flame. The photodiode allows a burst of current to flow for each ultraviolet photon that hits the active area of the tube. When the number of current bursts per unit time reaches a predetermined level, the detector initiates an alarm. [**72:**A.17.8.2]

A single wavelength infrared flame detector uses one of several different photocell types to detect the infrared emissions in a single wavelength band that are produced by a flame. These detectors generally include provisions to minimize alarms from commonly occurring infrared sources such as incandescent lighting or sunlight. An ultraviolet/infrared (UV/IR) flame detector senses ultraviolet radiation with a vacuum photodiode tube and a selected wavelength of infrared radiation with a photocell and uses the combined signal to indicate a fire. These detectors need exposure to both types of radiation before an alarm signal can be initiated. A multiple wavelength infrared (IR/IR) flame detector senses radiation at two or more narrow bands of wavelengths in the infrared spectrum. These detectors electronically compare the emissions between the bands and initiate a signal where the relationship between the two bands indicates a fire. [**72:**A.17.8.2]

Statement of Problem and Substantiation for Public Input

Multispectrum Infrared (IR/IR) flame detectors have been proven to be more false alarm resistant than single frequency IR flame detectors. These IR/IR detectors can be used successfully in high background IR applications including turbine enclosures, oil and gas refinery process monitoring and engine test cells. As such, they should be allowed for use in the protection of hydrogen gasifiers.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 3-NFPA 2-2023 [Section No. 13.5.3.10.3.2]	

Submitter Information Verification

Submitter Full Name: Aaron Paterson
Organization: Detector Electronics
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 05 14:39:38 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-185-NFPA 2-2024

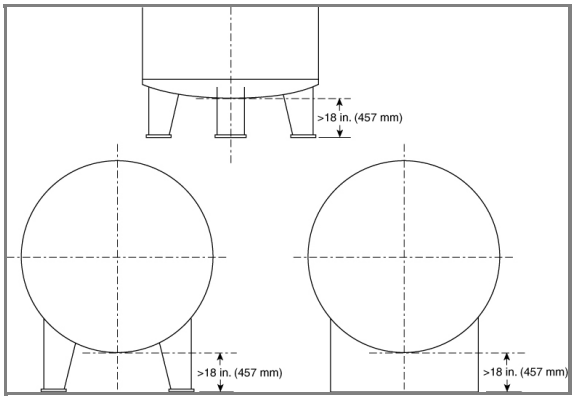
Statement: Multispectrum Infrared (IR/IR) flame detectors have been proven to be more false alarm resistant than single frequency IR flame detectors. These IR/IR detectors can be used successfully in high background IR applications including turbine enclosures, oil and gas refinery process monitoring and engine test cells.

Public Input No. 49-NFPA 2-2023 [Section No. A.8.3.1.2.1.1]

A.8.3.1.2.1.1

Refer to Figure A.8.3.1.2.1.1 for application of the 18 in. (46 cm) dimension to typical tank supports._ **Replace vertical tanl figure with attached drawing.**

Figure A.8.3.1.2.1.1 Dimensions for Typical Tank Supports.



Additional Proposed Changes

File Name	Description	Approved
PC_39794_vertical_LHY_tank_supports.docx	Updated vertical HY tank supports	

Statement of Problem and Substantiation for Public Input

The drawing is not correct and inconsistent with the drawing in CGA H-3 as called out in support requirements in NFPA 2 chapter 8.

The 18 inches on vertical tanks applies to where the support attaches at the lowest point.

Submitter Information Verification

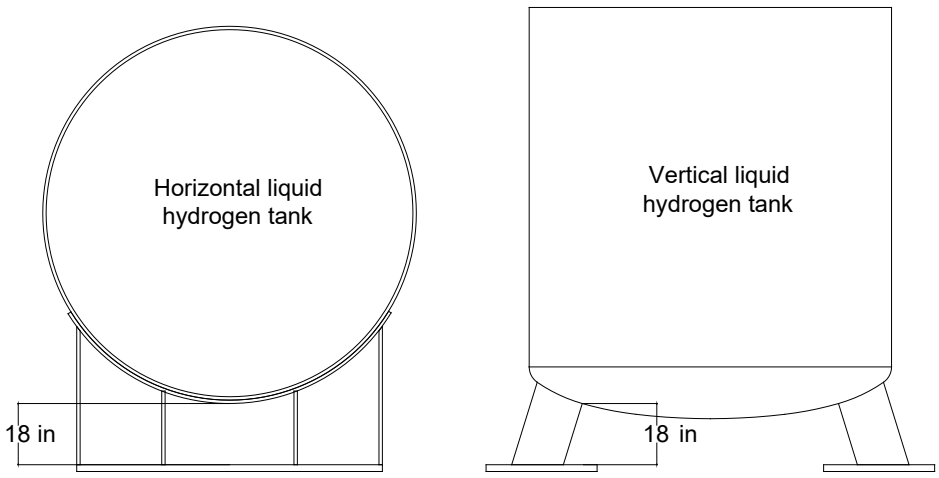
Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Street Address:
City:
State:
Zip:
Submittal Date: Mon Sep 11 14:46:52 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-168-NFPA 2-2024

Statement: The drawing is not correct and inconsistent with the drawing in CGA H-3 as called out in support requirements in NFPA 2 Chapter 8.

The 18 inches on vertical tanks applies to where the support attaches at the lowest point.


Horizontal liquid
hydrogen tank
18 in
Vertical liquid
hydrogen tank
18 in

Public Input No. 17-NFPA 2-2023 [Section No. A.8.3.2.3.1.5(D)]

A.8.3.2.3.1.5(D)

The placement of stationary containers is limited with respect to exposure hazards. Table 8.3.2.3.1.6(A) establishes the minimum separation distance between a building and any stationary tank at 1 ft (0.3 m). Additional limitations are placed on wall openings, air intakes, and other exposures. The material-specific tables for liquid ~~hydrogen and liquid oxygen specify~~ hydrogen specify increased distances according to the type of construction adjacent to the tank. A problem arises when courtyards are configured so as to interrupt the free movement of air around a tank where ~~an~~ asphyxiation hazard ~~, a flammable hazard, or an oxygen-enriched environment can~~ or a flammable hazard can be created.

Placement of stationary containers proximate to the wall of the building served is allowable, provided the minimum separation distances for exposure hazards are met. When additional walls encroach on the installation to form a court, the focus of concern shifts away from the exposure hazards associated with the building itself to the hazards associated with personnel due to hazardous atmospheres that can be created due to the lack of free air movement and ventilation.

By specifying the minimum distance between the tank and the encroaching walls that form the court, the circulation of adequate air is ensured. Placing the tank at not less than the height of two of the three encroaching walls results in creating an opening such that the angular dimension between the top of two of the three encroaching walls and the point over which the tank is placed is not greater than 45 degrees, thereby allowing the circulation of air through the space in which the tank is installed.

Statement of Problem and Substantiation for Public Input

NFPA 2 no longer covers hydrogen, so the references to NFPA 55 gases should be removed.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Affiliation: NFPA 2/55 hydrogen alignment task group
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 24 14:37:28 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-5-NFPA 2-2024
Statement: The scope of NFPA 2 has been revised to contain all requirements for hydrogen storage, use, and handling. The scope of NFPA 55 has been revised so that it no longer contains requirements for hydrogen storage, use, and handling. These sections of NFPA 2 were originally extracted from NFPA 55's general language that applies to all cryogenic fluids and compressed gases, including oxygen, nitrogen, and other gases along with

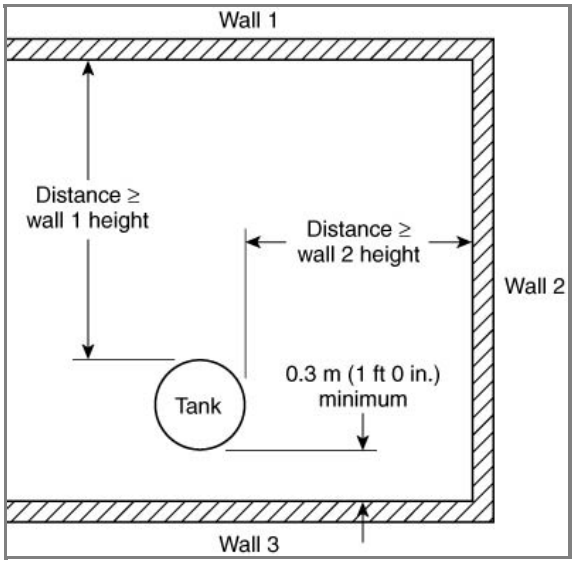
hydrogen. NFPA 2 has removed the extract tags and now maintains the requirements for hydrogen in these sections.

Public Input No. 18-NFPA 2-2023 [Section No. A.8.3.2.3.1.5(D)(1)]

A.8.3.2.3.1.5(D)(1)

The separation distances shown in Figure A.8.3.2.3.1.5(D)(1) are required to provide for ventilation in the space in order to avoid creating a confined space. ~~Chapter 8 of NFPA 55, is a generic chapter used to establish minimum requirements for all cryogens~~ . ~~Material-specific requirements for oxygen, hydrogen, or other gases might require greater separation distances based on the type of construction or the related exposure.~~ For example, wall number 3 shown in Figure A.8.3.2.3.1.5(D)(1) could be an exterior building wall, and the gas could be hydrogen. Refer to Table 8.3.2.3.1.6(a) for specific details regarding building walls, wall openings, air intakes, and similar conditions.

Figure A.8.3.2.3.1.5(D)(1) Bulk Cryogenic System Located in a Courtyard.



Statement of Problem and Substantiation for Public Input

This section was extracted from NFPA 55 but is now resident in NFPA 2. The sentences dealing with gases other than hydrogen are no longer applicable to NFPA 2 and should be deleted.

Submitter Information Verification

Submitter Full Name: Rob Early
Organization: Compressed Gas Association
Affiliation: NFPA 2/55 hydrogen alignment task group.
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 24 14:43:31 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-5-NFPA 2-2024

Statement: The scope of NFPA 2 has been revised to contain all requirements for hydrogen storage, use, and handling. The scope of NFPA 55 has been revised so that it no longer contains requirements for hydrogen storage, use, and handling. These sections of NFPA 2 were originally extracted from NFPA 55's general language that applies to all cryogenic fluids and compressed gases, including oxygen, nitrogen, and other gases along with hydrogen. NFPA 2 has removed the extract tags and now maintains the requirements for hydrogen in these sections.

Public Input No. 161-NFPA 2-2023 [New Section after A.10.1.1.5]

,10.5.1.5.1

SAE J2601/5 High-Flow Prescriptive Fueling Protocols for Gaseous Hydrogen Powered Medium and Heavy-Duty Vehicles, is strongly recommended as the standard fueling protocol for heavy duty dispensers. This standard has been developed by the automotive and hydrogen industry, to ensure that the fueling protocol will not overheat, overpressurize, or overfill the vehicle fuel supply container. SAE J2601 provides methods of fueling fuel supply containers from 50 to 250 L at service pressures of 35 or 70 MPa. SAE J2601 assumes that the fuel systems and fuel supply containers meet the requirements in SAE J2578, Recommended Practice for General Fuel Cell Vehicle Safety, and SAE J2579, Standard for Fuel Systems in Fuel Cell and Other Hydrogen Vehicles. Vehicles not designed to these standards should not use public dispensers without appropriate review or safeguards. A default protocol is the protocol used to fuel a hydrogen vehicle without any action by the user or operator of the dispenser.

Statement of Problem and Substantiation for Public Input

When the current version of NFPA2 was published, there were no fueling protocols for medium/heavy duty vehicles. Now, SAE J2601/5 is a published standard which provides a protocol for buses, trucks, etc. CSA TS HGV 4.3.5 will be the accompanying standard which is used to validate SAE J2601/5. The language in this section matches 10.5.1.4 for light duty vehicles. Vehicles are designed to standard fueling protocols, so it is important for stations to use this as their default otherwise, damage to the vehicle and fuel supply container (vehicle tank) may occur.

This Public Input is submitted on behalf of the NFPA 2 Fueling Task Group.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 160-NFPA 2-2023 [Section No. 10.5.1.5]	Annex Material
Public Input No. 162-NFPA 2-2023 [Section No. A.10.5.1.5.1.1]	Related Annex Material
Public Input No. 163-NFPA 2-2023 [Section No. 2.3.11]	Reference
Public Input No. 160-NFPA 2-2023 [Section No. 10.5.1.5]	
Public Input No. 162-NFPA 2-2023 [Section No. A.10.5.1.5.1.1]	
Public Input No. 163-NFPA 2-2023 [Section No. 2.3.11]	
Public Input No. 164-NFPA 2-2023 [Section No. 2.3.6]	

Submitter Information Verification

Submitter Full Name: Spencer Quong
Organization: Quong & Associates Inc.
Affiliation: Toyota
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 21 17:13:54 EST 2023

Committee: HYD-AAA

Committee Statement

Resolution: FR-39-NFPA 2-2024

Statement: SAE published J2601/5 as a TIR and it provides a fast fueling protocol for H35 and H70 dispensers serving a wide range of buses, trucks, etc. CSA TS HGV 4.3.5 will be the accompanying standard which is used to validate SAE J2601/5 when issued. It is likely to be published before 2nd draft and can be resubmitted as a Public Comment.

Public Input No. 203-NFPA 2-2023 [Section No. A.10.2.1.1]

A.10.2.1.1

Several standards have been published and are in use for product certification, listing, or labeling of fueling facility equipment. For example, light-duty vehicle fueling, a specific-use case of material covered by dispensing to the public, applicants might propose a system that uses CSA HGV 4.9, *Hydrogen Fueling Stations*. Also, for powered industrial trucks (e.g., forklifts), a specific-use case of material covered by dispensing to nonpublic users, applicants might propose a system that uses CSA HPIT 2, *Dispensing systems and components for fueling hydrogen powered industrial trucks.* Additional information regarding certification and approval for hydrogen systems is available through the H2 Tools website at https://www.h2tools.org.

Professional Engineers can be used to certify that dispensing facilities meet NFPA 2.

Statement of Problem and Substantiation for Public Input

Substantiation: The existing annex note discusses components but offers little guidance regarding how to certify a station as meeting NFPA 2, the actual enforceable requirement). Adding text to explain that Professional Engineers can do this makes sense. Professional Engineers offer a unique combination of qualifications and licensure requirements that makes their certification carry more weight than certification by almost any other individual. For example: PEs are subject to rigorous knowledge examinations. PE licensure includes rigorous and recurring confirmation of education and experience. All 50 US states accept the NCEES (National Council of Examiners for Engineering and Surveying) record which retains the key requirements for a record holders qualification including: Education completed, Examinations completed, Professional references, contact and personal information. Once licensed in a particular state, PEs are regulated by ethics requirements that typically include a primary duty to the public, requirements to be in responsible charge of work stamped, requirements not to practice outside their area of expertise, etc.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 15:55:19 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-173-NFPA 2-2024
Statement: The existing annex note discusses components but offered little guidance regarding how to certify a station as meeting NFPA 2 (the actual enforceable requirement). Professional Engineers offer a unique combination of qualifications and licensure requirements that makes their certification carry more weight than certification by almost any other individual.

PEs are subject to rigorous knowledge examinations. PE licensure includes rigorous and recurring confirmation of education and experience. All 50 US states accept the NCEES (National Council of Examiners for Engineering and Surveying) record which retains the key requirements for a record holders qualification including: Education completed, Examinations completed, Professional references, contact and personal information. Once licensed in a particular state, PEs are regulated by ethics requirements that typically include a primary duty to the public, requirements to be in responsible charge of work stamped, requirements not to practice outside their area of expertise, etc.

Public Input No. 71-NFPA 2-2023 [Section No. A.10.5.1.1.1]

A.10.5.1.1.1

In addition to the initial integrity check at the beginning of the fueling event, additional integrity checks have been effective at finding leaks that develop during the fueling process. The 2011 edition of NFPA 2 required this integrity check at 3000 psi (20 MPa) increments. Specifying the pressures at which these tests occur will result in greater standardization and consistency of the fueling process. The leak tests should occur within 5 percent of the specified pressure values. For example, the 85 percent fill-point check can occur between 80 percent and 90 percent of the service pressure.

Medium and Heavy Duty (MD/HD). vehicles, Classes 5 to 8, will have large onboard storage systems. Dispensers designed to support MD and HD fueling will have the capability of fueling faster (5 to 10 kg per minute) than light duty vehicles (1-2 kg per minute). The time to equalize and stabilize the hose pressure between the stop valve in the dispenser and the vehicle tank(s) system to determine if there are leaks in the fueling hose assembly and onboard high pressure fuel delivery system can take considerably more time than five seconds.

Statement of Problem and Substantiation for Public Input

This additional language proposed for the annex note is to support proposed changes to the dispensing process leak testing requirements to support the introduction of medium and heavy duty fuel cell vehicle fleets to support carbon emission reduction targets

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 72-NFPA 2-2023 [Sections 10.5.1.1.1, 10.5.1.1.2]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: BoydH2
Street Address:
City:
State:
Zip:
Submittal Date: Fri Dec 01 11:30:33 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-111-NFPA 2-2024

Statement: The changes in 10.5.1.1.1 clarify that the integrity test checks for leaks, not only in the hose assembly, but also the vehicle. The use of “back pressure” is not defined, but intended to be the pressure in the fuel supply container (i.e., vehicle tank per 3.3.50.2).

The five second detection time was originally determined for light duty vehicle

dispensers. Because larger vehicles with larger dispensing systems are entering the market place, the integrity test may require a longer time to determine if a leak is present. For the same sized leak and over the same time period, a system with a larger volume will have a smaller pressure drop compared to a system

with a smaller volume. Changing the requirement to allow for different monitoring times will ensure that these systems will be able to find a leak.

In 10.5.1.1.2, “service” is changed to “nominal working pressure” because the use of service pressure is “The settled pressure of the fuel container at a uniform gas temperature of 70°F (21°C) and full gas content” (3.3.197.7). Nominal working pressure is a new term defined for H2 fueling.

The repetition of the last part of each numbered section (“…by stopping flow…”) is not needed because it is discussed in 10.5.1.1.1.

The annex note is to support proposed changes to the dispensing process leak testing requirements to support the introduction of medium and heavy duty fuel cell vehicle fleets to support carbon emission reduction targets

Public Input No. 162-NFPA 2-2023 [Section No. A.10.5.1.5.1.1]

A.10.5.1.5.1.1

~~There are currently no standard fueling protocols with high flow rates for medium- and heavy-duty hydrogen motor vehicles. It is recommended that a third party approve the protocol based upon the existing requirements for light-duty hydrogen motor vehicle fueling protocols.~~

CSA Technical Specification HGV 4.3.5, Test Methods for Hydrogen Fueling Parameter Evaluation for Heavy Duty Vehicles, is a standard test method to validate that a dispenser properly applies the fueling protocols in SAE J2601, Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles, and communication protocols in SAE J2799, Hydrogen Surface Vehicle to Station Communications Hardware and Software, and has the proper fault controls in place. CSA TS HGV 4.3.5, Test Methods for Hydrogen Fueling Parameter Evaluation for Heavy Duty Vehicles, is a standard test method to validate that a dispenser properly applies the fueling protocols in SAE J2601/5 High-Flow Prescriptive Fueling Protocols for Gaseous Hydrogen Powered Medium and Heavy-Duty Vehicles

Care should be taken that the fueling protocol is validated with the appropriate version of CSA TS HGV 4.3.5

Statement of Problem and Substantiation for Public Input

When the current version of NFPA2 was published, there were no fueling protocols for medium/heavy duty vehicles. Now, SAE J2601/5 is a published standard which provides a protocol for buses, trucks, etc. CSA TS HGV 4.3.5 will be the accompanying standard which is used to validate SAE J2601/5. The language in this section matches 10.5.1.4 for light duty vehicles. Vehicles are designed to standard fueling protocols, so it is important for stations to use this as their default otherwise, damage to the vehicle and fuel supply container (vehicle tank) may occur.

This Public Input is submitted on behalf of the NFPA 2 Fueling Task Group.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 160-NFPA 2-2023 [Section No. 10.5.1.5]	Annex Material
Public Input No. 161-NFPA 2-2023 [New Section after A.10.1.1.5]	Related Annex Material
Public Input No. 163-NFPA 2-2023 [Section No. 2.3.11]	Reference
Public Input No. 164-NFPA 2-2023 [Section No. 2.3.6]	Reference
Public Input No. 160-NFPA 2-2023 [Section No. 10.5.1.5]	
Public Input No. 161-NFPA 2-2023 [New Section after A.10.1.1.5]	
Public Input No. 163-NFPA 2-2023 [Section No. 2.3.11]	
Public Input No. 164-NFPA 2-2023 [Section No. 2.3.6]	

Submitter Information Verification

Submitter Full Name: Spencer Quong
Organization: Quong & Associates Inc.

Affiliation: Toyota
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 21 17:17:43 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-39-NFPA 2-2024

Statement: SAE published J2601/5 as a TIR and it provides a fast fueling protocol for H35 and H70 dispensers serving a wide range of buses, trucks, etc. CSA TS HGV 4.3.5 will be the accompanying standard which is used to validate SAE J2601/5 when issued. It is likely to be published before 2nd draft and can be resubmitted as a Public Comment.

Public Input No. 21-NFPA 2-2023 [Section No. A.12.2]

A.12.2

Fuel cell technology is evolving. Early editions of the standard for testing fuel cell power systems, CSA/ ANSI ~~/CSA FC1,~~ FC1 * CSA C22.2 No. 62282-3-100 - *Fuel cell technologies — Part 3-100: Stationary fuel cell power systems — Safety*, limited designs by output power, fuels, and construction techniques. CSA/ ANSI ~~/CSA~~ FC 1 ~~has~~ * CSA C22.2 No. 62282-3-100 has matured so that its current edition has no limitation on output power, permits all credible fuels and fuel cell technologies, and allows designs to be packaged in a single enclosure or matched modules to be assembled on-site. Outside the scope of ~~ANSI~~ CSA /~~CSA FC 1~~ ANSI FC 1 * CSA C22.2 No. 62282-3-100 , there are one-of-a-kind designs that could possibly be constructed on-site. In the latter's case, engineered and field-constructed fuel cell power systems may be accepted at the site based on documentation. This documentation includes a fire risk evaluation that can be prepared by a registered engineer or by a third-party that is acceptable to the AHJ. See Section 4.4, Engineered and Field-Constructed Fuel Cell Power Systems, in NFPA 853. [**853:**A.4.1]

Statement of Problem and Substantiation for Public Input

New binational edition has been published which is an adoption of the newest edition of IEC 62282-3-100.This is the first edition of CSA/ANSI FC 1 • CSA C22.2 No. 62282-3-100, Fuel cell technologies — Part 3-100: Stationary fuel cell power systems — Safety, which is an adoption with Canadian and U.S. deviations of the identically titled IEC (International Electrotechnical Commission) Standard 62282-3-100 (second edition, 2019-02). It replaces ANSI/CSA FC 1-2014 (adopted IEC 62282-3-100:2012, with U.S. deviations).

Submitter Information Verification

Submitter Full Name: Mark Duda
Organization: CSA Group
Street Address:
City:
State:
Zip:
Submittal Date: Tue Aug 15 10:14:37 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: The language of A.12.2 is extracted material from NFPA 853. Any updates to extracted matieral need to be submitted to the source document, in this case NFPA 853.

Public Input No. 132-NFPA 2-2023 [New Section after A.13.2.1]

A.13.2.6 Piping

Hydrogen generation systems include piping, valves, and fittings for other fluids in addition to hydrogen such as water for electrolyzers and natural gas for reformers. These systems use flanges and threaded connections that may be prohibited by Sections 704.1.2.3, 704.1.2.4, and 704.1.2.5 of the ICC International Fuel Gas Code (IFGC).

ASME B31.12 specifically addresses piping for hydrogen and is referenced by hydrogen equipment standards internationally. ASME B31 is both necessary and sufficient piping code.

Note: ASME B31.12 does not include the restrictions in the IFGC.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

A.13.2.6 provides some of the reasoning for the addition of 13.2.6 and clarifies that it does not include the restrictions in the IFGC that are imbedded in 6.5.1.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 131-NFPA 2-2023 [New Section after 13.2.5]	Explanatory information for new section 13.2.6 re: piping.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 21:57:53 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-25-NFPA 2-2024

Statement: Piping systems for hydrogen systems should be designed and constructed to minimize the likelihood of a release (leak). Welded connections are generally considered the best way to achieve this, however, they are not always practical.

In addition, many types of hydrogen systems include piping for fluids other than hydrogen. For example, electrolyzer based hydrogen generators include piping for water and reformer-based hydrogen generators often include piping for natural gas.

The Code for Pressure Piping, ASME B31, addresses the design, fabrication, assembly, and testing of piping systems for all types of fluid including hydrogen. ASME B31.12, Hydrogen Piping and Pipelines, addresses piping system for hydrogen in particular.

ASME B31 has been used successfully in hydrogen systems for many decades. And, many product safety standards for hydrogen equipment such as CSA FC 1 for fuel cells and CSA/ANSI B22734 for electrolyzers refer specifically to ASME B31.

For the renumbered 6.5.1.2 is a contradiction between the International Fuel Gas Code (IFGC) and the American Society of Mechanical Engineers (ASME) B31 piping codes in the pressure testing requirements of hydrogen systems for high-pressure applications. The contradiction concerns the acceptable resultant hoop (circumferential) stress from a pneumatic or hydrostatic pressure test. The requirement in the IFGC is limiting and would require a lower test pressure and, in some cases, below the MAWP, where the B31 codes state that no test pressure reduction is required. B31 allows for testing up to the yield. For example, a 1" stainless steel tube has a wall thickness of 0.083". If they follow the IFGC Section 705, it limits the pressure test based on 50% of the hoop stress, resulting in a pressure test at 2507psig.

Meanwhile, the Barlow formula provided by B31 can establish an MAWP of 3100psig. ASME B31 would require a pressure test at 1.1xMAWP.

Public Input No. 127-NFPA 2-2023 [Section No. A.13.2.1]

A.13.2.1

~~The equipment referenced is intended to include stationary applications and generation of hydrogen from portable or transportable hydrogen generation equipment. It does not include hydrogen production facilities intended to produce hydrogen used for distribution or repackaging operations operated by gas producers, distributors, and repackagers.~~

Where the listing of the hydrogen generator already addresses the requirements in specific sections of Chapter 6 and/or 7, the provisions of those specific sections do not need to be applied. Many of these sections typically are not relevant for small hydrogen generation equipment. For generators in unoccupiable enclosures, the enclosure is typically not considered to be a building.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

The first paragraph of A13.2.1 contradicts the application statement at the beginning of Chapter 13; see 13.1.1. For example Chapter 13 applies only to permanently installed hydrogen generators not portable or transportable hydrogen generators and it may include hydrogen production operated by gas producers, distributors, etc. This paragraph should be deleted.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 21:19:35 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-13-NFPA 2-2024

Statement: A recent trend in hydrogen generation is the manufacturing and supply of hydrogen generation modules. These modules are subsets of complete hydrogen generators. They typically consist of one or more cell stacks, some related piping, and potentially some environmental control equipment such as heaters or HVAC equipment. Therefore, these modules should be addressed in Chapter 13.

The first paragraph of A13.2.1 contradicts the application statement at the beginning of Chapter 13; see 13.1.1. For example, Chapter 13 applies only to permanently installed hydrogen generators not portable or transportable hydrogen generators and it may include hydrogen production operated by gas producers, distributors, etc. Therefore, this paragraph should be deleted.

The addition of the word “system” in the second paragraph is an editorial change to use the same terminology as used in the rest of Chapter 13 i.e., "hydrogen generation systems"

Public Input No. 136-NFPA 2-2023 [Section No. A.13.3.1]

A.13.3.1

Listing standards for water electrolyzers are available. The 2019 edition of ISO 22734, *Hydrogen generators using water electrolysis process—Industrial, commercial, and residential applications,* combines and supersedes the 2008 edition of ISO 22734-1, *Hydrogen generators using water electrolysis process—Part 1: Industrial and commercial applications*, and the 2011 edition of ISO 22734-2, *Hydrogen generators using water electrolysis process—Industrial, commercial, and residential applications*. CSA Group ~~is working~~ in cooperation with the Compressed Gas Association ~~regarding~~ published the binational adoption of ISO 22734 with US ~~deviations~~ & Canadian deviations as CSA/ANSI B22734 .

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

The Annex A information for 13.3.1 was out of date.
Updated to indicate that the binational adoption of ISO 22734 was published as CSA/ANSI B22734.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 133-NFPA 2-2023 [Section No. 13.3.1 [Excluding any Sub-Sections]]	Explanatory information for 13.3.1.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 22:25:20 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-15-NFPA 2-2024
Statement: The binational, U.S. & Canadian, adoption of ISO 22734, CSA/ANSI B22734 was published in 2023 and should replace the reference to ISO 22734. However, the Chapter 13 TG thinks it prudent to keep the ISO 22734 reference for one more code cycle to give users of this code time to make the transition to CSA/ANSI B22734 so, the proposal is simply to add CSA/ANSI B22734 for now. The binational adoption of ISO 22734 was published as CSA/ANSI B22734.

Public Input No. 27-NFPA 2-2023 [Section No. A.13.3.1]

A.13.3.1

Listing standards for water electrolyzers are available. ~~The~~ The 2023 edition of CSA/ANSI B22734 - *Hydrogen generators using water electrolysis process – Industrial, commercial, and residential applications,* is an adoption with Canadian and U.S. deviations of the identically titled ISO 22734. The 2019 edition of ISO 22734*, Hydrogen generators using water electrolysis process—Industrial, commercial, and residential applications,* combines and supersedes the 2008 edition of ISO 22734-1, *Hydrogen generators using water electrolysis process—Part 1: Industrial and commercial applications*, and the 2011 edition of ISO 22734-2, *Hydrogen generators using water electrolysis ~~process—Industrial, commercial, and residential applications~~* ~~. CSA Group is working with the Compressed Gas Association regarding the adoption of ISO 22734 with US deviations.~~ *process— Part 2: Residential applications* .

Statement of Problem and Substantiation for Public Input

Rationale: Correct the title of ISO 22734-2. The 2023 edition of CSA/ANSI B22734, Hydrogen generators using water electrolysis process – Industrial, commercial, and residential applications, which is an adoption with Canadian and U.S. deviations of the identically titled ISO 22734 standard, has been published and is a suitable additional listing reference.

Submitter Information Verification

Submitter Full Name: Mark Duda
Organization: CSA Group
Street Address:
City:
State:
Zip:
Submittal Date: Tue Sep 05 08:38:39 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-15-NFPA 2-2024

Statement: The binational, U.S. & Canadian, adoption of ISO 22734, CSA/ANSI B22734 was published in 2023 and should replace the reference to ISO 22734. However, the Chapter 13 TG thinks it prudent to keep the ISO 22734 reference for one more code cycle to give users of this code time to make the transition to CSA/ANSI B22734 so, the proposal is simply to add CSA/ANSI B22734 for now. The binational adoption of ISO 22734 was published as CSA/ANSI B22734.

Public Input No. 135-NFPA 2-2023 [New Section after A.13.3.1.1]

A.13.3.1.2

These electrolyzers that are excluded from ISO 22734 and CSA B22734 may have additional hazards such as high temperatures that must be addressed in addition to the applicable parts of ISO 22734 and CSA B22734 .

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

This Annex A information explains that electrolyzers that are excluded from ISO 22734 and CSA B22734 may have additional hazards that are not addressed in those standards.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 134-NFPA 2-2023 [New Section after 13.3.1.1]	Annex A explanatory information for new section 13.3.1.2.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 22:16:46 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-119-NFPA 2-2024

Statement: The scopes of ISO 22734 and CSA/ANSI B22734 do not include all technologies for water electrolyzers and specifically exclude some such as solid oxide electrolyzers. However, most of the requirements in ISO 22734 and CSA/ANSI B22734 do apply to those excluded electrolyzers and they should comply with those requirements as approved. This allows approval by an AHJ since these excluded electrolyzers cannot be certified ("listed") to ISO 22734 or CSA/ANSI B22734.

Public Input No. 141-NFPA 2-2023 [New Section after A.13.3.1.1]

A.13.3.2.6

It is not uncommon to construct larger water electrolysis systems using multiple factory-matched water electrolysis systems co-located adjacent to each other.

Factory matched water electrolysis systems listed to CSA B22734 or ISO 22734 undergo a mandatory structured risk assessment to comply with these listing standards. Particular attention is given in this risk assessment to mitigating the hazards of process hydrogen and oxygen hazards within the equipment and to the installation environment. These listed systems are then validated and verified to apply multiple process safeguards and layers of protection that mitigate potential hazards associated with the process H2 and O2 volumes, so that fire-separation distance is not necessary.

For example, these listed water electrolysis systems stop hydrogen and oxygen generation upon detection of leaks, overpressure, excessive temperature, and other critical process upset conditions, removing the source of H2 and O2. Further, these systems then typically vent the internal hydrogen and oxygen pressurized inventory to a safe area via process vent terminals. These measures are implemented before conditions can escalate into a loss of containment and a fire condition.

Note: Requirements to apply fire separation distances from water electrolysis systems to gas storage and other exposures may still apply.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

This Annex A information explains the reasoning behind the exemption from fire-rated separation requirements between water electrolysis systems .
And, it notes that separation distances to storage or other exposures may still apply.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 140-NFPA 2-2023 [New Section after 13.3.2.5]	Annex A information for new section 13.3.2.6.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 22:50:33 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-223-NFPA 2-2024

Statement: It is not uncommon to construct larger water electrolysis systems using multiple, smaller, factory-matched water electrolysis systems or modules co-located adjacent to each other.

Parts of Chapter 7 could be interpreted as requiring separation between these systems or modules to prevent the spread of fire from one unit to another. Some examples are 7.1.9.1, 7.2.1.1, 7.2.2.2.2.2, 7.2.2.3.2, & 7.3.2.3.1.2.

Water electrolysis systems and modules listed to CSA/ANSI B22734 or ISO 22734 undergo a mandatory structured risk assessment to comply with these listing standards. Particular attention is given in this risk assessment to mitigating the hazards of process hydrogen and oxygen hazards within the equipment and to the installation environment. These listed systems are then validated and verified to apply multiple process safeguards and layers of protection that mitigate potential hazards associated with the process hydrogen and oxygen volumes, so that fire-separation distances between these water electrolysis systems is not necessary.

For example, these listed water electrolysis systems stop hydrogen and oxygen generation upon detection of leaks, overpressure, excessive temperature, and other critical process upset conditions, removing the source of hydrogen and oxygen. Further, these systems then typically vent the internal, pressurized hydrogen and oxygen inventory to a safe area via process vent terminals. These measures are implemented before conditions can escalate into a loss of containment and a fire condition. Unlike equipment that uses hydrogen as an input or that processes hydrogen, electrolyzers produce the hydrogen from water and electricity and stop the production of hydrogen immediately upon shutdown. Electrolyzers typically contain large quantities of water that help mitigate the risks from external fires. And, the primary hazard to an electrolyzer from an external fire is damage to the electrolyzer equipment and not to personnel.

Fire and explosion hazard protection requirements are located in section 4.4.1 of ISO 22734 and CSA/ANSI B22734. In addition, these standards require protection against the spread of fire including fire resistant enclosures; see section 4.3.3.3 of ISO 22734 and CSA/ANSI B22734.

Public Input No. 143-NFPA 2-2023 [New Section after A.13.3.1.1]

A.13.3.2.6.1

It is not uncommon to construct larger water electrolysis systems using multiple factory-matched water electrolysis modules co-located adjacent to each other.

Factory matched water electrolysis modules listed to CSA FC6 / CSA 62282-2-100 undergo a mandatory structured risk assessment to comply with these listing standards. Particular attention is given in this risk assessment to mitigating the hazards of process hydrogen and oxygen hazards within the equipment and to the installation environment. These listed modules are then validated and verified to apply multiple process safeguards and layers of protection that mitigate potential hazards associated with the process H2 and O2 volumes, so that fire-separation distance is not necessary.

For example, these listed water electrolysis systems stop hydrogen and oxygen generation upon detection of leaks, overpressure, excessive temperature, and other critical process upset conditions, removing the source of H2 and O2. Further, these systems then typically vent the internal hydrogen and oxygen pressurized inventory to a safe area via process vent terminals. These measures are implemented before conditions can escalate into a loss of containment and a fire condition.

Note: Requirements to apply fire separation distances from water electrolysis modules to gas storage and other exposures may still apply.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

This Annex A information explains the rationale for the exemption to the requirement for fire-rated separation between water electrolysis modules.
It also notes that separation distances to storage and other exposures may still apply.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 142-NFPA 2-2023 [New Section after 13.3.2.5]	Explanatory information for new section 13.3.2.6.1.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13 TG
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 19 23:02:50 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-223-NFPA 2-2024

Statement: It is not uncommon to construct larger water electrolysis systems using multiple, smaller, factory-matched water electrolysis systems or modules co-located adjacent to each other.

Parts of Chapter 7 could be interpreted as requiring separation between these systems or modules to prevent the spread of fire from one unit to another. Some examples are 7.1.9.1, 7.2.1.1, 7.2.2.2.2.2, 7.2.2.3.2, & 7.3.2.3.1.2.

Water electrolysis systems and modules listed to CSA/ANSI B22734 or ISO 22734 undergo a mandatory structured risk assessment to comply with these listing standards. Particular attention is given in this risk assessment to mitigating the hazards of process hydrogen and oxygen hazards within the equipment and to the installation environment. These listed systems are then validated and verified to apply multiple process safeguards and layers of protection that mitigate potential hazards associated with the process hydrogen and oxygen volumes, so that fire-separation distances between these water electrolysis systems is not necessary.

For example, these listed water electrolysis systems stop hydrogen and oxygen generation upon detection of leaks, overpressure, excessive temperature, and other critical process upset conditions, removing the source of hydrogen and oxygen. Further, these systems then typically vent the internal, pressurized hydrogen and oxygen inventory to a safe area via process vent terminals. These measures are implemented before conditions can escalate into a loss of containment and a fire condition. Unlike equipment that uses hydrogen as an input or that processes hydrogen, electrolyzers produce the hydrogen from water and electricity and stop the production of hydrogen immediately upon shutdown. Electrolyzers typically contain large quantities of water that help mitigate the risks from external fires. And, the primary hazard to an electrolyzer from an external fire is damage to the electrolyzer equipment and not to personnel.

Fire and explosion hazard protection requirements are located in section 4.4.1 of ISO 22734 and CSA/ANSI B22734. In addition, these standards require protection against the spread of fire including fire resistant enclosures; see section 4.3.3.3 of ISO 22734 and CSA/ANSI B22734.

Public Input No. 28-NFPA 2-2023 [Section No. A.13.3.3]

A.13.3.3

Listing standards for residential-use electrolyzers, such ~~as ISO~~ as CSA/ANSI B22734 - *Hydrogen generators using water electrolysis process – Industrial, commercial, and residential applications* and SO 22734, *Hydrogen generators using water electrolysis — Industrial, commercial, and residential applications,* allow manufacturers to list electrolyzers for residential applications, such as energy conversion and vehicle fueling. Limiting GH_2 content to 250 scf, GH_2 per 6.4.1.5.1.1 aligns with non-industrial use.

Statement of Problem and Substantiation for Public Input

Rationale: The 2023 edition of CSA/ANSI B22734, Hydrogen generators using water electrolysis process – Industrial, commercial, and residential applications, which is an adoption with Canadian and U.S. deviations of the identically titled ISO 22734 standard, has been published and is a suitable additional listing reference.

Submitter Information Verification

Submitter Full Name: Mark Duda
Organization: CSA Group
Street Address:
City:
State:
Zip:
Submittal Date: Tue Sep 05 08:40:34 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-18-NFPA 2-2024
Statement: The 2023 edition of CSA/ANSI B22734, Hydrogen generators using water electrolysis process – Industrial, commercial, and residential applications, which is an adoption with Canadian and U.S. deviations of the identically titled ISO 22734 standard, has been published and is a suitable additional listing reference.

Public Input No. 147-NFPA 2-2023 [Section No. A.13.4.1]

~~**A.13.4.1** —~~

~~CSA Group is working with the Compressed Gas Association regarding the adoption of ISO 16110-1, *Hydrogen Generators Using Fuel Processing Technologies – Part 1: Safety,* with US deviation.~~

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

The adoption of ISO 16110-1 as CSA/ANSI FC 5 has been complete for several years; this Annex A information is no longer needed.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13 TG.
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 20 10:32:04 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-16-NFPA 2-2024
Statement: The U.S. adoption of ISO 16110-1, CSA/ANSI FC 5, was published in 2007. The intent was always to replace the ISO standard with the CSA/ANSI standard when it became available. The adoption of ISO 16110-1 as CSA/ANSI FC 5 has been complete for several years; this Annex A information is no longer needed.

Public Input No. 25-NFPA 2-2023 [Section No. A.13.4.1]

A.13.4.1

~~CSA Group is working with the Compressed Gas Association regarding the adoption of ISO 16110-1, *Hydrogen Generators Using Fuel Processing Technologies – Part 1: Safety,* with US deviation.~~ The 2021 edition of CSA/ANSI FC 5, *Hydrogen generators using fuel processing technologies – Part 1: Safety,* is an adoption with U.S. deviations of the identically titled ISO 16110-1.

Statement of Problem and Substantiation for Public Input

The 2021 edition of CSA/ANSI FC 5, Hydrogen generators using fuel processing technologies – Part 1: Safety, is an adoption with U.S. deviations of the identically titled ISO 16110-1 and is a suitable listing standard reference.

Submitter Information Verification

Submitter Full Name: Mark Duda
Organization: CSA Group
Street Address:
City:
State:
Zip:
Submittal Date: Tue Aug 15 11:11:36 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-16-NFPA 2-2024
Statement: The U.S. adoption of ISO 16110-1, CSA/ANSI FC 5, was published in 2007. The intent was always to replace the ISO standard with the CSA/ANSI standard when it became available. The adoption of ISO 16110-1 as CSA/ANSI FC 5 has been complete for several years; this Annex A information is no longer needed.

Public Input No. 22-NFPA 2-2023 [Section No. A.13.4.2]

A.13.4.2

NFPA 853 specifically addresses installation of stationary fuel cell power systems that are listed or approved to CSA/ANSI FC1 * CSA C22.2 No. 62282-3-100 , *Fuel cell technologies — Part 3-100: Stationary fuel cell power systems — Safety*. CSA ~~FC 1~~ /ANSI FC 1 * CSA C22.2 No. 62282-3-100 was originally written for fuel cells using reformers. Since CSA/ANSI FC 1 * CSA C22.2 No. 62282-3-100 and NFPA 853 are written primarily for reformer-based fuel cells and reformer-based hydrogen generators are essentially a subset of these fuel cells (see Annex B of NFPA 853), most of NFPA 853 is also applicable to reformer-based hydrogen generators.

Statement of Problem and Substantiation for Public Input

New binational edition has been published which is an adoption of the newest edition of IEC 62282-3-100.This is the first edition of CSA/ANSI FC 1 • CSA C22.2 No. 62282-3-100, Fuel cell technologies — Part 3-100: Stationary fuel cell power systems — Safety, which is an adoption with Canadian and U.S. deviations of the identically titled IEC (International Electrotechnical Commission) Standard 62282-3-100 (second edition, 2019-02). It replaces ANSI/CSA FC 1-2014 (adopted IEC 62282-3-100:2012, with U.S. deviations).

Submitter Information Verification

Submitter Full Name: Mark Duda
Organization: CSA Group
Street Address:
City:
State:
Zip:
Submittal Date: Tue Aug 15 10:17:41 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-24-NFPA 2-2024
Statement: New binational edition has been published which is an adoption of the newest edition of IEC 62282-3-100.This is the first edition of CSA/ANSI FC 1 • CSA C22.2 No. 62282-3-100, Fuel cell technologies — Part 3-100: Stationary fuel cell power systems — Safety, which is an adoption with Canadian and U.S. deviations of the identically titled IEC (International Electrotechnical Commission) Standard 62282-3-100 (second edition, 2019-02). It replaces ANSI/CSA FC 1-2014 (adopted IEC 62282-3-100:2012, with U.S. deviations).

Public Input No. 148-NFPA 2-2023 [Section No. A.13.5.2.3]

A.13.5.2.3

Protection can either be integral to ~~the hydrogen generator gasifier~~ the gasifier system (e.g., locked enclosures, guards, and so on), or ~~the hydrogen generator gasifier~~ the gasifier can be installed in a controlled-access area.

Statement of Problem and Substantiation for Public Input

This PI is submitted on behalf of the Chapter 13 TG.

Editorial changes to improve clarity.

Submitter Information Verification

Submitter Full Name: Stephen Goyette
Organization: Nel Hydrogen
Affiliation: NFPA 2, Chapter 13 TG.
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 20 10:34:09 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-23-NFPA 2-2024
Statement: Section 13.5 is specific to gasifier systems and does not apply generally to all hydrogen generators. Text was changed to indicate this specificity.

Public Input No. 225-NFPA 2-2024 [Sections A.14.1.1, A.14.3.1.2, A.14.3.1.2.1, A.14.3.1.2.2, ...]

Sections A.14.1.1, A.14.3.1.2, A.14.3.1.2.1, A.14.3.1.2.2, A.14.3.1.2.4, A.14.3.1.2.6.1

A.14.1.1

—

~~Examples~~

Examples of the use of hydrogen used as a fuel involving flame, include, but would not be limited to, combustion of the gas in a torch used in welding or heating operations where the gas is used to provide a flame and accompanied by a reducing atmosphere. The melting of quartz or glass frequently involves the use of hydrogen combustion operations.

Several European countries are pre-mixing hydrogen up to 20% concentration in the distribution pipelines. Although this is outside the scope of NFPA 2, it is worth noting for awareness.

There is a move to start mixing hydrogen into the fuel supply for industrial Internal Combustion Engines and Gas Turbines. In Europe, this will be provided by way of the pipeline premixed fuel and the vision is for additional hydrogen to be added from a "local" source, up to 100% hydrogen, as hydrogen availability increases. For Gas Turbines, this path was formalized in January 2020 by the European Turbine Network (ETN Global) Hydrogen Working Group in their report " The Path Towards a Zero-Carbon Gas Turbine " which is available at https://etn.global/news-and-events/news/hydrogen-gas-turbines-report/ . With this direction in mind, a Task Group was formed to develop initial guidance for the use of "Hydrogen Enriched Fuels" in the 2024 edition of NFPA 37.

The provisions for premixed hydrogen in pipelines will also affect all other gas consumers such as Boilers and Combustion Systems (NFPA 85), Ovens and Furnaces (NFPA 86), and Fluid Heaters (NFPA 87)

A.14.3.1.

~~2~~ —

~~**1** - NFPA 497 provides guidance on the classification of areas.~~

~~**A. 14.3.1.1.2** - The higher the pressure, the greater the risk of hydrogen leaking through O-rings and other seals, which are leak tight when tested with air or natural gas. Examples of leak prevention would be the use of conduit plugs. This requirement would not apply to wiring methods that do not use conduit, cable such as SO / SOOW because gas does not freely pass through such cable.~~

~~**A.14.3.1.2.1** - Features such as solid beams that form a tight fit with the roof deck should be avoided. The intakes for the ventilation system should be located at high points in the ceiling to prevent the trapping of hydrogen in the thermal spraying area.~~

~~**A.14.3.1.3.3** - The maximum gas concentration value for action should be no higher than 25% of the Lower Flammability Limit.~~

~~**A.14.3.1.4.1** - If ignited, external leakage of hydrogen or hydrogen enriched fuels from the piping and gas control system supplying the equipment can result in an invisible flame and risk of personnel injury.~~

~~**A.14.3.1. 4.1.2** - The historical detection technology for hydrogen flames is Ultraviolet (UV) or Ultraviolet/Infrared (UV/IR). These systems are susceptible to "false detection" due to sun light, either direct or reflected, and other sources such as welding and activities that result in sparks. In recent years, a Multi-Spectrum IR (MIR) technology has been developed that reduces the potential for false alarms. Additionally, detectors that are specific to the fuel being burned (e.g., natural gas, hydrogen, etc.) are available and some detectors are capable of selectively detecting fires from various fuels.~~

~~**A.14.3.1. 4.2** - Combination visual and aural warning devices are essential. The local warning devices are independent from other fire and hazard warning devices (e.g., general~~

~~fire alarm, toxic gas, etc.) and the visual and aural signals must be distinct from the other local hazard warning devices to ensure no confusion as to the hazard that is being highlighted.~~

~~**A.14.3.1. 4.2(3)** - Multiple devices along the exit path may be required~~

~~**A.14.3.1.5** - Given the flammability characteristics of hydrogen versus natural gas with respect to the gas supply pressure, the - 345 kPa - (50 psig) low pressure limit defined in NFPA 54, 1.1.1.1(C) is used for the equipment identified in this chapter. Where the fuel supply is greater than - 345 kPa - (50 psig) the specific requirements for Combustion Engines and Gas Turbines defined in NFPA 37 as modified in 14.3.3 are applicable~~

~~**A.14.3.1.5.1.2** - The reset may be either a physical reset of the valve actuation or clearing of the "fault" in the control system that returns the valve to the normal operation state.~~

~~**A.14.3.1.5.2.1(B)** - It is recommended that the valve manufacturer consider independent testing laboratory verification and certification of the valve leakage using 10% minimum helium – nitrogen blend.~~

~~**A.14.3.1.5.2.2(C)** - It is recommended that the valve manufacturer consider independent testing laboratory verification and certification of the valve leakage using 10% minimum helium – nitrogen blend.~~

~~**A.14.3.1.5.3** - A "separate dedicated enclosure" is a structure that has no separate rooms and only the hydrogen consuming equipment is located within the enclosure or building.~~

~~**A.14.3.1.5.4** - see NFPA 86 Annex section A.7.4.10 for additional guidance.~~

~~**A.14.3.1.6.1** - Two basic configurations for the flame arrestor are recognized. One is to provide a separate flame arrestor at each burner, the other is to provide a flame arrestor at each group of burners. The single a flame arrestor for a group of burners is more practical if a system consists of many closely spaced burners.~~

~~**A.14.3.1.6.5** - It is recommended to include a safety blowout regardless of the mixture pressure. Acceptable safety blowouts are available from some manufacturers of air–fuel mixing machines. They incorporate all the following components and design features:~~

~~(1) Flame arrester~~

~~(2) Blowout disk~~

~~(3) Provision for automatically shutting off the supply of air–gas mixture to the burners in the event of a flashback passing through an automatic fire check~~

~~**A.14.3.2.1.2** - Thermal spraying is typically conducted with robotic equipment in isolated chambers or otherwise protected areas to isolate persons from hazards such as noise, intense ultraviolet light, process gases, and vapors. The equipment includes multiple flexible piping or hoses, which pass through the chamber walls to deliver the gas from a control source to the process device or gun. The flexible portions of the fuel delivery system represent potential leak sources.~~

~~NFPA 497~~

NFPA 497 provides guidance on the classification of areas.

A.14.3. 2. 1.2.1

–

-

~~System preventive maintenance typically includes regular leak checks and the replacement~~

~~of hoses in accordance with the manufacturer's recommendations. An increase in the frequency might be warranted based on maintenance experience.~~

~~A~~
~~A14.~~

~~14~~
~~3.3.1.2~~

~~.2~~

~~NFPA 497 provides guidance on the classification of areas~~

The categories of equipment identified in NFPA 85 that may use a gaseous fuel, to include hydrogen or a hydrogen enriched fuel, are:

(1) Single Burner Boilers

(2) Multiple Burner Boilers

(3) Warm-Up Burners and Lances for Fluidized Bed Boilers

(4) Duct Burners included in a Heat Recovery Steam Generator

(5) An Auxiliary Boiler associated with a Stoker

This guidance can also be applied to the equipment covered by ASME/CSD-1 Controls and Safety Devices for Automatically Fired Boilers.

A.14.3.3.1.2.

~~4~~

~~Features such as solid beams that form a tight fit with the roof deck should be avoided. The intakes for the ventilation system should be located at high points in the ceiling to prevent the trapping of hydrogen in the thermal spraying area~~

1 System preventive maintenance typically includes regular leak checks and the replacement of hoses in accordance with the manufacturer's recommendations. An increase in the frequency might be warranted based on maintenance experience. Additional guidance for leak checks is provided a 14.3.1.5.4.

A.14.3.3.2.2.1 System preventive maintenance typically includes regular leak checks and the replacement of hoses in accordance with the manufacturer's recommendations. An increase in the frequency might be warranted based on maintenance experience.

A.14.3.

~~1~~
3.2.

~~6~~
2.

~~1~~

~~The gas detection should be located in the spray area, at the gas controller, and at the gas supply when the source of supply is located indoors.~~

3 NFPA 86 permits a single safety shutoff valve for radiant tube-fired burner systems based on an explosion resistance validation of the assembly. The explosion pressure from a hydrogen or hydrogen enriched fuel can be significantly greater that for other fuels, and the validation must consider the fuel being used for the installation.

A.14.3.3.3.2.1 System preventive maintenance typically includes regular leak checks and the replacement of hoses in accordance with the manufacturer's recommendations. An increase in the frequency might be warranted based on maintenance experience. NFPA 87 Chapter 7

provides specific guidance for system maintenance.

A.14.3.4

a) Reciprocating engines have demonstrated operation at 100% hydrogen

b) Today's gas turbines are fully capable of operating on 20% hydrogen

c) Gas turbines have demonstrated reliable operation at hydrogen concentrations of 50% and greater using "Syngas", Refinery Gas and Coke Oven Gas; these uses have been limited primarily to industrial settings that, in general, fall into the "petrochemical plant" category.

d) The gas turbine industry has committed to achieving the ability to run on 100% hydrogen by 2030

A.14.3.4.1 NFPA 37 provides detailed information and requirements related to:

(1) Ventilation of system enclosures

(2) Gas detection and emergency action

(3) Fire detection and suppression

Statement of Problem and Substantiation for Public Input

Various combustion process equipment is being shifted from natural gas to blends of natural gas and hydrogen as part of the global shift to hydrogen fuel. These blends range from 5% to 95% plus hydrogen. The most common blend seen to date is 20% hydrogen enriched pipeline natural gas blend in Europe; however, mixing systems have been proposed to increase the use of hydrogen in the near future. This led directly to the formation of the Chapter 14 Task group to capture the known industrial processes on this path and provide the appropriate guidance within the chapter.

In the development of the expanded Chapter 14, the Task Group identified NFPA 37, NFPA 85, NFPA 86 and NFPA 87 to be the applicable Codes and Standards for the combustion process equipment affected by the introduction of hydrogen enriched fuels. Due to the extent and complexity of the changes, this PI is being submitted as a complete Annex Section replacement. A marked up Word document with commentary regarding the changes is attached to PI 224. The Word Document includes both the mandatory Chapter and Annex text.

This PI is submitted by Lawrence Danner, CSP on behalf of the Chapter 14 Task Group.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 221-NFPA 2-2024 [Section No. 1.3.3]	
Public Input No. 222-NFPA 2-2024 [New Section after 3.3.121]	
Public Input No. 223-NFPA 2-2024 [New Section after 3.3.215]	
Public Input No. 224-NFPA 2-2024 [Chapter 14]	
Public Input No. 226-NFPA 2-2024 [New Section after A.3.3.120.2]	

Submitter Information Verification

Submitter Full Name: Larry Danner
Organization: GE Power
Street Address:

City:
State:
Zip:
Submittal Date: Tue Jan 02 11:46:07 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: CI-133-NFPA 2-2024

Statement: Hydrogen enriched fuel sources for combustion are becoming more prominent in industrial applications. The rewrite of Chapter 14 is being developed to keep NFPA 2 relevant with the industry. However, the committee requires more time to ensure the revisions being proposed are adequate and align with the NFPA manual of style. It is encouraged that the public also provide comments concerning this rewrite of Chapter 14.

Public Input No. 168-NFPA 2-2023 [New Section after A.18.3.2.6]

A.18.2.5.1.2

Many hydrogen vehicles use composite fuel supply containers with a polymer liner. This liner can collapse and leak if the pressure in the fuel supply container is too low. The increase of the allowable limit from 400 scf to 1000 scf is intended to protect the polymer liner of medium-/heavy-duty vehicles that have significantly larger volumes over 85 cubic feet. At room temperature, the pressure of 1000 scf of hydrogen is roughly 145 psi which is high enough to protect the fuel supply container liner.

Statement of Problem and Substantiation for Public Input

The medium-/heavy-duty vehicles can contain over 40,000 scf of hydrogen in much larger fuel supply containers. The original volume of 400 scf could lead to low pressures in the container which could damage the liner or allow air to leak. The increase to less than1000 scf allows for increased pressure in the system. Although fuel supply containers are not considered part of the maximum allowable quantity, for reference the MAQ for flammable gases is 1000 scf.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 167-NFPA 2-2023 [Section No. 18.2.5.1.2]	Annex Material
Public Input No. 167-NFPA 2-2023 [Section No. 18.2.5.1.2]	

Submitter Information Verification

Submitter Full Name: Spencer Quong
Organization: Quong & Associates Inc.
Affiliation: Toyota
Street Address:
City:
State:
Zip:
Submittal Date: Thu Dec 21 17:48:46 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: The proposed increase would allow major repairs in a minor garage without requiring a major repair garage and its related safety features, and there is no current justification to allow this increase. This would also need to be correlated with the relevant fire codes.

Public Input No. 156-NFPA 2-2023 [Chapter D]

Annex D ~~Physical~~ Properties of Hydrogen

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1

~~– Physical Properties (Informative).~~
~~Physical Properties~~

~~D.1.1~~ ~~Hydrogen is a flammable gas~~ ~~at standard conditions~~ ~~. It is colorless, odorless, tasteless, and nontoxic. It~~ ~~can cause asphyxiation when it displaces the normal 21 percent oxygen to less than 19.5 percent. Because hydrogen~~ ~~is~~ ~~colorless, odorless, and tasteless, its presence cannot be detected by~~ ~~the~~ ~~human senses. Hydrogen is the~~ ~~lightest gas known, having a specific gravity of 0.0695 (air = 1.0). Hydrogen diffuses rapidly in air and through materials not normally considered porous. Hydrogen remains a gas even at high pressures, with a critical pressure (above which it cannot be liquefied regardless of temperature) of 188 psi (13.0 bar).~~

~~D.1.~~

~~1 –~~

~~2~~ ~~Liquefied hydrogen is transparent, odorless, and not corrosive. Hydrogen is liquefied when cooled to its boiling point of −423°F (−253°C) at atmospheric pressure. Liquefied hydrogen is only 1/14 as heavy as water. Liquefied hydrogen converted to gaseous hydrogen at standard conditions expands in volume by approximately 850 times.~~

~~D.2~~ ~~Combustion Properties~~

~~D.2.1~~ ~~Hydrogen burns in air with a pale blue, almost invisible flame. At atmospheric pressure~~ ~~,~~ ~~the ignition temperature of hydrogen–air mixtures has been reported by the U.S. Bureau of Mines to be as low as 932°F (500°C).~~

~~D.2.2~~ ~~The flammable limits of hydrogen–air mixtures depend on pressure, temperature, and water-vapor content.~~

~~At~~

For a well-mixed and quiescent mixture (i.e. purposefully created, typically in a laboratory setting) at atmospheric pressure, the

~~flammable range is approximately 4 percent to 75 percent~~

lower flammability limit (LFL) is approximately 4% and the upper flammability limit (UFL) is approximately 75% by volume of hydrogen in air.

D. ~~1.~~ **2** –

~~Hydrogen remains a gas even at high pressures~~

~~:~~

~~It is liquefied when cooled to its boiling point of −423°F (−253°C).~~

~~**D.1.3** –~~

~~Hydrogen is nontoxic, but it can cause anoxia (asphyxiation) when it displaces the normal 21 percent oxygen in a confined area without ventilation that will maintain an oxygen content exceeding 19.5 percent. Because hydrogen is colorless, odorless, and tasteless, its presence cannot be detected by the human senses.~~

~~**D.2** – Physical Properties.~~

~~Liquefied hydrogen is transparent, odorless, and not corrosiveor noticeably reactive. The boiling point at atmospheric pressure is −423°F (−253°C). It is only **1/14** as heavy as water. Liquefied hydrogen converted to gaseous hydrogen at standard conditions expands approximately 850 times.~~

3 Hazardous Limit - At concentrations between 4% and 8% by volume in air, buoyancy will drive flame propagation in stagnant mixtures primarily in an upward direction; the entire mixture will likely not burn. Momentum and turbulence also have an important role in ignition and flame propagation in practical release scenarios. Average concentrations in the release direction between 4% and 8% by volume in air for a pressure-driven jet release will not ignite into a sustained jet flame. In summary, attempts to ignite average or absolute mixtures between 4% and 8% by volume of hydrogen in air will self-extinguish after a very short time (e.g., blow-off) or fail, limiting the consequences to only a brief flame in the air or no ignition at all. Thus, a concentration of 8% by volume of hydrogen in air is the practical hazardous limit for the determination of safety or setback distances from indoor or outdoor pressurized release scenarios.

Statement of Problem and Substantiation for Public Input

There is often confusion as to why 8% by volume is used as a criteria for the calculation of setback distances when 4% is the lower flammability limit for hydrogen-air mixtures. This language clarifies why 8% is used as a practical hazardous limit for hydrogen-air mixtures. It also reorganizes the existing material to improve readability.

Submitter Information Verification

Submitter Full Name: Ethan Hecht
Organization: Sandia National Laboratories
Street Address:
City:
State:
Zip:
Submittal Date: Wed Dec 20 14:00:41 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-101-NFPA 2-2024
Statement: There is often confusion as to why 8% by volume is used as a criteria for the calculation of setback distances when 4% is the lower flammability limit for hydrogen-air mixtures. This language clarifies why 8% is used as a practical hazardous limit for hydrogen-air mixtures. It also reorganizes the existing material to improve readability.

Public Input No. 214-NFPA 2-2023 [New Section after D.2]

D.3 Combustion _ Properties

D.3.1 Hydrogen burns in air with a pale blue, almost invisible flame. At atmospheric pressure, the ignition temperature of hydrogen–air mixtures has been reported by the U.S. Bureau of Mines to be as low as 932°F (500°C).

D.3.2 The flammable limits of hydrogen–air mixtures depend on pressure, temperature, and water-vapor content. For a well-mixed and quiescent mixture at atmospheric pressure, the lower flammability limit (LFL) is approximately 4% and the upper flammability limit (UFL) is approximately 75% by volume of hydrogen in air.

D.3.3 Hazardous Limit - At concentrations between 4% and 8% by volume in air, buoyancy will drive flame propagation in stagnant mixtures primarily in an upward direction; the entire mixture will not burn. Momentum and turbulence also have an important role in ignition and flame propagation in practical release scenarios. Average concentrations in the release direction between 4% and 8% by volume in air for a pressure-driven jet release will not ignite into a sustained jet flame. In summary, attempts to ignite average or absolute mixtures between 4% and 8% by volume of hydrogen in air will self-extinguish after a very short time, limiting the consequences to only a brief flame in the air or no ignition at all. Thus, a concentration of 8% by volume of hydrogen in air is the practical hazardous limit for indoor or outdoor pressurized release scenarios. .

...

Statement of Problem and Substantiation for Public Input

Substantiation: This is based on input from Sandia Labs as interpreted by the submitter.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 16:27:56 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: CI-207-NFPA 2-2024

Statement: Action was taken by the committee which revised Annex D and addressed similar concerns raised by Public Input No. 214. The committee will review differences between PI-214 and the First Revision of Annex D and make any necessary changes at the Second Draft meeting. The public is also encouraged to provide public comments to address similar changes to Annex D.

Public Input No. 209-NFPA 2-2023 [Section No. E.1]

E.1 Separation Distances Tables Methodology History.

See section E.7 for methodology and assumption updates.

The evaluation of separation distances for bulk gaseous hydrogen systems was the subject of study of a joint task group that comprised members of NFPA's Hydrogen Technology Technical Committee and the Industrial and Medical Gases Technical Committee. The task of the group was to examine the exposure distances published in Table 10.3.2.2.1 of the 2005 edition of NFPA 55 for the purpose of validation or revision based on a scientific approach that could be substantiated either through testing or through generally accepted scientific means for the 2010 edition of NFPA 55.

In the 2016 edition of NFPA 2, exposures were grouped in Table 7.4.3.2.3.1.1(A)(a) based upon the rationale for determining the associated hazard, as shown in Table E.1(a) and Table E.1(b). Table E.1(a) is cross-referenced to Table 7.4.3.2.3.1.1(A)(a) by exposure group number and row letter. Notes are provided to indicate the specific rationale considered for each of the exposures listed. The notes are then cross-referenced to specific hazard scenarios further defined in Table E.1(b). The performance criteria and design scenarios have been extracted from NFPA 1 as indicated in the extracts provided. [1] For each exposure, the effects of a release were considered within the context of hazard scenarios developed in the performance approach foundational to determining the design scenarios outlined in the performance-based option in NFPA 1.

In the event alternative materials or methods are to be employed when bulk systems are installed, code users should be aware of the specific hazard scenarios used to analyze each exposure.

Studies by Houf and Schefer of Sandia National Laboratories (Sandia) predicted the radiative heat flux at various distances resulting from the ignition of turbulent jet releases of hydrogen from systems at various pressures. In addition, the concentrations of an unignited hydrogen jet in the surrounding air and the envelope where the concentration falls below the lower flammability limit for hydrogen were determined. [2] Understanding the consequences of release in terms of thermal flux or the boundaries of the unignited cloud were then used to determine distances that were believed to be appropriate based on the consequence of a release. The consequence approach is referred to as a deterministic approach because distances are determined based on consequence alone. Another consequence-based approach, found in a project sponsored by NFPA's Fire Research Foundation, to determine appropriate separation distances for certain installations of bulk gaseous hydrogen systems was also reviewed by the task group, and comparisons were made to the existing requirements in the 2005 edition of NFPA 55.[3]

As the group evaluated the impact of the deterministic tables, it became apparent that the probability of occurrence of events should have a bearing on determining a reasonable level of safety.

The work of the task group integrated the efforts of Sandia's risk and reliability department, as part of the US Department of Energy Hydrogen, Fuel Cells & Infrastructure Technologies Program.

Researchers at Sandia developed benchmark experiments and a defensible analysis strategy for risk and consequence assessment of unintended releases from gaseous hydrogen systems. This work included experimentation and modeling to understand the fluid mechanics and dispersion of hydrogen for different release scenarios, including investigations of hydrogen combustion and subsequent heat transfer from hydrogen flames. The resulting technical information was incorporated into engineering models that were used for assessment of different hydrogen release scenarios and for input into quantitative risk assessments (QRA) of hydrogen facilities.

The QRAs were used to identify and quantify scenarios for the unintended release of hydrogen, identify the significant risk contributors at different types of hydrogen facilities, and to identify potential accident prevention and mitigation strategies to reduce the risk to acceptable levels. [4]

To evaluate risk, the history of leakage data from high-pressure compressed gas systems was needed. Hydrogen-specific leak data were provided by one of the major suppliers through the use of a 5-year documented collection of leak data from both industrial and fueling uses. These data were augmented with data from other sources after being reviewed for applicability, and

representative values were selected. The source documents considered in augmentation of hydrogen-specific data included the following publications:

(1) "Determination of Safety Distances," European Industrial Gases Association, IGC Doc 75/07/E, 2007.

(2) A. W. Cox, F. P. Lees, and M. L. Ang, "Classification of Hazardous Locations," Institution of Chemical Engineers, May 2003.

(3) C. H. Blanton and S. A. Eide, "Savannah River Site Generic Data Base Development," WSRC-TR-93-262, Westinghouse Savannah River Company, June 30, 1993.

(4) J. Spouge, "New Generic Leak Frequencies for Process Equipment," *Process Safety Progress* (Vol. 24, No. 4), December 2005.

A hierarchy was developed that gave hydrogen-specific data the highest priority, followed by non-gas-specific data where available for high-pressure components. Piping and instrumentation drawings (P&IDs) were then prepared to define a standard bulk supply system in terms of modules that might be found in the typical system. The P&IDs can be found in A.3.3.95.9.1 of NFPA 55. The P&IDs were reviewed by suppliers and the typical nature verified.

Frequency and size of leaks encountered were evaluated across a number of systems, including both industrial and fueling operations. The leak/failure data were then applied to "typical" fitting counts (i.e., components) integral to each of the modules identified in the P&IDs for each of the components. The failure data were based on the most recent 5-year history for high-pressure systems. Hydrogen-specific data were provided by Compressed Gas Association (CGA) representatives. These data were augmented by failure data from other resources obtained by researchers from Sandia and combined to quantify a probability for failure on a component-by-component basis [e.g., hoses (pigtails), valves, instruments, joints, pipe]. The analysis resulted in a probability for failure being developed for each component, which could then be wrapped into failures expected across the spectrum of the various modules included in the array of P&IDs developed.

A Bayesian approach to the determination of probability was used in the analysis of data by researchers at Sandia. The technical approach and supporting details can be found in the articles listed in Annex H of NFPA 55 and informational articles found in Section I.2 of NFPA 55. The advantage of the Bayesian approach is that it can combine data from different sources to include uncertainty. This approach is contrary to what has been done in other sources. For example, judgment can be used as a means to determine risk; however, that method does not provide for uncertainty. Such methods are qualitative at best. By comparison, the use of specific leak data results in a quantitative approach.

The tables developed for inclusion in Chapter 10 of the 2010 edition of NFPA 55 are said to be *risk informed,* not *risk based,* the difference being that integral to the risk tables is a series of decisions based on the applicability of various factors. For example, with respect to thermal flux, one could use a series of exposures from *no harm* to *fatality,* and those exposures could then be taken from the point of various receptors (workers, people on the property where the installation is located, people off the property, etc.). One of the primary decisions made by the group was that in the final analysis the risk presented for the typical GH_2 installation (either industrial or fueling applications) should present no greater risk to the public in terms of fatalities or injuries than does an existing gasoline service station. The average frequency of a fatality associated with the operation of a single gasoline station has been reported to be approximately 2E-5/yr. [5] Other key decisions of the group included the parameters given in Sections E.2 through E.5.

Table E.1(a) Hazard Scenario

Row	Group 1 Exposures greater of a or b	Hazard Scenario Rationale[c]
(a)	Lot lines	1, 2, 3, 4, 5
(b)	Air intakes (HVAC, compressors, other)	1
(c)	Operable openings in buildings and structures	1, 2

Row	Group 1 Exposures greater of a or b	Hazard Scenario Rationale[c]
(d)	Ignition sources such as open flames and welding	3, 5
Row	**Group 2 Exposures[d]**	**Hazard Scenario Rationale[c]**
(a)	Exposed persons other than those involved in servicing of the system	4
(b)	Parked cars	4
Row	**Group 3 Exposures[e]**	**Hazard Scenario Rationale[c]**
(a)	Buildings of noncombustible non-fire-rated construction	2
(b)	Buildings of combustible construction	2
-	-	-
(c)	Flammable gas storage systems above or below ground	2
(d)	Hazardous materials storage systems above or below ground	6, 7, 8, 9
(e)	Heavy timber, coal, or other slow-burning combustible solids	2
(f)	Ordinary combustibles, including fast-burning solids such as ordinary lumber, excelsior, paper, or combustible waste and vegetation other than that found in maintained landscaped areas	2
(g)	Unopenable openings in buildings and structures	1, 2
(h)	Encroachment by overhead utilities (horizontal distance from the vertical plane below the nearest overhead electrical wire of building service)	2, 10
(i)	Piping containing other hazardous materials	6, 7, 8, 9
(j)	Flammable gas metering and regulating stations such as natural gas or propane	6, 7, 8, 9

[a]Unignited jet concentration decay distance to 4 percent mole fraction (volume fraction) hydrogen.

[b]Drad – radiation heat flux level of 1577 W/m^2.

[c]See Table E.1(b) of NFPA 55 for explanation of notes.

[d]Drad for heat flux level of 4732 W/m^2 exposure to employees for a maximum of 3 minutes.

[e]The greater of Drad for combustible heat flux level of 20,000 W/m^2 or the visible flame length.

Table E.1(b) Hazard Scenario Rationale Notes to Table E.1(a) of NFPA 55

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
1	Gas release and subsequent entrainment or accumulation by the receptor	**Explosion Conditions.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the	**Hazardous Materials Design Scenario 1.** Hazardous Materials Design Scenario 1 involves an unauthorized release of hazardous materials from a single control area.

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
		effects of unintentional detonation or deflagration. [**1:**5.2.2.2]	This design scenario shall address the concern regarding the spread of hazardous conditions from the point of release. [**1:**5.4.4.1]
2	Fire spread to or from adjacent equipment or structure	**Property Protection.** The facility design shall limit the effects of all required design scenarios from causing an unacceptable level of property damage. [**1:**5.2.2.4]	**Hazardous Materials Design Scenario 2.** Hazardous Materials Design Scenario 2 involves an exposure fire on a location where hazardous materials are stored, used, handled, or dispensed. This design scenario shall address the concern regarding how a fire in a facility affects the safe storage, handling, or use of hazardous materials. [**1:**5.4.4.2]
3	Gas explosion hazard on site or affecting adjacent property	**Explosion Conditions.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of unintentional detonation or deflagration. [**1:**5.2.2.2]	**Hazardous Materials Design Scenario 1.** Hazardous Materials Design Scenario 1 involves an unauthorized release of hazardous materials from a single control area. This design scenario shall address the concern regarding the spread of hazardous conditions from the point of release. [**1:**5.4.4.1]
4	Threat of injuries on site or adjacent property	**Hazardous Materials Exposure.** The facility design	**Hazardous Materials Design Scenario 2.** Hazardous

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
			Materials Design Scenario 2 involves an exposure fire on a location where hazardous materials are stored, used, handled, or dispensed. This design scenario shall address the concern regarding how a fire in a facility affects the safe storage, handling, or use of hazardous materials. [**1:**5.4.4.2] **Hazardous Materials Design Scenario 4.** Hazardous Materials Design Scenario 4 involves an unauthorized discharge with each protection system independently rendered ineffective. This set of design hazardous materials scenarios shall address concern regarding each protection system or protection feature, considered individually, being unreliable or becoming unavailable. [**1:**5.4.4.4.1]
		shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of an unauthorized release of hazardous materials or the unintentional reaction of hazardous materials. [**1:**5.2.2.3]	
5	Ignition of an unignited release/vented hydrogen	**Explosion Conditions.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the	**Hazardous Materials Design Scenario 1.** Hazardous Materials Design Scenario 1 involves an unauthorized release of hazardous materials from a single control area.

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
		effects of unintentional detonation or deflagration. [**1:**5.2.2.2]	This design scenario shall address the concern regarding the spread of hazardous conditions from the point of release. [**1:**5.4.4.1]
6	Damage to exposed components of underground system that are exposed above ground	**Property Protection.** The facility design shall limit the effects of all required design scenarios from causing an unacceptable level of property damage. [**1:**5.2.2.4]	**Hazardous Materials Design Scenario 1.** Hazardous Materials Design Scenario 1 involves an unauthorized release of hazardous materials from a single control area. This design scenario shall address the concern regarding the spread of hazardous conditions from the point of release. [**1:**5.4.4.1]
7	Damage to aboveground system due to function of explosion control system used to vent underground vault or structure	**Property Protection.** The facility design shall limit the effects of all required design scenarios from causing an unacceptable level of property damage. [**1:**5.2.2.4] **Explosion Conditions.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of unintentional detonation or deflagration.	**Hazardous Materials Design Scenario 3.** Hazardous Materials Design Scenario 3 involves the application of an external factor to the hazardous material that is likely to result in a fire, explosion, toxic release, or other unsafe condition. This design scenario shall address the concern regarding the initiation of a hazardous materials event by the application of heat, shock, impact, or water onto a hazardous material being stored, used, handled, or

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
		[**1:**5.2.2.2]	dispensed in the facility. [**1:**5.4.4.3]
8	Fire or explosion in other hazardous materials resulting in release of hydrogen	**Hazardous Materials Exposure.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of an unauthorized release of hazardous materials or the unintentional reaction of hazardous materials. [**1:**5.2.2.3]	**Hazardous Materials Design Scenario 3.** Hazardous Materials Design Scenario 3 involves the application of an external factor to the hazardous material that is likely to result in a fire, explosion, toxic release, or other unsafe condition. This design scenario shall address the concern regarding the initiation of a hazardous materials event by the application of heat, shock, impact, or water onto a hazardous material being stored, used, handled, or dispensed in the facility. [**1:**5.4.4.3]
9	Fire or explosion in hydrogen system resulting in release of other hazardous materials	**Hazardous Materials Exposure.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of an unauthorized release of hazardous materials or the unintentional reaction of hazardous materials. [**1:**5.2.2.3]	**Hazardous Materials Design Scenario 2.** Hazardous Materials Design Scenario 2 involves an exposure fire on a location where hazardous materials are stored, used, handled, or dispensed. This design scenario shall address the concern regarding how a fire in a facility affects the safe storage, handling, or use of hazardous materials. [**1:**5.4.4.2]

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario		
10	Failure of equipment exposing hydrogen system to electrical hazard, physical, or health hazard; failure of system exposing utilities to failure	**Property Protection.** The facility design shall limit the effects of all required design scenarios from causing an unacceptable level of property damage. [**1:**5.2.2.4]	**Hazardous Materials Design Scenario 3.** Hazardous Materials Design Scenario 3 involves the application of an external factor to the hazardous material that is likely to result in a fire, explosion, toxic release, or other unsafe condition.		
		-	-	**Public Welfare.** For facilities that serve a public welfare role as defined in 4.1.5 of NFPA 1, the facility design shall limit the effects of all required design scenarios from causing an unacceptable interruption of the facility's mission. [**1:**5.2.2.5]	This design scenario shall address the concern regarding the initiation of a hazardous materials event by the application of heat, shock, impact, or water onto a hazardous material being stored, used, handled, or dispensed in the facility. [**1:**5.4.4.3]

Statement of Problem and Substantiation for Public Input

Adding a pointer reduces the liklihood that E.7 updates will be missed entirely. It may be better to rewrite Annex E in its entirety and make it apply to the 2026 edition. I think it will not change much more.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 16:11:56 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-208-NFPA 2-2024

Statement: Adding a pointer reduces the likelihood that E.7 updates will be missed by the user. Update reference to NFPA 55 where needed to retain methodology explanation.

User is directed to to E.6 and E.7 to avoid confusion regarding the concentration of hydrogen considered hazardous for these efforts. Correct conflicting information in E.3 which has been updated in E.7.Other revisions have been made which provides clarity that annex E is only referring to Bulk Gaseous Separation distances, and strengthens the reference to the technical report that details all of the calculations. Strengthening the reference ensures that knowledge is not lost if the majority of E.9 which has been deleted.

Public Input No. 210-NFPA 2-2023 [Section No. E.1]

E.1 Separation Distances Tables Methodology History.

The evaluation of separation distances for bulk gaseous hydrogen systems was the subject of study of a joint task group that comprised members of NFPA's Hydrogen Technology Technical Committee and the Industrial and Medical Gases Technical Committee. The task of the group was to examine the exposure distances published in Table 10.3.2.2.1 of the 2005 edition of NFPA 55 for the purpose of validation or revision based on a scientific approach that could be substantiated either through testing or through generally accepted scientific means for the 2010 edition of NFPA 55.

In the 2016 edition of NFPA 2, exposures were grouped in Table 7.4.3.2.3.1.1(A)(a) based upon the rationale for determining the associated hazard, as shown in Table E.1(a) and Table E.1(b). Table E.1(a) is cross-referenced to Table 7.4.3.2.3.1.1(A)(a) by exposure group number and row letter. Notes are provided to indicate the specific rationale considered for each of the exposures listed. The notes are then cross-referenced to specific hazard scenarios further defined in Table E.1(b). The performance criteria and design scenarios have been extracted from NFPA 1 as indicated in the extracts provided. [1] For each exposure, the effects of a release were considered within the context of hazard scenarios developed in the performance approach foundational to determining the design scenarios outlined in the performance-based option in NFPA 1.

In the event alternative materials or methods are to be employed when bulk systems are installed, code users should be aware of the specific hazard scenarios used to analyze each exposure.

Studies by Houf and Schefer of Sandia National Laboratories (Sandia) predicted the radiative heat flux at various distances resulting from the ignition of turbulent jet releases of hydrogen from systems at various pressures. In addition, the concentrations of an unignited hydrogen jet in the surrounding air and the envelope where the concentration falls below the lower flammability limit for hydrogen were determined. [2] Understanding the consequences of release in terms of thermal flux or the boundaries of the unignited cloud were then used to determine distances that were believed to be appropriate based on the consequence of a release. The consequence approach is referred to as a deterministic approach because distances are determined based on consequence alone. Another consequence-based approach, found in a project sponsored by NFPA's Fire Research Foundation, to determine appropriate separation distances for certain installations of bulk gaseous hydrogen systems was also reviewed by the task group, and comparisons were made to the existing requirements in the 2005 edition of NFPA 55.[3]

As the group evaluated the impact of the deterministic tables, it became apparent that the probability of occurrence of events should have a bearing on determining a reasonable level of safety.

The work of the task group integrated the efforts of Sandia's risk and reliability department, as part of the US Department of Energy Hydrogen, Fuel Cells & Infrastructure Technologies Program.

Researchers at Sandia developed benchmark experiments and a defensible analysis strategy for risk and consequence assessment of unintended releases from gaseous hydrogen systems. This work included experimentation and modeling to understand the fluid mechanics and dispersion of hydrogen for different release scenarios, including investigations of hydrogen combustion and subsequent heat transfer from hydrogen flames. The resulting technical information was incorporated into engineering models that were used for assessment of different hydrogen release scenarios and for input into quantitative risk assessments (QRA) of hydrogen facilities.

The QRAs were used to identify and quantify scenarios for the unintended release of hydrogen, identify the significant risk contributors at different types of hydrogen facilities, and to identify potential accident prevention and mitigation strategies to reduce the risk to acceptable levels. [4]

To evaluate risk, the history of leakage data from high-pressure compressed gas systems was needed. Hydrogen-specific leak data were provided by one of the major suppliers through the use of a 5-year documented collection of leak data from both industrial and fueling uses. These data were augmented with data from other sources after being reviewed for applicability, and representative values were selected. The source documents considered in augmentation of

hydrogen-specific data included the following publications:

(1) "Determination of Safety Distances," European Industrial Gases Association, IGC Doc 75/07/E, 2007.

(2) A. W. Cox, F. P. Lees, and M. L. Ang, "Classification of Hazardous Locations," Institution of Chemical Engineers, May 2003.

(3) C. H. Blanton and S. A. Eide, "Savannah River Site Generic Data Base Development," WSRC-TR-93-262, Westinghouse Savannah River Company, June 30, 1993.

(4) J. Spouge, "New Generic Leak Frequencies for Process Equipment," *Process Safety Progress* (Vol. 24, No. 4), December 2005.

A hierarchy was developed that gave hydrogen-specific data the highest priority, followed by non-gas-specific data where available for high-pressure components. Piping and instrumentation drawings (P&IDs) were then prepared to define a standard bulk supply system in terms of modules that might be found in the typical system. The P&IDs can be found in A.3.3.95.9.1 of NFPA 55. The P&IDs were reviewed by suppliers and the typical nature verified.

Frequency and size of leaks encountered were evaluated across a number of systems, including both industrial and fueling operations. The leak/failure data were then applied to "typical" fitting counts (i.e., components) integral to each of the modules identified in the P&IDs for each of the components. The failure data were based on the most recent 5-year history for high-pressure systems. Hydrogen-specific data were provided by Compressed Gas Association (CGA) representatives. These data were augmented by failure data from other resources obtained by researchers from Sandia and combined to quantify a probability for failure on a component-by-component basis [e.g., hoses (pigtails), valves, instruments, joints, pipe]. The analysis resulted in a probability for failure being developed for each component, which could then be wrapped into failures expected across the spectrum of the various modules included in the array of P&IDs developed.

A Bayesian approach to the determination of probability was used in the analysis of data by researchers at Sandia. The technical approach and supporting details can be found in the articles listed in ~~Annex H of NFPA 55~~ this Annex and informational articles found in Section I.2 of NFPA 55. The advantage of the Bayesian approach is that it can combine data from different sources to include uncertainty. This approach is contrary to what has been done in other sources. For example, judgment can be used as a means to determine risk; however, that method does not provide for uncertainty. Such methods are qualitative at best. By comparison, the use of specific leak data results in a quantitative approach.

The tables developed for inclusion in Chapter 10 of the 2010 edition of NFPA 55 ~~are said to be~~ and extracted into NFPA 2 are described as *risk informed,* not *risk based,* the difference being that integral to the risk tables is a series of decisions based on the applicability of various factors. For example, with respect to thermal flux, one could use a series of exposures from *no harm* to *fatality,* and those exposures could then be taken from the point of various receptors (workers, people on the property where the installation is located, people off the property, etc.). One of the primary decisions made by the group was that in the final analysis the risk presented for the typical GH_2 installation (either industrial or fueling applications) should present no greater risk to the public in terms of fatalities or injuries than does an existing gasoline service station. The average frequency of a fatality associated with the operation of a single gasoline station has been reported to be approximately 2E-5/yr. [5] Other key decisions of the group included the parameters given in Sections E.2 through E.5.

Table E.1(a) Hazard Scenario

Row	Group 1 Exposures greater of a or b	Hazard Scenario Rationale[c]
(a)	Lot lines	1, 2, 3, 4, 5
(b)	Air intakes (HVAC, compressors, other)	1
(c)	Operable openings in buildings and structures	1, 2
(d)	Ignition sources such as open flames and welding	3, 5

Row	Group 1 Exposures greater of a or b	Hazard Scenario Rationale[c]
Row	**Group 2 Exposures[d]**	**Hazard Scenario Rationale[c]**
(a)	Exposed persons other than those involved in servicing of the system	4
(b)	Parked cars	4
Row	**Group 3 Exposures[e]**	**Hazard Scenario Rationale[c]**
(a)	Buildings of noncombustible non-fire-rated construction	2
(b)	Buildings of combustible construction	2
-	-	-
(c)	Flammable gas storage systems above or below ground	2
(d)	Hazardous materials storage systems above or below ground	6, 7, 8, 9
(e)	Heavy timber, coal, or other slow-burning combustible solids	2
(f)	Ordinary combustibles, including fast-burning solids such as ordinary lumber, excelsior, paper, or combustible waste and vegetation other than that found in maintained landscaped areas	2
(g)	Unopenable openings in buildings and structures	1, 2
(h)	Encroachment by overhead utilities (horizontal distance from the vertical plane below the nearest overhead electrical wire of building service)	2, 10
(i)	Piping containing other hazardous materials	6, 7, 8, 9
(j)	Flammable gas metering and regulating stations such as natural gas or propane	6, 7, 8, 9

[a]Unignited jet concentration decay distance to 4 percent mole fraction (volume fraction) hydrogen.

[b]Drad – radiation heat flux level of 1577 W/m^2.

[c]See Table E.1(b) of NFPA 55 for explanation of notes.

[d]Drad for heat flux level of 4732 W/m^2 exposure to employees for a maximum of 3 minutes.

[e]The greater of Drad for combustible heat flux level of 20,000 W/m^2 or the visible flame length.

Table E.1(b) Hazard Scenario Rationale Notes to Table E.1(a) of NFPA 55

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
1	Gas release and subsequent entrainment or accumulation by the receptor	**Explosion Conditions.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of	**Hazardous Materials Design Scenario 1.** Hazardous Materials Design Scenario 1 involves an unauthorized release of hazardous materials from a single control area. This design

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
		unintentional detonation or deflagration. [**1:**5.2.2.2]	scenario shall address the concern regarding the spread of hazardous conditions from the point of release. [**1:**5.4.4.1]
2	Fire spread to or from adjacent equipment or structure	**Property Protection.** The facility design shall limit the effects of all required design scenarios from causing an unacceptable level of property damage. [**1:**5.2.2.4]	**Hazardous Materials Design Scenario 2.** Hazardous Materials Design Scenario 2 involves an exposure fire on a location where hazardous materials are stored, used, handled, or dispensed. This design scenario shall address the concern regarding how a fire in a facility affects the safe storage, handling, or use of hazardous materials. [**1:**5.4.4.2]
3	Gas explosion hazard on site or affecting adjacent property	**Explosion Conditions.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of unintentional detonation or deflagration. [**1:**5.2.2.2]	**Hazardous Materials Design Scenario 1.** Hazardous Materials Design Scenario 1 involves an unauthorized release of hazardous materials from a single control area. This design scenario shall address the concern regarding the spread of hazardous conditions from the point of release. [**1:**5.4.4.1]
4	Threat of injuries on site or adjacent property	**Hazardous Materials Exposure.** The facility design shall provide an	**Hazardous Materials Design Scenario 2.** Hazardous Materials Design

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
		acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of an unauthorized release of hazardous materials or the unintentional reaction of hazardous materials. [**1:**5.2.2.3]	Scenario 2 involves an exposure fire on a location where hazardous materials are stored, used, handled, or dispensed. This design scenario shall address the concern regarding how a fire in a facility affects the safe storage, handling, or use of hazardous materials. [**1:**5.4.4.2] **Hazardous Materials Design Scenario 4.** Hazardous Materials Design Scenario 4 involves an unauthorized discharge with each protection system independently rendered ineffective. This set of design hazardous materials scenarios shall address concern regarding each protection system or protection feature, considered individually, being unreliable or becoming unavailable. [**1:**5.4.4.4.1]
5	Ignition of an unignited release/vented hydrogen	**Explosion Conditions.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of	**Hazardous Materials Design Scenario 1.** Hazardous Materials Design Scenario 1 involves an unauthorized release of hazardous materials from a single control area. This design

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
		unintentional detonation or deflagration. [**1:**5.2.2.2]	scenario shall address the concern regarding the spread of hazardous conditions from the point of release. [**1:**5.4.4.1]
6	Damage to exposed components of underground system that are exposed above ground	**Property Protection.** The facility design shall limit the effects of all required design scenarios from causing an unacceptable level of property damage. [**1:**5.2.2.4]	**Hazardous Materials Design Scenario 1.** Hazardous Materials Design Scenario 1 involves an unauthorized release of hazardous materials from a single control area. This design scenario shall address the concern regarding the spread of hazardous conditions from the point of release. [**1:**5.4.4.1]

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
7	Damage to aboveground system due to function of explosion control system used to vent underground vault or structure	**Property Protection.** The facility design shall limit the effects of all required design scenarios from causing an unacceptable level of property damage. [**1:**5.2.2.4] **Explosion Conditions.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of unintentional detonation or deflagration. [**1:**5.2.2.2]	**Hazardous Materials Design Scenario 3.** Hazardous Materials Design Scenario 3 involves the application of an external factor to the hazardous material that is likely to result in a fire, explosion, toxic release, or other unsafe condition. This design scenario shall address the concern regarding the initiation of a hazardous materials event by the application of heat, shock, impact, or water onto a hazardous material being stored, used, handled, or dispensed in the facility. [**1:**5.4.4.3]
8	Fire or explosion in other hazardous materials resulting in release of hydrogen	**Hazardous Materials Exposure.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of an unauthorized release of hazardous materials or the unintentional reaction of hazardous materials. [**1:**5.2.2.3]	**Hazardous Materials Design Scenario 3.** Hazardous Materials Design Scenario 3 involves the application of an external factor to the hazardous material that is likely to result in a fire, explosion, toxic release, or other unsafe condition. This design scenario shall address the concern regarding the initiation of a hazardous materials event by the application of heat, shock, impact, or water onto a hazardous material being stored, used, handled, or

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario		
			dispensed in the facility. [**1:**5.4.4.3]		
9	Fire or explosion in hydrogen system resulting in release of other hazardous materials	**Hazardous Materials Exposure.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of an unauthorized release of hazardous materials or the unintentional reaction of hazardous materials. [**1:**5.2.2.3]	**Hazardous Materials Design Scenario 2.** Hazardous Materials Design Scenario 2 involves an exposure fire on a location where hazardous materials are stored, used, handled, or dispensed. This design scenario shall address the concern regarding how a fire in a facility affects the safe storage, handling, or use of hazardous materials. [**1:**5.4.4.2]		
10	Failure of equipment exposing hydrogen system to electrical hazard, physical, or health hazard; failure of system exposing utilities to failure	**Property Protection.** The facility design shall limit the effects of all required design scenarios from causing an unacceptable level of property damage. [**1:**5.2.2.4]	**Hazardous Materials Design Scenario 3.** Hazardous Materials Design Scenario 3 involves the application of an external factor to the hazardous material that is likely to result in a fire, explosion, toxic release, or other unsafe condition.		
		-	-	**Public Welfare.** For facilities that serve a public welfare role as defined in 4.1.5 of NFPA 1, the facility design shall limit the effects of all required design scenarios from causing an unacceptable interruption of the facility's mission.	This design scenario shall address the concern regarding the initiation of a hazardous materials event by the application of heat, shock, impact, or water onto a hazardous material being stored, used,

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario		
				[**1:**5.2.2.5]	handled, or dispensed in the facility. [**1:**5.4.4.3]

Statement of Problem and Substantiation for Public Input

Update reference to NFPA 55 where needed to retain methodology explanation. maybe a rewrite of Annex E to remove the chronology of sections (that was done to avoid a rewrite) is warranted.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 16:14:47 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-208-NFPA 2-2024

Statement: Adding a pointer reduces the likelihood that E.7 updates will be missed by the user. Update reference to NFPA 55 where needed to retain methodology explanation.

User is directed to to E.6 and E.7 to avoid confusion regarding the concentration of hydrogen considered hazardous for these efforts. Correct conflicting information in E.3 which has been updated in E.7.Other revisions have been made which provides clarity that annex E is only referring to Bulk Gaseous Separation distances, and strengthens the reference to the technical report that details all of the calculations. Strengthening the reference ensures that knowledge is not lost if the majority of E.9 which has been deleted.

Public Input No. 303-NFPA 2-2024 [Section No. E.1]

E.1– Bulk Gaseous Separation Distances Tables Methodology History.

The evaluation of separation distances for bulk gaseous hydrogen systems was the subject of study of a joint task group that comprised members of NFPA's Hydrogen Technology Technical Committee and the Industrial and Medical Gases Technical Committee. The task of the group was to examine the exposure distances published in Table 10.3.2.2.1 of the 2005 edition of NFPA 55 for the purpose of validation or revision based on a scientific approach that could be substantiated either through testing or through generally accepted scientific means for the 2010 edition of NFPA 55.

In the 2016 ~~edition~~ and later editions of NFPA 2, exposures were grouped in Table 7.4.3.2.3.1.1(A)(a) based upon the rationale for determining the associated hazard, as shown in Table E.1(a) and Table E.1(b). Table E.1(a) is cross-referenced to Table 7.4.3.2.3.1.1(A)(a) by exposure group number and row letter. Notes are provided to indicate the specific rationale considered for each of the exposures listed. The notes are then cross-referenced to specific hazard scenarios further defined in Table E.1(b). The performance criteria and design scenarios have been extracted from NFPA 1 as indicated in the extracts provided. [1] For each exposure, the effects of a release were considered within the context of hazard scenarios developed in the performance approach foundational to determining the design scenarios outlined in the performance-based option in NFPA 1.

In the event alternative materials or methods are to be employed when bulk systems are installed, code users should be aware of the specific hazard scenarios used to analyze each exposure.

Studies by Houf and Schefer of Sandia National Laboratories (Sandia) predicted the radiative heat flux at various distances resulting from the ignition of turbulent jet releases of hydrogen from systems at various pressures. In addition, the concentrations of an unignited hydrogen jet in the surrounding air and the envelope where the concentration falls below the lower flammability limit for hydrogen were determined. [2] Understanding the consequences of release in terms of thermal flux or the boundaries of the unignited cloud were then used to determine distances that were believed to be appropriate based on the consequence of a release. The consequence approach is referred to as a deterministic approach because distances are determined based on consequence alone. Another consequence-based approach, found in a project sponsored by NFPA's Fire Research Foundation, to determine appropriate separation distances for certain installations of bulk gaseous hydrogen systems was also reviewed by the task group, and comparisons were made to the existing requirements in the 2005 edition of NFPA 55.[3]

As the group evaluated the impact of the deterministic tables, it became apparent that the probability of occurrence of events should have a bearing on determining a reasonable level of safety.

The work of the task group integrated the efforts of Sandia's risk and reliability department, as part of the US Department of Energy Hydrogen, Fuel Cells & Infrastructure Technologies Program.

Researchers at Sandia developed benchmark experiments and a defensible analysis strategy for risk and consequence assessment of unintended releases from gaseous hydrogen systems. This work included experimentation and modeling to understand the fluid mechanics and dispersion of hydrogen for different release scenarios, including investigations of hydrogen combustion and subsequent heat transfer from hydrogen flames. The resulting technical information was incorporated into engineering models that were used for assessment of different hydrogen release scenarios and for input into quantitative risk assessments (QRA) of hydrogen facilities, all of which is detailed in a technical report . [4]

The QRAs were used to identify and quantify scenarios for the unintended release of hydrogen, identify the significant risk contributors at different types of hydrogen facilities, and to identify potential accident prevention and mitigation strategies to reduce the risk to acceptable levels. [4]

To evaluate risk, the history of leakage data from high-pressure compressed gas systems was needed. Hydrogen-specific leak data were provided by one of the major suppliers through the use of a 5-year documented collection of leak data from both industrial and fueling uses. These data were augmented with data from other sources after being reviewed for applicability, and representative values were selected. The source documents considered in augmentation of

hydrogen-specific data included the following publications:

(1) "Determination of Safety Distances," European Industrial Gases Association, IGC Doc 75/07/E, 2007.

(2) A. W. Cox, F. P. Lees, and M. L. Ang, "Classification of Hazardous Locations," Institution of Chemical Engineers, May 2003.

(3) C. H. Blanton and S. A. Eide, "Savannah River Site Generic Data Base Development," WSRC-TR-93-262, Westinghouse Savannah River Company, June 30, 1993.

(4) J. Spouge, "New Generic Leak Frequencies for Process Equipment," *Process Safety Progress* (Vol. 24, No. 4), December 2005.

A hierarchy was developed that gave hydrogen-specific data the highest priority, followed by non-gas-specific data where available for high-pressure components. Piping and instrumentation drawings (P&IDs) were then prepared to define a standard bulk supply system in terms of modules that might be found in the typical system. The P&IDs can be found in A.3.3.95.9.1 of NFPA 55. The P&IDs were reviewed by suppliers and the typical nature verified.

Frequency and size of leaks encountered were evaluated across a number of systems, including both industrial and fueling operations. The leak/failure data were then applied to "typical" fitting counts (i.e., components) integral to each of the modules identified in the P&IDs for each of the components. The failure data were based on the most recent 5-year history for high-pressure systems. Hydrogen-specific data were provided by Compressed Gas Association (CGA) representatives. These data were augmented by failure data from other resources obtained by researchers from Sandia and combined to quantify a probability for failure on a component-by-component basis [e.g., hoses (pigtails), valves, instruments, joints, pipe]. The analysis resulted in a probability for failure being developed for each component, which could then be wrapped into failures expected across the spectrum of the various modules included in the array of P&IDs developed.

A Bayesian approach to the determination of probability was used in the analysis of data by researchers at Sandia. The technical approach and supporting details can be found in the articles listed in Annex H of NFPA 55 and informational articles found in Section I.2 of NFPA 55. The advantage of the Bayesian approach is that it can combine data from different sources to include uncertainty. This approach is contrary to what has been done in other sources. For example, judgment can be used as a means to determine risk; however, that method does not provide for uncertainty. Such methods are qualitative at best. By comparison, the use of specific leak data results in a quantitative approach.

The tables developed for inclusion in Chapter 10 of the 2010 edition of NFPA 55 are said to be *risk informed,* not *risk based,* the difference being that integral to the risk tables is a series of decisions based on the applicability of various factors. For example, with respect to thermal flux, one could use a series of exposures from *no harm* to *fatality,* and those exposures could then be taken from the point of various receptors (workers, people on the property where the installation is located, people off the property, etc.). One of the primary decisions made by the group was that in the final analysis the risk presented for the typical GH_2 installation (either industrial or fueling applications) should present no greater risk to the public in terms of fatalities or injuries than does an existing gasoline service station. The average frequency of a fatality associated with the operation of a single gasoline station has been reported to be approximately 2E-5/yr. [5] Other key decisions of the group included the parameters given in Sections E.2 through E.5.

Table E.1(a) Hazard Scenario

Row	Group 1 Exposures greater of a or b	Hazard Scenario Rationale[c]
(a)	Lot lines	1, 2, 3, 4, 5
(b)	Air intakes (HVAC, compressors, other)	1
(c)	Operable openings in buildings and structures	1, 2
(d)	Ignition sources such as open flames and welding	3, 5

Row	Group 1 Exposures greater of a or b	Hazard Scenario Rationale[c]
Row	**Group 2 Exposures[d]**	**Hazard Scenario Rationale[c]**
(a)	Exposed persons other than those involved in servicing of the system	4
(b)	Parked cars	4
Row	**Group 3 Exposures[e]**	**Hazard Scenario Rationale[c]**
(a)	Buildings of noncombustible non-fire-rated construction	2
(b)	Buildings of combustible construction	2
-	-	-
(c)	Flammable gas storage systems above or below ground	2
(d)	Hazardous materials storage systems above or below ground	6, 7, 8, 9
(e)	Heavy timber, coal, or other slow-burning combustible solids	2
(f)	Ordinary combustibles, including fast-burning solids such as ordinary lumber, excelsior, paper, or combustible waste and vegetation other than that found in maintained landscaped areas	2
(g)	Unopenable openings in buildings and structures	1, 2
(h)	Encroachment by overhead utilities (horizontal distance from the vertical plane below the nearest overhead electrical wire of building service)	2, 10
(i)	Piping containing other hazardous materials	6, 7, 8, 9
(j)	Flammable gas metering and regulating stations such as natural gas or propane	6, 7, 8, 9

[a]Unignited jet concentration decay distance to 4 percent mole fraction (volume fraction) hydrogen.

[b]Drad – radiation heat flux level of 1577 W/m^2.

[c]See Table E.1(b) of NFPA 55 for explanation of notes.

[d]Drad for heat flux level of 4732 W/m^2 exposure to employees for a maximum of 3 minutes.

[e]The greater of Drad for combustible heat flux level of 20,000 W/m^2 or the visible flame length.

Table E.1(b) Hazard Scenario Rationale Notes to Table E.1(a) of NFPA 55

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
1	Gas release and subsequent entrainment or accumulation by the receptor	**Explosion Conditions.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of	**Hazardous Materials Design Scenario 1.** Hazardous Materials Design Scenario 1 involves an unauthorized release of hazardous materials from a single control area. This design

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
		unintentional detonation or deflagration. [**1:**5.2.2.2]	scenario shall address the concern regarding the spread of hazardous conditions from the point of release. [**1:**5.4.4.1]
2	Fire spread to or from adjacent equipment or structure	**Property Protection.** The facility design shall limit the effects of all required design scenarios from causing an unacceptable level of property damage. [**1:**5.2.2.4]	**Hazardous Materials Design Scenario 2.** Hazardous Materials Design Scenario 2 involves an exposure fire on a location where hazardous materials are stored, used, handled, or dispensed. This design scenario shall address the concern regarding how a fire in a facility affects the safe storage, handling, or use of hazardous materials. [**1:**5.4.4.2]
3	Gas explosion hazard on site or affecting adjacent property	**Explosion Conditions.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of unintentional detonation or deflagration. [**1:**5.2.2.2]	**Hazardous Materials Design Scenario 1.** Hazardous Materials Design Scenario 1 involves an unauthorized release of hazardous materials from a single control area. This design scenario shall address the concern regarding the spread of hazardous conditions from the point of release. [**1:**5.4.4.1]
4	Threat of injuries on site or adjacent property	**Hazardous Materials Exposure.** The facility design shall provide an	**Hazardous Materials Design Scenario 2.** Hazardous Materials Design

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
		acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of an unauthorized release of hazardous materials or the unintentional reaction of hazardous materials. [**1:**5.2.2.3]	Scenario 2 involves an exposure fire on a location where hazardous materials are stored, used, handled, or dispensed. This design scenario shall address the concern regarding how a fire in a facility affects the safe storage, handling, or use of hazardous materials. [**1:**5.4.4.2] **Hazardous Materials Design Scenario 4.** Hazardous Materials Design Scenario 4 involves an unauthorized discharge with each protection system independently rendered ineffective. This set of design hazardous materials scenarios shall address concern regarding each protection system or protection feature, considered individually, being unreliable or becoming unavailable. [**1:**5.4.4.4.1]
5	Ignition of an unignited release/vented hydrogen	**Explosion Conditions.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of	**Hazardous Materials Design Scenario 1.** Hazardous Materials Design Scenario 1 involves an unauthorized release of hazardous materials from a single control area. This design

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
		unintentional detonation or deflagration. [**1:**5.2.2.2]	scenario shall address the concern regarding the spread of hazardous conditions from the point of release. [**1:**5.4.4.1]
6	Damage to exposed components of underground system that are exposed above ground	**Property Protection.** The facility design shall limit the effects of all required design scenarios from causing an unacceptable level of property damage. [**1:**5.2.2.4]	**Hazardous Materials Design Scenario 1.** Hazardous Materials Design Scenario 1 involves an unauthorized release of hazardous materials from a single control area. This design scenario shall address the concern regarding the spread of hazardous conditions from the point of release. [**1:**5.4.4.1]

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario
7	Damage to aboveground system due to function of explosion control system used to vent underground vault or structure	**Property Protection.** The facility design shall limit the effects of all required design scenarios from causing an unacceptable level of property damage. [**1:**5.2.2.4] **Explosion Conditions.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of unintentional detonation or deflagration. [**1:**5.2.2.2]	**Hazardous Materials Design Scenario 3.** Hazardous Materials Design Scenario 3 involves the application of an external factor to the hazardous material that is likely to result in a fire, explosion, toxic release, or other unsafe condition. This design scenario shall address the concern regarding the initiation of a hazardous materials event by the application of heat, shock, impact, or water onto a hazardous material being stored, used, handled, or dispensed in the facility. [**1:**5.4.4.3]
8	Fire or explosion in other hazardous materials resulting in release of hydrogen	**Hazardous Materials Exposure.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of an unauthorized release of hazardous materials or the unintentional reaction of hazardous materials. [**1:**5.2.2.3]	**Hazardous Materials Design Scenario 3.** Hazardous Materials Design Scenario 3 involves the application of an external factor to the hazardous material that is likely to result in a fire, explosion, toxic release, or other unsafe condition. This design scenario shall address the concern regarding the initiation of a hazardous materials event by the application of heat, shock, impact, or water onto a hazardous material being stored, used, handled, or

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario		
			dispensed in the facility. [**1:**5.4.4.3]		
9	Fire or explosion in hydrogen system resulting in release of other hazardous materials	**Hazardous Materials Exposure.** The facility design shall provide an acceptable level of safety for occupants and for individuals immediately adjacent to the property from the effects of an unauthorized release of hazardous materials or the unintentional reaction of hazardous materials. [**1:**5.2.2.3]	**Hazardous Materials Design Scenario 2.** Hazardous Materials Design Scenario 2 involves an exposure fire on a location where hazardous materials are stored, used, handled, or dispensed. This design scenario shall address the concern regarding how a fire in a facility affects the safe storage, handling, or use of hazardous materials. [**1:**5.4.4.2]		
10	Failure of equipment exposing hydrogen system to electrical hazard, physical, or health hazard; failure of system exposing utilities to failure	**Property Protection.** The facility design shall limit the effects of all required design scenarios from causing an unacceptable level of property damage. [**1:**5.2.2.4]	**Hazardous Materials Design Scenario 3.** Hazardous Materials Design Scenario 3 involves the application of an external factor to the hazardous material that is likely to result in a fire, explosion, toxic release, or other unsafe condition.		
		-	-	**Public Welfare.** For facilities that serve a public welfare role as defined in 4.1.5 of NFPA 1, the facility design shall limit the effects of all required design scenarios from causing an unacceptable interruption of the facility's mission.	This design scenario shall address the concern regarding the initiation of a hazardous materials event by the application of heat, shock, impact, or water onto a hazardous material being stored, used,

Note Number	Statement	Performance Criteria	Hazardous Materials Design Scenario		
				[**1:**5.2.2.5]	handled, or dispensed in the facility. [**1:**5.4.4.3]

Statement of Problem and Substantiation for Public Input

This clarifies that annex E is only referring to Bulk Gaseous Separation distances, and strengthens the reference to the technical report that details all of the calculations. Strengthening the reference ensures that knowledge is not lost if the majority of E.9 to be deleted as proposed in PI-302.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 302-NFPA 2-2024 [Section No. E.9]	refers to material that is proposed to be deleted

Submitter Information Verification

Submitter Full Name: Ethan Hecht
Organization: Sandia National Laboratories
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 12:15:23 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-208-NFPA 2-2024

Statement: Adding a pointer reduces the likelihood that E.7 updates will be missed by the user. Update reference to NFPA 55 where needed to retain methodology explanation.

User is directed to to E.6 and E.7 to avoid confusion regarding the concentration of hydrogen considered hazardous for these efforts. Correct conflicting information in E.3 which has been updated in E.7.Other revisions have been made which provides clarity that annex E is only referring to Bulk Gaseous Separation distances, and strengthens the reference to the technical report that details all of the calculations. Strengthening the reference ensures that knowledge is not lost if the majority of E.9 which has been deleted.

Public Input No. 211-NFPA 2-2023 [Section No. E.2]

E.2 Lower Flammable Limit — ~~4 Percent H~~ $_2$ ~~by Volume.~~

~~In scenarios where the concern is that a plume of unignited GH~~ $_2$ ~~from a release might reach an ignition source, the separation distance was determined using a computational fluid dynamics (CFD) model to determine the distance required to reduce the GH~~ $_2$ ~~concentration to 4 percent by volume. A concentration of 4 percent hydrogen in air has been shown to be the lower bounds of an ignitible mixture under ideal conditions for burning. As such, 4 percent is the established lower flammable limit for hydrogen mixtures in air.~~

See Section E.7.

Statement of Problem and Substantiation for Public Input

Substantiation: Deleting this text and pointing to E.6 and E.7 avoids confusion regarding the concentration of hydrogen considered hazardous for these efforts.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 16:19:22 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-208-NFPA 2-2024

Statement: Adding a pointer reduces the likelihood that E.7 updates will be missed by the user. Update reference to NFPA 55 where needed to retain methodology explanation.

User is directed to to E.6 and E.7 to avoid confusion regarding the concentration of hydrogen considered hazardous for these efforts. Correct conflicting information in E.3 which has been updated in E.7.Other revisions have been made which provides clarity that annex E is only referring to Bulk Gaseous Separation distances, and strengthens the reference to the technical report that details all of the calculations. Strengthening the reference ensures that knowledge is not lost if the majority of E.9 which has been deleted.

Public Input No. 212-NFPA 2-2023 [Section No. E.3]

E.3 ~~Use of 3 Percent of Internal Area as~~ _ Leak Size

See E . 7 for updated leak size basis information.

A detailed description of the process used and the results achieved are provided in a technical article included in Annex H of NFPA 55. [6] This process follows guidance by the Fire Protection Research Foundation published in March 2007 that encourages NFPA Technical Committees to use risk concepts in their decision-making process. [7] The risk-informed approach included two considerations: the frequency of hydrogen system leakage and the risk from leakage events.

Component leak frequencies as a function of leak size were generated for several hydrogen components. The hydrogen-specific leakage rates were used to estimate the leakage frequency for four example systems used as the basis for the risk evaluation used in the study. The cumulative probability for different leak sizes was then calculated to determine what range of leaks represents the most likely leak sizes. The results of this analysis indicated that leaks less than 0.1 percent of the component flow areas represent 95 percent of the leakage frequency for the example systems. Leak areas less than 10 percent of the flow area are estimated to result in 99 percent of the leaks that could occur based on the results of the analysis.

The risks resulting from different size leaks were also evaluated for four standard gas storage configurations. The risk evaluations indicate that the use of 0.1 percent of the component flow area as the basis for determining separation distances results in risk estimates that significantly exceed the 2 × 10-5/yr risk guideline selected by the NFPA separation distance working group, particularly for the 7500 psig and 15,000 psig systems. On the other hand, use of a leak size equal to between 1 percent and 10 percent of the component flow area results in risk estimates that are reasonably close to the risk guideline. The fact that the risk estimates are a factor of 2 higher than the risk guideline for the 7500 psig and 15,000 psig example systems was weighed against the uncertainties in the QRA models, most of which result in conservative risk estimates.

Based on the results of both the system leakage frequency evaluation and the associated risk assessment, a diameter of 3 percent of the flow area corresponding to the largest internal pipe downstream of the highest pressure source in the system is used in the model. The use of a 3 percent leak area results in capturing an estimated 98 percent of the leaks that have been determined to be probable based on detailed analysis of the typical systems employed.

Statement of Problem and Substantiation for Public Input

Correct misleading/conflicting information in E.3 which has been updated in E.7.

Submitter Information Verification

Submitter Full Name: Martin Gresho
Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 16:21:57 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-208-NFPA 2-2024

Statement: Adding a pointer reduces the likelihood that E.7 updates will be missed by the user. Update reference to NFPA 55 where needed to retain methodology explanation.

User is directed to to E.6 and E.7 to avoid confusion regarding the concentration of hydrogen considered hazardous for these efforts. Correct conflicting information in E.3 which has been updated in E.7.Other revisions have been made which provides clarity that annex E is only referring to Bulk Gaseous Separation distances, and strengthens the reference to the technical report that details all of the calculations. Strengthening the reference ensures that knowledge is not lost if the majority of E.9 which has been deleted.

Public Input No. 287-NFPA 2-2024 [Section No. E.7]

E.7 Updates to the Gaseous Hydrogen Separation Distance Tables.

For each of the exposures listed in Table E.1(a), potential hazard scenarios associated with ignited and unignited hydrogen jets were identified. Harm criteria, including heat flux levels and a 4 percent mole fraction of hydrogen which represents the potential for a flash fire given delayed ignition, were chosen depending on the scenario. Three risk criteria thresholds that were used in the 2010 edition of NFPA 55 were reexamined: ~~lower flammable limit~~ unignited concentration , leak size, and heat flux levels.

~~Lower Flammable Limit~~ Unignited Concentration — 8 Percent H_2 by Volume.

The task group reviewed the hydrogen concentration threshold. Based on work done at Sandia National Laboratories Combustion Research Facility, the task group concluded that there would not be sustained ignition at hydrogen concentrations of 8 percent or less. [16] There could be localized hydrogen ignition, but it would not develop into sustained combustion.

Use of 1 Percent of Internal Pipe Diameter (ID) as Leak Size

The cumulative probability for different leak sizes was calculated to determine what range of leaks represents the most likely leak sizes, as discussed in Section E.3. The system leakage frequency corresponds to the largest internal pipe downstream of the highest pressure source in the system. The results of this analysis indicated that leaks less than 0.1 percent of the component flow areas represent 95 percent of the leakage frequency for the example systems, however the risk resulting from this small leak size significantly exceeded the 2 × 10-5/yr risk guideline set by the task group. At the same time, the use of a leak size between 1 percent and 10 percent of the component flow area results in risk estimates that are reasonably close to the risk guideline.

Based on the results of both the system leakage frequency evaluation and the associated risk assessment, the task group decided that adjusting to a diameter of 1 percent value, instead of a 3 percent, would remove excess conservatism from the input assumption to the model. The 1 percent value still accounts for 95 percent of the leakage frequency from the example systems and does not exceed the 2 × 10-5/year risk guideline established in the previous analysis. This results in more permissive separation distance requirements with no change in risk.

Selected Heat Flux Values

The task group reviewed the heat flux values discussed in Section E.4 and determined that the use of a “no harm” criteria was overly conservative. This heat flux assumes exposed persons will not take protective actions, such as moving away from the fire scene. The task group deemed it reasonable to assume that exposed personnel will relocate away from a fire scene within a few minutes and therefore the “no harm” criteria is not appropriate for establishing separation distances. Exposures that were analyzed based on this heat flux value were updated to reflect the harm distance for a radiation heat flux level of 4.7 kW/m^2. The task group decided not to change the three other heat flux values.

Table E.7 shows the revised separation distances for the four storage pressure ranges based on the task group’s recommended changes in risk criteria and exposures grouped by the harm criteria that the distance is based upon. The safety distances in the table are rounded to the nearest whole number and a safety factor of 1.5 has been added to the values. The significance of these potential changes can be shown in the high-pressure column for the Group 1 Exposures. The reduction in separation distances from 34 feet to 16 feet for bulk gaseous systems would allow these systems to be placed in more locations, including existing gasoline fueling stations and other space constrained locations.

Table E.7 Updated Values to 2016 NFPA 2 and NFPA 55 Tables with 1.5 Safety Factor

		-	-	Separation Distance	
Exposures		**>0.10 to 1.7 MPa (>15 to 250 psig)**	**>1.7 to 20.7 MPa (>250 to 3000 psig)**	**>20.7 to 51.7 MPa (>3000 to 7500 psig)**	**51.7 to 103.4 MPa (7500 to 15000 psig)**
Group 1	2010 edition	12 m (40 ft)	14 m (46 ft)	9 m (29 ft)	10 m (34 ft)

		-	-	Separation Distance		
Exposures		>0.10 to 1.7 MPa (>15 to 250 psig)	>1.7 to 20.7 MPa (>250 to 3000 psig)	>20.7 to 51.7 MPa (>3000 to 7500 psig)	51.7 to 103.4 MPa (7500 to 15000 psig)	
	-	2019 edition	5 m (16 ft)	6 m (20 ft)	4 m (13 ft)	5 m (16 ft)
Group 2	2010 edition	6 m (20 ft)	7 m (24 ft)	4 m (13 ft)	5 m (16 ft)	
	-	2019 edition	5 m (16 ft)	6 m (20 ft)	3 m (10 ft)	4 m (13 ft)
Group 3	2010 edition	5 m (17 ft)	6 m (19 ft)	4 m (12 ft)	4 m (14 ft)	
	-	2019 edition	4 m (13 ft)	5 m (16 ft)	3 m (10 ft)	4 m (13 ft)

Notes:

(1) Group 1 Exposures include: lot lines, air intakes, operable openings in buildings and structures, and ignition sources. Group 1 separation distances are based on the higher value of radiation heat flux of 4.7 kW/m^2 or the unignited jet concentration decay distance of 8percent hydrogen volume fraction concentration. In this instance, the separation distance is higher for the concentration value than the heat flux value.

(2) Group 2 Exposures include parked cars, exposed persons other than those servicing the system. Group 2 separation distances are based on the higher value of the incident radiation heat flux of 4.7 kW/m^2 exposure to employees for a maximum of 3 minutes or the visible flame length.

(3) Group 3 Exposures include everything else (e.g., buildings of combustible construction, ordinary combustibles, openings in buildings and structures, etc.). Group 3 separation distances are based on the higher value of the radiant heat flux for noncombustible equipment of 25.2 kW/m^2 or the visible flame length.

Statement of Problem and Substantiation for Public Input

As written, the language and paragraph heading imply that the lower flammability limit of hydrogen should be 8% rather than 4%. This is misleading; the Lower Flammability Limit (LFL) for hydrogen in air is 4% by volume, as determined by ASTM E681 and the NFPA 2 code is not re-defining that already existing property. Rather, a different unignited concentration threshold was used as a more practical "hazardous limit" for the sustained ignition of hydrogen in air at 8% by volume and above. This change clarifies that difference.

Submitter Information Verification

Submitter Full Name: Brian Ehrhart
Organization: Sandia National Laboratories
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 10:02:28 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-115-NFPA 2-2024

Statement: As written, the language and paragraph heading imply that the lower flammability limit of hydrogen should be 8% rather than 4%. This is misleading; the Lower Flammability Limit (LFL) for hydrogen in air is 4% by volume, as determined by ASTM E681 and the NFPA 2 code is not re-defining that already existing property. Rather, a different unignited concentration threshold was used as a more practical "hazardous limit" for the sustained ignition of hydrogen in air at 8% by volume and above. This change clarifies that difference.

The bulk gaseous hydrogen setback distance revisions changed the leak size from 3% to 1% of internal pipe area, not 1% of inner pipe diameter. This clarifies how the setback distances were calculated.

Public Input No. 297-NFPA 2-2024 [Section No. E.7]

E.7 Updates to the Gaseous Hydrogen Separation Distance Tables.

For each of the exposures listed in Table E.1(a), potential hazard scenarios associated with ignited and unignited hydrogen jets were identified. Harm criteria, including heat flux levels and a 4 percent mole fraction of hydrogen which represents the potential for a flash fire given delayed ignition, were chosen depending on the scenario. Three risk criteria thresholds that were used in the 2010 edition of NFPA 55 were reexamined: lower flammable limit, leak size, and heat flux levels.

Lower Flammable Limit — 8 Percent H_2 by Volume.

The task group reviewed the hydrogen concentration threshold. Based on work done at Sandia National Laboratories Combustion Research Facility, the task group concluded that there would not be sustained ignition at hydrogen concentrations of 8 percent or less. [16] There could be localized hydrogen ignition, but it would not develop into sustained combustion.

Use of 1 Percent of Internal Pipe ~~Diameter (ID)~~ Area as Leak Size

The cumulative probability for different leak sizes was calculated to determine what range of leaks represents the most likely leak sizes, as discussed in Section E.3. The system leakage frequency corresponds to the largest internal pipe downstream of the highest pressure source in the system. The results of this analysis indicated that leaks less than 0.1 percent of the component flow areas represent 95 percent of the leakage frequency for the example systems, however the risk resulting from this small leak size significantly exceeded the 2 × 10-5/yr risk guideline set by the task group. At the same time, the use of a leak size between 1 percent and 10 percent of the component flow area results in risk estimates that are reasonably close to the risk guideline.

Based on the results of both the system leakage frequency evaluation and the associated risk assessment, the task group decided that adjusting to a ~~diameter~~ leak size of 1 percent ~~value~~ , instead of a 3 percent, of pipe area would remove excess conservatism from the input assumption to the model. The 1 percent value still accounts for 95 percent of the leakage frequency from the example systems and does not exceed the 2 × 10-5/year risk guideline established in the previous analysis. This results in more permissive separation distance requirements with no change in risk.

Selected Heat Flux Values

The task group reviewed the heat flux values discussed in Section E.4 and determined that the use of a “no harm” criteria was overly conservative. This heat flux assumes exposed persons will not take protective actions, such as moving away from the fire scene. The task group deemed it reasonable to assume that exposed personnel will relocate away from a fire scene within a few minutes and therefore the “no harm” criteria is not appropriate for establishing separation distances. Exposures that were analyzed based on this heat flux value were updated to reflect the harm distance for a radiation heat flux level of 4.7 kW/m^2. The task group decided not to change the three other heat flux values.

Table E.7 shows the revised separation distances for the four storage pressure ranges based on the task group’s recommended changes in risk criteria and exposures grouped by the harm criteria that the distance is based upon. The safety distances in the table are rounded to the nearest whole number and a safety factor of 1.5 has been added to the values. The significance of these potential changes can be shown in the high-pressure column for the Group 1 Exposures. The reduction in separation distances from 34 feet to 16 feet for bulk gaseous systems would allow these systems to be placed in more locations, including existing gasoline fueling stations and other space constrained locations.

Table E.7 Updated Values to 2016 NFPA 2 and NFPA 55 Tables with 1.5 Safety Factor

		-	-	Separation Distance	
Exposures		**>0.10 to 1.7 MPa (>15 to 250 psig)**	**>1.7 to 20.7 MPa (>250 to 3000 psig)**	**>20.7 to 51.7 MPa (>3000 to 7500 psig)**	**51.7 to 103.4 MPa (7500 to 15000 psig)**
Group 1	2010 edition	12 m (40 ft)	14 m (46 ft)	9 m (29 ft)	10 m (34 ft)

		-	-	Separation Distance		
Exposures		>0.10 to 1.7 MPa (>15 to 250 psig)	>1.7 to 20.7 MPa (>250 to 3000 psig)	>20.7 to 51.7 MPa (>3000 to 7500 psig)	51.7 to 103.4 MPa (7500 to 15000 psig)	
	-	2019 edition	5 m (16 ft)	6 m (20 ft)	4 m (13 ft)	5 m (16 ft)
Group 2	2010 edition	6 m (20 ft)	7 m (24 ft)	4 m (13 ft)	5 m (16 ft)	
	-	2019 edition	5 m (16 ft)	6 m (20 ft)	3 m (10 ft)	4 m (13 ft)
Group 3	2010 edition	5 m (17 ft)	6 m (19 ft)	4 m (12 ft)	4 m (14 ft)	
	-	2019 edition	4 m (13 ft)	5 m (16 ft)	3 m (10 ft)	4 m (13 ft)

Notes:

(1) Group 1 Exposures include: lot lines, air intakes, operable openings in buildings and structures, and ignition sources. Group 1 separation distances are based on the higher value of radiation heat flux of 4.7 kW/m^2 or the unignited jet concentration decay distance of 8percent hydrogen volume fraction concentration. In this instance, the separation distance is higher for the concentration value than the heat flux value.

(2) Group 2 Exposures include parked cars, exposed persons other than those servicing the system. Group 2 separation distances are based on the higher value of the incident radiation heat flux of 4.7 kW/m^2 exposure to employees for a maximum of 3 minutes or the visible flame length.

(3) Group 3 Exposures include everything else (e.g., buildings of combustible construction, ordinary combustibles, openings in buildings and structures, etc.). Group 3 separation distances are based on the higher value of the radiant heat flux for noncombustible equipment of 25.2 kW/m^2 or the visible flame length.

Statement of Problem and Substantiation for Public Input

The bulk gaseous hydrogen setback distance revisions changed the leak size from 3% to 1% of internal pipe area, not 1% of inner pipe diameter. This clarifies how the setback distances were calculated.

Submitter Information Verification

Submitter Full Name: Brian Ehrhart
Organization: Sandia National Laboratories
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 11:17:27 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-115-NFPA 2-2024

Statement: As written, the language and paragraph heading imply that the lower flammability limit of hydrogen should be 8% rather than 4%. This is misleading; the Lower Flammability Limit (LFL) for hydrogen in air is 4% by volume, as determined by ASTM E681 and the NFPA 2 code is not re-defining that already existing property. Rather, a different unignited concentration threshold was used as a more practical "hazardous limit" for the sustained ignition of hydrogen in air at 8% by volume and above. This change clarifies that difference.

The bulk gaseous hydrogen setback distance revisions changed the leak size from 3% to 1% of internal pipe area, not 1% of inner pipe diameter. This clarifies how the setback distances were calculated.

Public Input No. 298-NFPA 2-2024 [Section No. E.8]

E.8 – Separation Distances for Bulk Liquefied Hydrogen Storage Based on a Risk-Informed Methodology.

The steps based on a risk-informed methodology are as follows:

(1) Define a representative bulk liquefied hydrogen storage system.

(2) Perform a risk analysis on the system to determine the release scenarios with the highest risk.

(3) Evaluate the risk criteria for each of the highest risk release scenarios by using a scientific model that predicts the extent of specific hydrogen concentrations and heat fluxes.

(4) Acquire leak frequency data from the discharge points from the highest risk release scenarios.

(5) Perform an integrated analysis of releases and leak frequencies to estimate the system separation distances using the risk threshold of 2×10^{-5} fatalities/yr.

The task group decided to use the liquefied hydrogen system described in the Compressed Gas Association, Inc. (CGA) P-28, *OSHA Process Safety Management and EPA Risk Management Plan Guidance Document for Bulk Liquid Hydrogen Systems,* as the representative system. The representative system contains a liquid hydrogen storage tank, a pressure buildup circuit and economizer, vaporizer, and pump. CGA P-28 also contained a representative hazard and operability study (HAZOP) that was performed on the representative bulk liquid hydrogen system. The process was divided into seven segments, called nodes, which were as follows:

(1) Delivery trailer, hose, and fill line to the storage vessel

(2) Storage tank

(3) Pressure buildup circuit and economizer

(4) Hydrogen line — liquid through the vaporizer to the final line

(5) Hydrogen pump

(6) Vent stacks

(7) General items

In CGA P-28, each node was examined based on deviations from normal operating parameters that could have potentially hazardous consequences. The task group started with this division of the system and analyzed each node deviation to come up with event likelihood and hazard severity. Event likelihood was the annual probability that the deviation may occur for each node, with the highest level expecting the deviation to occur once per year or more and the lowest level expected to occur once per 10,000 years, documented in Table E.8(a) . Hazard severity classified the consequence from the node deviation. The hazard severity ranged from negligible to catastrophic, documented in Table E.8(b) . The task group estimated the event likelihood and severity based on industry experience and subject matter expertise and had to agree with the levels given to each node deviation.

Table E.8(a) Event Likelihood Classification Table

Level Annual Probability Probability Description 1 Frequent > 1.0 Expected to occur once per year or more frequently. 2 Reasonably probable 1.0 to 0.1 Expected to occur once per 10 years. 3 Occasional 0.01 to 0.1 Expected to occur once per 100 years. 4 Remote 0.001 to 0.01 Expected to occur once per 1000 years. 5 Extremely remote 0.0001 to 0.001 Expected to

occur once per 10,000 years. 6 Improbable < 0.0001 Expected to occur less than once per 10,000 years. Extremely unlikely to occur.

Table E.8(b) Hazard Severity Classification Table

Level Description Potential Consequences 1 Catastrophic Could cause fatality to nonassociated members of the public 2 Critical Could cause severe injury to nonassociated members of the public, fatality or serious injury to works of the public, fatality or serious injury to workers of persons conducting business at a refueling site or significant damage to equipment/ facilities 3 Marginal Could cause minor injury, or minor system damage 4 Negligible Will not result in injury or system damage

Based on the level of likelihood and severity, the node deviation was given a risk ranking, documented in Figure E.8 . A few assumptions were made for this analysis. First, the task group assumed an NFPA 55 and a CGA H-5 code-compliant system. The scenarios would only have a single failure, and cascading failures would not be analyzed. The current setback distances did not provide any credit during this analysis and tornadoes were not included in the natural disaster considerations.

Figure E.8 Risk Ranking Table.

		Likelihood					
		1	2	3	4	5	6
Severity	1	1	1	1	2	3	4
	2	1	1	2	3	3	4
	3	2	2	3	3	4	4
	4	4	4	4	4	4	4

1: High risk
2: Moderate risk
3: Low risk
4: Routine risk

After the task group had prioritized all 102 node deviations, the risk-ranked results were reviewed and discussed. Two scenarios were added, based on feedback from the task group, which analyzed high and normal flow from a trailer vent stack. In total, the task group chose nine scenarios with the highest risk to analyze further. The first six scenarios listed occur during liquid hydrogen (LH 2) transfer operations from a tanker truck to the bulk LH 2 storage tank. The two scenarios that the task group added are included in this list. The other three scenarios occur during normal system operations. For each of the scenarios, the task group decided upon the inputs to liquid hydrogen models and the risk criteria for analysis.

Sandia developed a cryogenic hydrogen integral jet and plume model, called COLDPLUME, which is intended to be used to predict release characteristics from various real-world hydrogen storage states. [17] Sandia is also developing a network flow model that accounts for internal system flows from the storage vessel to the release plane, called NETFLOW, which will be suitable for liquid and multiphase cryogen flows. [18] These models are currently under development and experimental validation. Once modeling results are available, the hydrogen exposure risk criteria used for the bulk gaseous separation distances will be used to develop the new liquid separation distance table. *[See Table E.8(c) .]*

Table E.8(c) HAZOP Scenarios and Modeling Notes

HAZOP Number and Description Modeling Notes Separation Distance Driver Release scenarios during liquid transfer to bulk storage tank 1.18 High-flow gaseous hydrogen from trailer vent stack

~~due to venting excess pressure after LH 2 transfer Sandia's NETFLOW and COLDPLUME models will characterize the temperature and concentration from the trailer vent stack. The task group would like to model an estimate of up to 50 kg of cold, gaseous hydrogen.~~ ~~1.19 Normal flow from trailer vent stack due to venting excess pressure after LH 2 transfer Sandia's NETFLOW and COLDPLUME models will characterize the temperature and concentration from the trailer vent stack. The task group would like to model an estimate of up to 50 kg of cold, gaseous hydrogen. Modeling results will be used to calculate separation distance from air intakes and overhead utilities because this is the highest frequency release and the release point is in closest proximity to these exposures.~~ ~~1.6 High flow from line rupture, valve or component failure during transfer process Sandia's NETFLOW and COLDPLUME models will characterize the temperature and concentration from the release to the air. A model is needed to characterize pooling and evaporation effects.~~ ~~1.4 High temperature caused by external fire will cause high flow venting through tank vent stack Sandia's NETFLOW and COLDPLUME models will characterize the temperature and concentration from the trailer vent stack. This is the worst case venting scenario from the pressure relief device to a high ambient temperature.~~ ~~1.8 Reverse flow during transfer process caused by human error and pressure mismanagement Sandia's NETFLOW and COLDPLUME models will characterize the temperature and concentration from the release to the air. A model is needed to characterize pooling and evaporation effects.~~ ~~1.16 Loss of containment from external impacts, consider all causes The task group postulated a vehicle crash into the tanker during transfer. This causes a transfer hose rupture with NETFLOW and COLDPLUME models characterizing the release to the air. A model is needed to characterize pooling and evaporation effects.~~ ~~Release scenarios during normal system operation 4.15 Loss of containment from pipe leading from tank to vaporizer or vaporizer itself caused by thermal cycles or ice falling from vaporizers Sandia's NETFLOW and COLDPLUME models will characterize the temperature and concentration from the release to the air. A model is needed to characterize pooling and evaporation effects. Modeling results of hydrogen concentration plume and heat flux from a subsequent fire will be used for all other separation distance exposures because this is the highest risk priority during normal operations.~~ ~~6.15 Misdirected flow caused by operator error resulting in large low-level release of cold gaseous hydrogen through bottom drain valve of vent stack during normal tank venting process Sandia's NETFLOW model will capture how much gas is going out of the drain vent and vent stack. Sandia's COLDPLUME model can characterize the temperature and concentrations from the releases to the air. A model is needed to characterize pooling and evaporation effects.~~ ~~2.1 High pressure because of a leak in inner vessel allowing hydrogen into the vacuum area Sandia's NETFLOW and COLDPLUME models can characterize the flow out of the casing vent (a large hole instead of a pipe orifice).~~

Statement of Problem and Substantiation for Public Input

Annex section E.8 refers to a potential methodology to revise liquid hydrogen setback distances. The revised liquid hydrogen setback distances were implemented in the last edition and the methodology for doing so is described in Annex N. So this section is no longer needed and may cause confusion.

Submitter Information Verification

Submitter Full Name: Brian Ehrhart
Organization: Sandia National Laboratories
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 11:21:27 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-102-NFPA 2-2024

Statement: Annex section E.8 refers to a potential methodology to revise liquid hydrogen setback distances. The revised liquid hydrogen setback distances were implemented in the last edition and the methodology for doing so is described in Annex N. So this section is no longer needed and may cause confusion.

Public Input No. 302-NFPA 2-2024 [Section No. E.9]

E.9 ~~Determination of Separation Distances for Bulk Gaseous Hydrogen Systems.~~

~~This section is a paper by William Houf and Robert Schefer titled "Description of Hazard Models Used in the Development of Separation Distance Tables for NFPA 55 and NFPA 2" (Sandia National Laboratories, P.O. Box 969, Livermore, CA 94551-0969).~~

~~This paper has been provided for historical reference to how the separation distance tables for bulk gaseous hydrogen systems were calculated.~~

~~E.9.1~~ ~~– Introduction.~~

~~Separation distances in NFPA 55 and NFPA 2 are based on the prediction of the characteristics of unignited jets or ignited jet flames from hydrogen leaks. Because the characteristics of hydrogen jets and jet flames depend on the source pressure and effective diameter of the leak, the separation distance table was broken into four pressure ranges. The effective leak diameter for each pressure range was based on a characteristic pipe diameter (I.D. = inside diameter), where the leak flow area was taken to be 3 percent of the flow area of the pipe (based on I.D. of the pipe). For a round leak the effective diameter of the leak is:~~

~~$d_{leak} = (0.03)^{1/2} d_{pipe(I.D.)}$~~

~~where d_{leak} is the effective leak diameter and $d_{pipe\ (I.D.)}$ is the inside diameter of the pipe. Table E.9.1(a) lists the pressure ranges for the separation distances table and the associated inside pipe diameter of the characteristic pipe used to determine the leak effective diameter for each pressure range.~~

~~When using the separation distance table one must first determine the storage pressure. The storage pressure determines what pressure range in the table is to be used in the determination of separation distances. The storage pressure is defined as the maximum pressure of a storage array with volume greater than 400 scf (standard cubic feet) in the system. If the system has more than one storage array with a volume greater than 400 scf then a storage pressure must be determined for each array. The next parameter that must be determined is the largest diameter (I.D.) of the piping within the system or portion of the system downstream of the stored volume. If the largest pipe diameter associated with the storage pressure is less than the characteristic pipe diameter listed in Table E.9.1(a) for that pressure range, then the values listed in the separation distance table can be used, or alternately the formulas at the bottom of the table can be applied using the determined value of largest pipe diameter (I.D.).~~

~~If the value of the largest pipe diameter (I.D.) is greater than the characteristic pipe diameter for the storage pressure range of interest, then the formulas at the bottom of the separation distance table must be used to determine separation distances. These formulas reproduce the numeric values in the separation distance tables for the pipe diameters shown in Table E.9.1(a) .~~

~~The formulas are based on performing curve-fits to hazard distance calculations performed over a range of pipe diameters (assuming 3 percent flow area leak) and pressures using the hazard models discussed in Section E.9.2 . The formulas are simple enough that they can easily be entered into an Excel spreadsheet program or programmable calculator for computation of separation distances for any value of pipe diameter (I.D.). An Excel spreadsheet based on these formulas was developed and distributed to the NFPA Hydrogen Technology Committee members as part of the development of separation distance tables.~~

~~If a system contains multiple storage arrays (greater than 400 scf) at different pressures, then storage pressures and largest pipe diameters must be determined for each storage array in the system. The separation distance table and formula procedure outlined above is then applied to each storage array in the system, and the largest separation distance for each storage array defines the value of the separation distance for the overall system.~~

A description of the models used to determine the values of the separation distances are discussed in the sections that follow. More detailed descriptions of the models and the experiments used in their development and validation can be found in the publications Houf and Schefer, 2007, 2008, and Schefer et al., 2006, 2007. The models consider either the concentration decay of an unignited high-momentum hydrogen leak or in the case where the mixture ignites, a high-momentum hydrogen jet flame, its visible length, and the radiation heat flux from the flame. Table E.9.1(b) lists the hazard criteria that were used with the unignited jet and jet flames models to create a risk informed consequence-based separation distance table for NFPA 55 and NFPA 2.

Table E.9.1(a) Pressure Ranges for Separation Distances Table and the Associated System Characteristic Pipe Diameter

Storage Pressure Range - Characteristic Pipe Diameter (I.D.) kPa (gauge) psig - mm in. >103 to ≤ 1724 >15 to ≤250 - 52.50 2.067 >1724 to ≤ 20684 >250 to ≤3000 - 18.97 0.75 >20684 to ≤ 51711 >3000 to ≤7500 - 7.92 0.312 >51711 to ≤ 103421 >7500 to ≤15000 - 7.16 0.282

Table E.9.1(b) Hazard Parameters for Separation Distances Tables

Hydrogen unignited jet Distance to point where concentration has decayed to 4 percent mole fraction hydrogen in air Hydrogen jet flame Visible flame length Hydrogen jet flame Distance to radiation heat flux level of 1577 W/m ^{2} (500 Btu/hr · ft ^{2}) Hydrogen jet flame Distance to radiation heat flux level of 4732 W/m ^{2} (1500 Btu/hr · ft ^{2}) exposure to employees for a maximum of 3 minutes Hydrogen jet flame Distance to combustible heat flux level of 20,000 W/ m ^{2} (6340 Btu/hr · ft ^{2}) Hydrogen jet flame Distance to non-combustible equipment heat flux level of 25,237 W/m ^{2} (8000 Btu/hr · ft ^{2})

E.9.2 – Description of Engineering Hazard Models: Nomenclature.

See Table E.9.2 for specification of the parameters used in engineering hazard models.

Table E.9.2 Parameters Used in Hazard Models

b Coefficient for hydrogen in the Abel-Nobel equation of state (7.691 × 10 $^{-3}$ m ^{3} /kg) Btu British thermal unit C* Non-dimensional radiant power CH_4 Methane C_2H_2 Acetylene C_3H_8 Propane d_{eff} The effective diameter, m d_j Jet exit diameter, m d* Jet momentum diameter, m D_{rad} Radiation distance, m Fr $_f$ Froude number (dimensionless parameter based on the ratio of momentum effects to buoyancy effects) f_s Mass fraction of fuel at stoichiometric conditions g Acceleration due to gravity (9.8 m/sec ^{2}) H_2 Molecular hydrogen hr Hour K The entrainment constant K_e The entrainment constant for a round jet L_{vis} Visible flame length, m L* Non-dimensional flame length LFL Lower flammability limit LFL_{DPF} Lower flammability limit for a downward propagating flame LFL_{UPF} Lower flammability limit for an upward propagating flame m_{fuel} Total fuel mass flow rate, kg/sec $m_{fuel}\Delta H_c$ Total heat released due to chemical reaction, W p_j The jet exit pressure, bar p_{supply} The pressure in the supply, bar p_{tank} The pressure in the tank, bar p_∞ The ambient pressure, bar q_{rad} (x,r) The radiant heat flux measured at a particular axial location, x, and radial location, r, W/m ^{2} r Radial position, m R_{H2} Gas constant for hydrogen (4124.18 J/kg/K) R_u Universal gas constant (8314.34 J/kmol/K) R_{max} The maximum radial position from the flame centerline for the given heat flux level, m S_{rad} The total emitted radiative power, W T_{ad} Adiabatic flame temperature of hydrogen in air (2390 K) u_j Jet exit velocity, m/sec u_{eff} The effective velocity at the end of expansion, m/sec x Axial position, m x_o The virtual origin of the jet, m $X(R_{max})$ The axial location at which the maximum heat flux level occurs, m X_{rad} The radiant fraction or the fraction of the total chemical heat release that is radiated to the surroundings W_f Flame width, m W_{mix} Mean molecular weight of the products of stoichiometric combustion of hydrogen in air (24.54 kg/kmol) Z The compressibility factor [Z = p/(ρRT)] ΔH_c Heat of combustion, J/kg ΔT_f Peak

flame temperature rise due to combustion heat release, K π Pi ρ ƒ Flame density, kg/m 3 ρ gas The density of the exiting gas evaluated at ambient temperature and pressure, kg/m 3 ρ j Jet exit density, kg/m 3 (ρ j /ρ∞) Ratio of jet gas density to ambient gas density ρ∞ Density of the ambient fluid, kg/m 3

$\bar{\eta}$

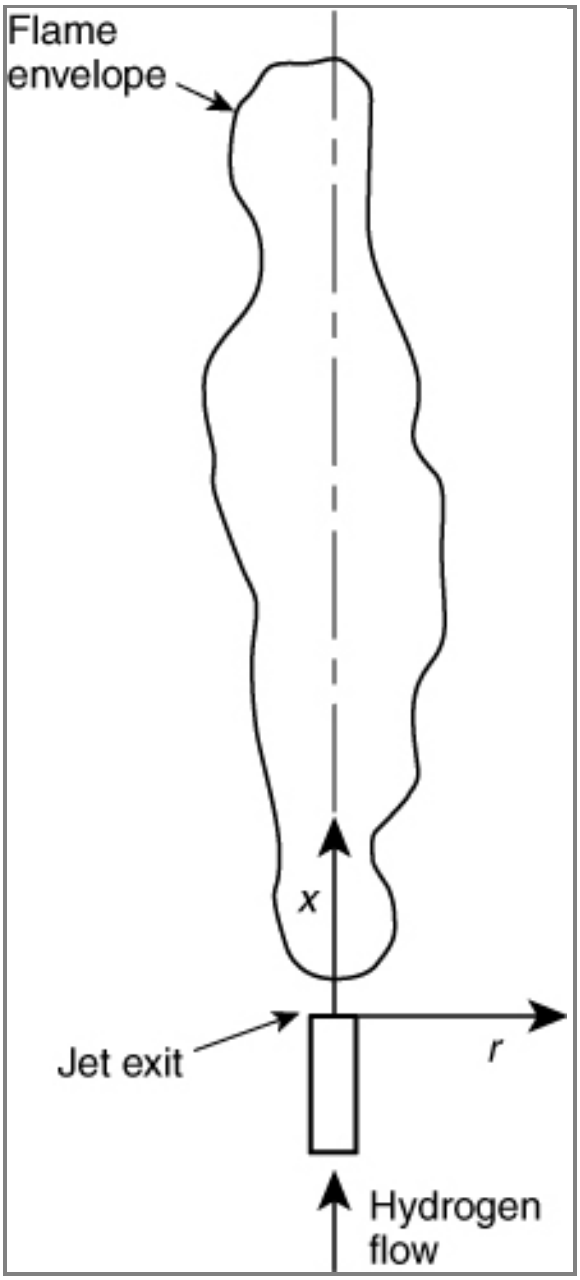
Volume fraction (mole fraction) along the centerline of the jet τ ƒ Global flame residence time, sec

The development of an infrastructure for hydrogen utilization requires safety codes and standards that establish guidelines for building the components of this infrastructure. Based on a recent workshop on unintended hydrogen releases, one release case of interest involves leaks from pressurized hydrogen-handling equipment (Schefer et al., 2004). These leaks range from small-diameter, slow-release leaks originating from holes in delivery pipes to larger, high-volume releases resulting from accidental breaks in the tubing from high-pressure storage tanks. In all cases, the resulting hydrogen jet represents a potential fire hazard, and the buildup of a combustible cloud poses a hazard if ignited downstream of the leak.

A case in which a high-pressure leak of hydrogen is ignited at the source is best described as a classic turbulent jet flame, shown schematically in Figure E.9.2 . The distances of importance are the radial distance from the geometrical flame centerline, r, and the distance downstream of the jet exit, x. Other variables of interest are the jet exit diameter, d j , and the jet exit velocity and density, u j and ρ j , respectively. Schefer et al. (2006, 2007) reported experimental measurements of large-scale hydrogen jet flames and verified that measurements of flame length, flame width, radiative heat flux, and radiant fraction are in agreement with nondimensional flame correlations reported in the literature. This work verifies that such correlations can be used to predict the radiative heat flux from a wide variety of hydrogen flames. The present analysis builds upon this work by incorporating the experimentally verified correlations into an engineering model that predicts flame length, flame width, and the radiative heat flux at an axial position, x, and radial distance, r. The engineering model is then used to predict radiative heat fluxes for hydrogen flames.

For cases where the high-pressure leak of hydrogen is unignited, a classic high-momentum turbulent jet is formed that can be described using the same coordinate system shown in Figure E.9.2 . The hydrogen concentration within the jet varies with axial and radial position due to entrainment and turbulent mixing with the ambient air. The concentration contour beyond which the hydrogen-air mixture is no longer ignitable is of importance to hydrogen ignition studies. The present study develops an engineering model for the concentration decay of a high-momentum turbulent jet based on experimentally-measured entrainment rates and similarity scaling laws for turbulent jets. The model is then verified by comparing simulations for high-pressure natural gas leaks with the experimental data of Birch (1984) for the concentration decay of high-pressure natural gas jets. The engineering model is then applied to hydrogen and used to predict unignited jet mean (time-averaged over turbulent fluctuations) concentration contours for high-pressure hydrogen leaks.

Figure E.9.2 Coordinate System for Turbulent Jet Flame and Unignited Jet.


Flame
envelope
x
Jet exit
r
Hydrogen
flow

~~**E.9.2.1** – Flame Radiation Heat Flux and Flame Length Model.~~

Gaseous flame radiation is the primary heat transfer mechanism from hydrogen flames. The flame radiation heat flux model follows the approach of Sivathanu and Gore (1993) where the flame properties of importance are the visible flame length, L_{vis}, total radiative power emitted from the flame, S_{rad}, and total heat released due to chemical reaction, $m_{fuel}\,\Delta H_c$ where m_{fuel} and ΔH_c are the total fuel mass flow rate and the heat of combustion, respectively. The radiant fraction, X_{rad}, is defined as the fraction of the total chemical heat release that is radiated to the surroundings and is given by an expression of the following form:

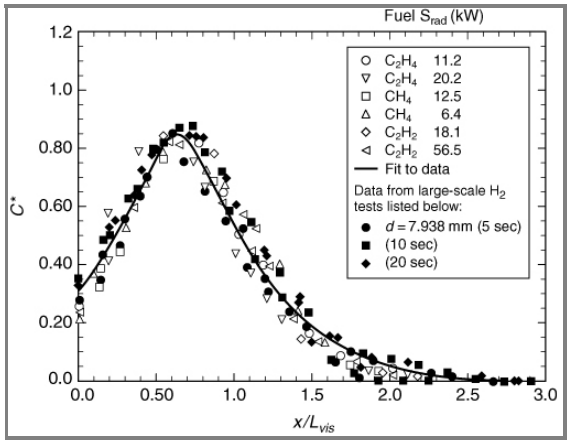
$$X_{rad} = S_{rad} / m_{fuel}\Delta H_c \qquad \textbf{[E.9.2.1a]}$$

For turbulent-jet flames, the radiative heat flux at an axial position x and radial position r can be expressed in terms of the non-dimensional radiant power, C*, and, S_{rad}, the total emitted radiative power. The radiative heat flux is given by an expression of the following form (Sivathanu and Gore, 1993):

$$q_{rad}(x, r) = C^*(x/L_{vis})S_{rad} / 4\pi r^2 \qquad \textbf{[E.9.2.1b]}$$

where q_{rad} (x, r) is the radiant heat flux measured at a particular axial location, x, and radial location, r. Experimental data further show that C* can be expressed in non-dimensionalized form as a function of burner diameter, flow rate, and fuel type and for turbulent-jet flames is dependent only on the normalized axial distance. Figure E.9.2.1(a) shows typical profiles of C* measured in six different turbulent-jet flames using CH_4, C_2H_2 and C_2H_4 as the fuel (Sivanthanu and Gore, 1993) as well as the measurements of Schefer *et al.* (2006, 2007) for large-scale H_2 jet flames.

Figure E.9.2.1(a) Axial Variation of Normalized Radiative Heat Flux.



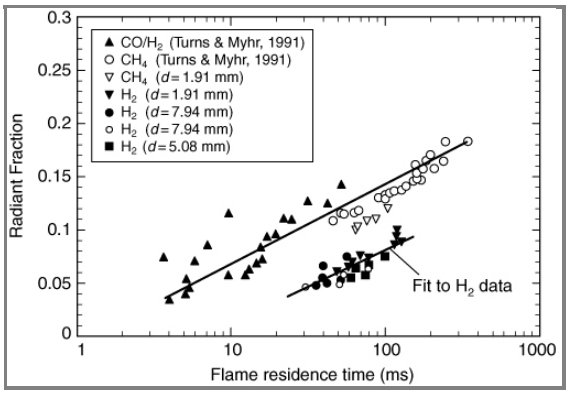
The use of Equation E.9.2.1b to calculate flame radiation heat flux levels requires knowledge of the flame radiant fraction. Turns and Myhr (1991) measured the radiant fraction from turbulent jet flames using four hydrocarbon fuels with a wide variety of sooting tendencies. These fuels included methane, ethylene, propane, and a 57 percent CO/43 percent H_2 mixture. A plot of the radiant fraction data from Turns and Myhr (1991) along with the radiant fraction data for large-scale H_2 flames is shown in Figure E.9.2.1(b). The radiant fraction data, X_{rad}, is plotted versus the global flame residence time where the residence time is given by an expression of the following form:

$$\tau_f = \left(\rho_f W_f^2 L_{vis} f_s\right) / \left(3\rho_j d_j^2 u_j\right) \qquad \textbf{[E.9.2.1c]}$$

where ρ_f, W_f, and L_{vis} are the flame density, width, and length, and f_s is the mass fraction of hydrogen in a stoichiometric mixture of hydrogen and air. For turbulent-jet flames, the flame width, W_f, is approximately equal to 0.17 L_{vis} (Schefer et al., 2006). This definition of residence time takes into account the actual flame density and models the flame

as a cone. The flame density, ρ_f, is calculated from the expression $\rho_f = p_\infty W_{mix} / (R_u T_{ad})$, where p_∞ is the ambient pressure, W_{mix} is the mean molecular weight of the stoichiometric products of hydrogen combustion in air, R_u is the universal gas constant, and T_{ad} is the adiabatic flame temperature for hydrogen. The figure suggests that for flames with a lower sooting tendency, there is a well-defined relationship between radiant fraction and global flame residence time. Both methane and the CO/H_2 mixture show a well-behaved dependence on residence time and nearly collapse onto the same curve over the range of conditions studied. Values for the large-scale hydrogen jet flames are approximately a factor of two lower than the hydrocarbon flames for the same flame residence time.

Figure E.9.2.1(b) Radiant Fraction as a Function of Flame Residence Time (Lab H_2 Flame Data for Diameters of 1.905 mm and 3.75 mm, Large-Scale H_2 Flame Test Data at Diameter of 7.94 mm).



The visible flame length, L_{vis}, is required for computing the global flame residence time, τ_f, to determine the flame radiant fraction. Based on an analysis of the transition from momentum-controlled to buoyancy-controlled turbulent jet flame dynamics, Delichatsios (1993) developed a useful correlation for turbulent flame lengths. The correlation is based on a non-dimensional Froude number that measures the ratio of buoyancy to momentum forces in jet flames. Using the nomenclature of Turns (2000) the Froude number is defined as follows:

$$Fr_f = \frac{u_j f_s^{3/2}}{\left(\rho_j / \rho_\infty\right)^{1/4} \left[\frac{\Delta T_f}{T_\infty} g d_j\right]^{1/2}} \qquad \text{[E.9.2.1d]}$$

where u_j is the jet exit velocity, f_s is the mass fraction of fuel at stoichiometric conditions, (ρ_j / ρ_∞) is the ratio of jet gas density to ambient gas density, d_j is the jet exit diameter, and ΔT_f is the peak flame temperature rise due to combustion heat release. Small values of Fr_f correspond to buoyancy-dominated flames while large values of Fr_f correspond to momentum-dominated flames. Note that the parameters known to control turbulent flame length such as jet diameter, flow rate, stoichiometry, and (ρ_j / ρ_∞) are included in Fr_f. Further, a non-dimensional flame length, L*, can be defined as follows:

$$L^* = \frac{L_{vis} f_s}{d_j \left(\rho_j / \rho_\infty\right)^{1/2}} = \frac{L_{vis} f_s}{d^*} \qquad \text{[E.9.2.1e]}$$

where L_{vis} is the visible flame length and d* is the jet momentum diameter. Figure E.9.2.1(c) shows the resulting correlation of flame length data for a range of fuels (H_2, C_3H_8, and CH_4) and inlet flow conditions. In the buoyancy-dominated regime, L* is correlated by the following expression:

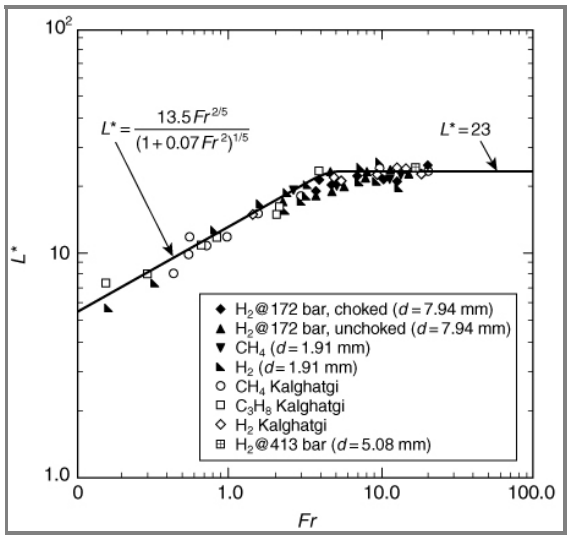
$$L^* = \frac{13.5 Fr_f^{2/5}}{\left(1 + 0.07 Fr_f^2\right)^{1/5}} \text{ for } Fr_f < 5 \qquad \text{[E.9.2.1f]}$$

and in the momentum-dominated regime by the following expression:

$$L^* = 23 \text{ for } Fr_f > 5 \qquad \text{[E.9.2.1g]}$$

The flame length data of Schefer et al. (2006, 2007) for large-scale hydrogen flames is shown on the plot and is found to be in good agreement with the L* correlations given by Equations E.9.2.1f and E.9.2.1g. For choked flow conditions, the concept of a notional expansion and effective source diameter *(see E.9.2.2)* was used to reduce the hydrogen flame length measurements for plotting in terms of L* in Figure E.9.2.1(c) . The simulation also uses this same effective diameter approach to recover the visible flame length, L_{vis} , from the values of L* computed from Equations E.9.2.1f and E.9.2.1g.

Figure E.9.2.1(c) Variation of Dimensionless Visible Flame Length with Flame Froude Number.



If the jet exit velocity and density of a hydrogen flame are known, then Equation E.9.2.1d can be used to calculate the flame Froude number and Equation E.9.2.1e and both Equation E.9.2.1f and Equation E.9.2.1g can then be used to compute the visible length of the flame, L_{vis} . The flame width, W_f , can be computed from the expression $W_f = 0.17 L_{vis}$ and used in Equation E.9.2.1c to compute the global flame residence time, τ_f . Knowing the flame residence time, a curve-fit to the hydrogen radiant fraction data in Figure E.9.2.1(b) can be used to determine the radiant fraction of the hydrogen flame. Knowing the radiant fraction and using a curve-fit to the C* curve shown in Figure E.9.2.1(a) , Equation E.9.2.1b can be used to compute the radiant heat flux from the hydrogen flame at any axial position, x, and radial position r.

~~**E.9.2.2** – Unignited Jet Concentration Decay Model.~~

For cases where the high-pressure leak of hydrogen is unignited, a classic high-momentum turbulent jet is formed that can be described using the same coordinate system shown in Figure E.9.2 . The hydrogen concentration within the jet varies with axial position, x, and radial position, r, due to entrainment and turbulent mixing with the ambient air.

The nature of the concentration field of subsonic, momentum-dominated incompressible turbulent free jets is well documented in the literature (Chen and Rodi, 1980). The decay of the mean volume fraction, η_{cl} , (or mean mole fraction) along the centerline of the jet is given by an expression of the following form:

$$\eta_{cl}(x) = \frac{Kd_j}{x + x_o}\left(\frac{\rho\infty}{\rho_{gas}}\right)^{1/2} \quad \text{[E.9.2.2a]}$$

where K is the entrainment constant, $\rho\infty$ is the density of the ambient fluid, ρ_{gas} , is the density of the exiting gas evaluated at ambient temperature and pressure, and x_o is the virtual origin of the jet (Chen and Rodi, 1980).

For high-pressure leaks of hydrogen, the exit flow chokes at the sonic velocity if the pressure ratio across the leak is greater than the critical pressure ratio (approximately 1.9 for hydrogen). At pressure ratios higher than the critical value, the exit velocity remains locally sonic. For these supercritical releases, the flow leaves the exit to form an underexpanded jet that quickly expands to ambient pressure through a complex flow structure involving one or more shocks. As a result, the concentration field behaves as if it were produced by a larger source than the actual exit diameter, and the diameter of this effective source is referred to as the effective diameter, d_{eff} . The work of Birch (1984, 1987) for natural gas jets indicates that the classical laws for concentration decay for turbulent jets in pressure equilibrium (i.e., Equation E.9.2.2a) can be applied to underexpanded jets resulting from supercritical releases provided that the jet exit diameter, d_j , is replaced by the effective diameter d_{eff} . The reports of Britter (1994, 1995) discuss various approaches for computing effective diameter source models for underexpanded jets.

The effective source diameter model used in this work is formulated by considering a notional expansion (Birch, 1987) that conserves both mass and momentum while retaining the assumption that the pressure is reduced to ambient pressure at the end of the expansion. Based on the work of Birch (1987), the equation for the effective source diameter is as follows:

$$d_{eff} = \left(\frac{\rho_j u_j}{\rho_{gas} u_{eff}}\right)^{1/2} d_j \quad \text{[E.9.2.2b]}$$

where ρ_j is the jet exit density, u_j is the jet exit velocity, ρ_{gas} is the density of the exiting gas evaluated at ambient pressure and temperature, d_j is the jet exit diameter, and u_{eff} is the velocity at the end of the expansion. The effective velocity at the end of the expansion is given by an expression of the following form:

$$u_{eff} = u_j + \left(P_j - P\infty\right)/\left(\rho_j u_j\right) \quad \text{[E.9.2.2c]}$$

where p_j is the jet exit pressure and $p\infty$ is the ambient pressure. Equations E.9.2.2b and E.9.2.2c can be used to compute the effective source diameter for supercritical releases and are valid for real gas as well as ideal gas models as long as the jet exit conditions are computed properly. For hydrogen at 200 bar and 300K the compressibility factor Z (where $Z = p/(\rho RT)$) is approximately 1.12; at a pressure of 800 bar and the same temperature the compressibility factor is approximately 1.51. For an ideal gas, Z is equal to unity.

For supercritical releases the effective source diameter replaces the jet diameter in Equation E.9.2.2a and centerline concentration decay equation becomes the following:

$$\eta_{cl}(x) = \frac{Kd_{eff}}{x + x_o}\left(\frac{\rho\infty}{\rho_{gas}}\right)^{1/2} \quad \text{[E.9.2.2d]}$$

At each axial position, x, the radial variation of the concentration is computed from the following expression:

$$\eta(x,r) = \eta_{cl}(x)e^{-K_c(r/x+x_o)^2} \quad \text{[E.9.2.2e]}$$

where the value of K_c = 57 for a round jet (Chen and Rodi, 1980). Equations E.9.2.2b, E.9.2.2c, E.9.2.2d, and E.9.2.2e can be used to compute the concentration field from a high-momentum turbulent jet resulting from the supercritical release of hydrogen. For the studies performed in this paper, a value of the entrainment coefficient equal to K = 5.40 (Birch, 1987) was used for the simulations. The value of the virtual origin, x_o, is typically a small multiple (less than 5) of the jet exit diameter and was set to zero for these studies in accordance with the work of Birch (1987).

E.9.3 – Comparison of Models with Experimental Data.

~~**E.9.3.1** – Flame Radiation Heat Flux and Flame Length Model.~~

The hydrogen flame radiation and flame length models were compared against the large-scale hydrogen jet flame experiments of Schefer et al. (2006, 2007). In these experiments, hydrogen gas was released from a "six-pack" of high-pressure cylinders, each connected to a central manifold with a common outlet. Typical pressure in the full cylinders was 137.9 bar (2000 psia) to 172.3 bar (2500 psia).

To obtain jet exit conditions, a network flow model of the piping and high-pressure cylinders used in the experiment was developed using the Sandia developed Topaz code (Winters, 1984). The network flow model considers the non-ideal gas behavior of hydrogen through an Abel-Nobel equation of state (Chenoweth, 1983) of the following form:

$$p = \frac{\rho R_{H_2} T}{(1 - b\rho)} \qquad \text{[E.9.3.1]}$$

where the values of R_{H2} = 4,124.18 J/kg-K and b = 7.691 × 10^{-3} m^3/kg were used for hydrogen. The model can also be used with an ideal-gas equation of state by setting the value b equal to zero.

The tank blow-down and network flow model was used to predict the flow and pressure drop through the piping leading to the jet exit. These jet exit conditions were then used with the flame length and radiant fraction correlations described in the previous section to predict the hydrogen jet flame characteristics. Comparisons of the measured and predicted pressure history curves in the high-pressure cylinders were used to validate the tank blow-down network flow model (Schefer et al., 2006). Simulations with the network flow model indicated that significant pressure drop occurred in the piping of the experiment with the total pressure at the jet exit being approximately 16.4 bar (226 psig) or a static pressure of approximately 13.6 bar (182 psig) at 0.1 second into the blow-down.

Figure E.9.3.1(a) shows a comparison of the flame length predictions from the model with the large-scale hydrogen jet flame length data. Because an approximate ±10 percent scatter occurs in the data around the L* correlation *[see Figure E.9.2.1(c)]* used in the model, an uncertainty analysis was performed where the L* correlation was increased and then decreased by 10 percent from its nominal value. Calculations are shown in Figure E.9.3.1(a) for the nominal L* correlation, and an increase in L* of 10 percent and a decrease in L* of –10 percent. Predictions from the model are found to be in good agreement with the measured hydrogen flame lengths.

Figure E.9.3.1(a) Comparison of Simulation of Hydrogen Visible Flame Length with the Hydrogen Jet Flame Data of Schefer et al. (2006).

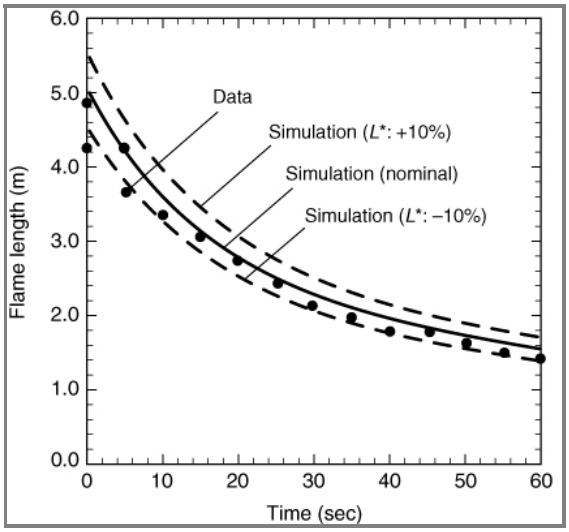


Figure E.9.3.1(b) shows a comparison of simulations and measured radiation heat flux data along the axis of a hydrogen jet flame at a radial distance of 1.82 m (6 ft) from the flame centerline at a time 5 seconds into the blow-down of the high-pressure hydrogen cylinders. An

approximate ±10 percent scatter occurs in the data around the L* correlation *[see Figure E.9.2.1(c)]* , the C* correlation *[see Figure E.9.2.1(a)]* , and the radiant fraction correlation *[see Figure E.9.2.1(b)]* , X_{rad} . Hence, an uncertainty analysis was performed where model calculations were performed with the nominal values of these correlations, and an increase of 10 percent to each of the 3 correlations (upper bound on radiative heat flux), and a decrease of –10 percent to each of the correlations (lower bound on radiative heat flux). The results of these calculations are shown in Figure E.9.3.1(b) . An additional comparison with data using the same approach is shown in Figure E.9.3.1(c) at a time of 10 seconds into the blow-down. The range of the calculations with either an increase of 10 percent or decrease of 10 percent in each of the correlations for L*, C*, and X_{rad} are able to bound the range of experimental data adequately at both times.

Figure E.9.3.1(b) Comparison of Simulation of Radiative Heat Flux from a Hydrogen Flame at a Radial Position of r = 1.83 m with the Data at 5 Seconds into the Blow-Down.

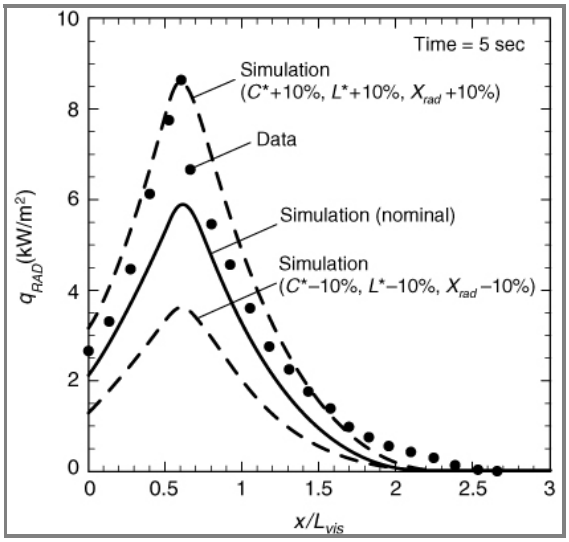
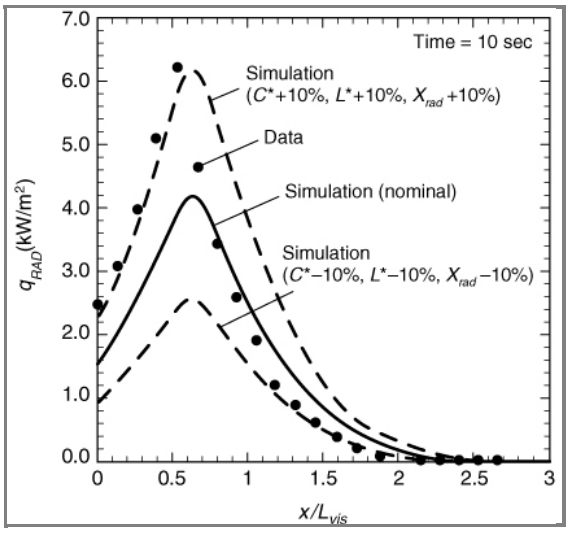


Figure E.9.3.1(c) Comparison of Simulation of Radiative Heat Flux from a Hydrogen Flame at a Radial Position of r = 1.83 m with the Data at 10 Seconds into the Blow-Down.

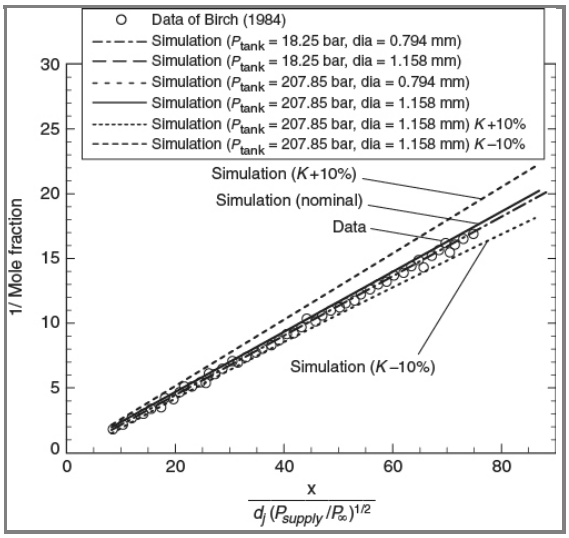


E.9.3.2 – Unignited Jet Concentration Decay Model.

There appears to be a lack of data in the literature for the concentration decay of momentum-dominated, choked flow, unignited turbulent hydrogen jets resulting from supercritical releases. Hence the unignited jet model was compared with the jet concentration decay data of Birch (1984) for supercritical releases of natural gas. Birch measured the concentration decay of natural gas into air for a 2.7 mm diameter round nozzle connected to a regulated high-pressure natural gas supply. The method of concentration measurement in the experiment integrated the turbulent concentration fluctuations in the flow and resulted in a time-averaged concentration measurement at each axial location. Measurements of the mean concentration level at different axial positions along the jet centerline were made for supply pressures ranging from 3.5 to 71 bar. Birch found if the mean concentration decay along centerline was plotted in terms of the non-dimensional coordinate $x/(d_j (p_{supply}/p_\infty)^{0.5})$, then the data collapsed onto a single curve.

Calculations with the unignited jet model discussed in the previous section were performed using natural gas properties and generating jet exit conditions for a large high-pressure supply attached to a short round nozzle. The Topaz network flow code with an ideal gas equation of state for natural gas was used to generate jet exit conditions for this geometry. Calculations were performed at pressures of 18.25 bar (250 psig) and 207.85 bar (3000 psig) for jet exit diameters of 0.794 mm and 1.158 mm. The axial variation of the reciprocal of the mean concentration ($1/\eta_{cl}$) on jet centerline was plotted in terms of the non-dimensional axial coordinate, $x/(d_j (p_{supply}/p_\infty)^{0.5})$, where d_j is the jet exit diameter, p_{supply} is the pressure in high-pressure supply, p_∞ is the ambient pressure. Comparison of the calculations from the model with the data of Birch (1984) using the nominal value of the turbulent entrainment constant ($K = 5.40$) is shown in Figure E.9.3.2. Based on data reported by Birch (1984, 1987) there appears to be approximately ±10 percent variation in the value of the turbulent entrainment constant, K. Hence, in addition to using the nominal value of K, calculations were performed for the 207.85 bar 1.158 diameter nozzle by varying K ±10 percent from the nominal value. Results of the calculations using the nominal value of K are in excellent agreement with the data of Birch. Moreover the calculations at 207.8 bar, which are well beyond the maximum pressure of 71 bar used in Birch's experiments, are found to be in excellent agreement with the collapsed data curve plotted in terms of $x/(d_j (p_{supply}/p_\infty)^{0.5})$. The work of Ruffin et al. (1996) also appears to confirm the notional expansion concentration decay model of Birch for supercritical jets of methane and hydrogen at a pressure of 40 bar.

Figure E.9.3.2 Comparison of Simulation of Centerline Concentration Decay for Gas Unignited Jets with the Data of Birch [3].



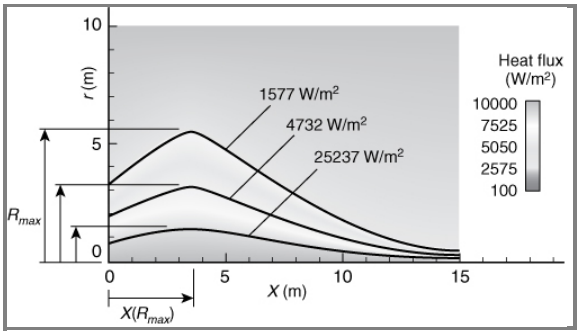
E.9.4 – Simulation of Unintended Releases.

E.9.4.1 – Hydrogen Jet Flame Radiation and Unignited Jet Concentration Decay.

Simulations for unintended releases of hydrogen were performed by considering a break in the tubing directly connected to a large hydrogen storage container. Based on a survey of a panel of experts (ICC, 2003) familiar with current and intended uses of hydrogen, pressures in the range from 18.25 bar (250 psig) to 1,035.21 bar (15,000 psig) and leak diameters in the range from 9.525 mm ($\frac{3}{8}$ in.) to 0.25 mm were suggested for analysis.

For the simulations reported in this section a storage tank volume of 29.7 m^3 was used based on the recommendation of the expert panel. Calculations are reported for pressures of 18.25 bar (250 psig), 207.85 bar (3000 psig), 518.11 bar (7500 psig), and 1,035.21 bar (15,000 psig) and leak diameters ranging between 1.587 mm ($\frac{1}{16}$ in.) and 6.35 mm ($\frac{1}{4}$ in.). Jet exit conditions were computed using the Topaz network flow code with an Abel-Nobel equation of state for hydrogen to simulate a large tank of hydrogen connected to a short length of tubing (3.175 mm) with a diameter equal to the diameter of the leak under consideration. The tank temperature was assumed to be initially at ambient temperature (294 K) with the end of the tubing exiting to the ambient environment (1.0133 bar, 294 K). Calculations were performed for hydrogen jet flames and unignited jets with the results for radiative heat flux and concentration decay being reported at 1 second into the tank blow-down for each case. At 1 second, the tank pressure has not changed significantly from its initial value and the radiative and concentration length scales are at their largest values.

Figure E.9.4.1(a) Simulation of Radiation Heat Flux from a Hydrogen Jet Flame with a Leak Diameter of 3.175 mm and a Tank Pressure of 207.85 bar (3000 psig).



For the hydrogen jet flames, radiative heat flux contours were recorded for heat flux levels of 1577 W/m^2 (500 Btu/hr-ft^2), 4732 W/m^2 (1500 Btu/hr-ft^2), and 25237 W/m^2 (8000 Btu/hr-ft^2). These heat flux levels corresponding to values listed in the 2003 International Fire Code (2002) for exposure at property line, exposure for employees for a maximum of 3 minutes, and exposure for noncombustible equipment, respectively. Figure E.9.4.1(a) shows results for the radiative heat flux from a hydrogen jet flame with a tank pressure of 207.85 bar (3000 psig) and a leak diameter of 3.175 mm ($\frac{1}{8}$ in.). Important safety related information recorded from the simulations includes the maximum radial position from the flame centerline for the given heat flux level, R_{max}, the axial location at which the maximum occurs, $X(R_{max})$, the combination of these two distances, $D_{rad} = [R_{max} + X(R_{max})]$, and the visible flame length, L_{vis}. Figure E.9.4.1(b) shows a plot of D_{rad} and the visible flame length for various leak diameters for a tank pressure of 207.85 bar. Also included on the plot are the upper and lower bounds for D_{rad} and L_{vis} assuming an uncertainty of ±10 percent in each of the values of C*, L*, and X_{rad}. Figure E.9.4.1(c) shows a plot of R_{max} and $X(R_{max})$ for various leak diameters for a tank pressure of 207.85 bar, including the upper and lower bounds for R_{max} and $X(R_{max})$ assuming ±10 percent uncertainty in each of the values of C*, L*, and X_{rad}. At this pressure the value of D_{rad} can be computed to approximately ±14 percent to ±18 percent depending on the jet diameter, while the flame length can be computed to approximately ±10 percent.

Figure E.9.4.1(b) Simulations of Hydrogen Jet Flame Radiation from a Tank at Pressure 207.85 bar (3000 psig) for Various Diameter Leaks. Results showing radiation distance, $D_{rad} = (X(R_{max}) + R_{max})$, for a heat flux level of 1577 W/m^2 and the visible flame length. Solid lines show distances using nominal values of C*, L*, and X_{rad}. Dashed lines show upper and lower bounds for D_{rad} and visible flame length with ±10 percent uncertainty in each of the values of C*, L*, and X_{rad}.

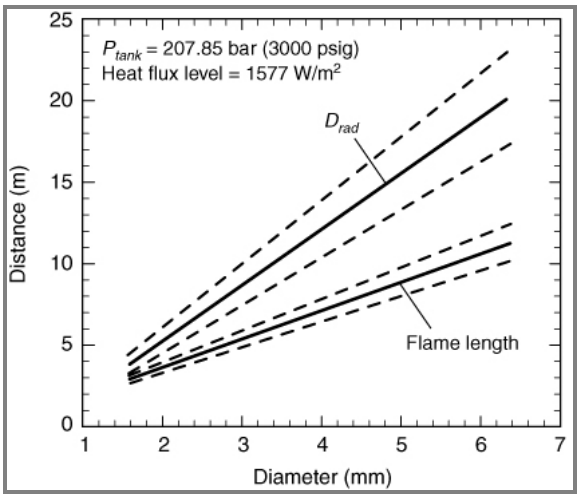


Figure E.9.4.1(c) Simulations of Hydrogen Jet Flame Radiation from a Tank at Pressure 207.85 bar (3000 psig) for Various Diameter Leaks. Results showing maximum radial distance from the flame centerline, R_{max}, for a heat flux level of 1577 W/m^2 and the axial location on centerline, $X(R_{max})$, where the maximum occurs. Solid lines show distances using nominal values of C*, L*, and X_{rad}. Dashed lines show upper and lower bounds for R_{max} and $X(R_{max})$ with ±10 percent uncertainty in each of the values of C*, L*, and X_{rad}.

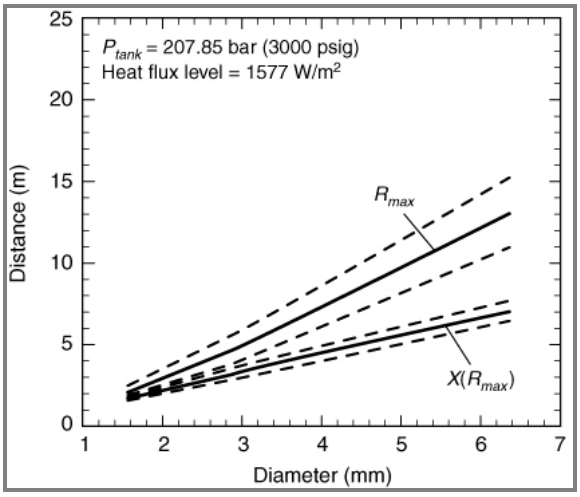


Figure E.9.4.1(d) Simulations of Concentration Decay of an Unignited Hydrogen Jet with a Diameter of 3.175 mm (1/8 in.) and a Tank Pressure of 207.85 bar (3000 psig). Contour lines correspond to mole fraction levels shown in the color legend.

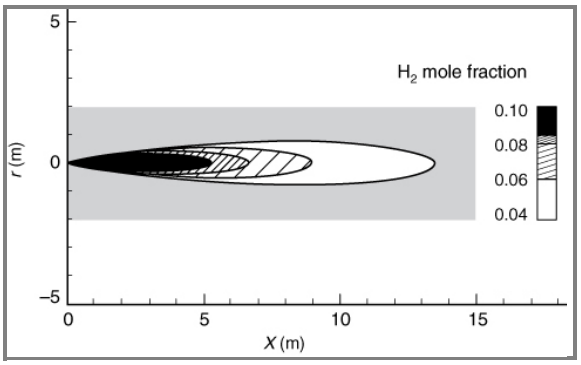


Figure E.9.4.1(d) shows mole fraction contours for the simulation of the concentration decay of an unignited jet of hydrogen for a tank pressure of 207.85 bar (3000 psig) and a leak diameter of 3.175 mm (1/8 in.). Important safety information recorded from the simulations is the distance from the jet exit to where the mean concentration decays to a given concentration level on the jet centerline. Although the generally accepted value for the upward-propagating lower flammability limit of hydrogen in air is 0.04 mole fraction, experimental data in the literature indicate that the limit can be as high as 0.072 mole fraction for horizontal-propagating flames and 0.095 mole fraction for downward-propagating flames (Zebetakis, 1965, Coward and Jones, 1952). For the unignited hydrogen jet simulations, distances from the origin to jet centerline concentration levels of 0.08, 0.06, 0.04, and 0.02 mole fraction were recorded, and these distances are referred to as x8 percent, x6 percent, x4 percent, and x2 percent respectively. Figure E.9.4.1(e) shows a plot of unignited jet concentration decay distances for a tank pressure of 207.85 bar (3000 psig) for various leak diameters. Upper and lower bounds for the concentration decay distances are also shown on the plot assuming a ±10 percent uncertainty in the turbulent jet entrainment constant *K* .

Figure E.9.4.1(e) Simulations of Concentration Decay for a Turbulent High-Momentum Supercritical Unignited Hydrogen Jet from a Tank at Pressure 207.85 bar (3000 psig) for Various Diameter Leaks. Results showing axial distance from jet origin to the point where jet concentration reaches 2.0 percent, 4.0 percent, 6.0 percent, and 8.0 percent mole fraction on jet centerline. Solid lines show distances using the nominal value of the turbulent jet entrainment constant, K = 5.40. Dashed lines show upper and lower bounds for distances with ±10 percent uncertainty in the value of K.

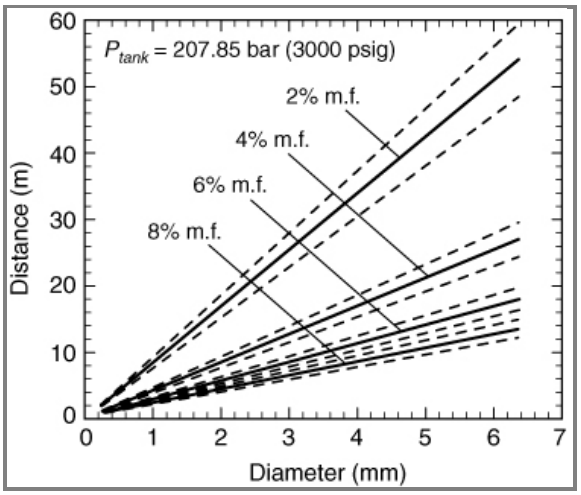


Table E.9.4.1(a) shows a summary of radiation distances recorded from hydrogen jet flame simulations for tank pressures of 18.25 bar (250 psig), 207.85 bar (3000 psig), 518.11 bar (7500 psig), and 1035.21 bar (15,000 psig) for selected leak diameters using the nominal values of C*, L*, and X rad . Table E.9.4.1(b) shows a summary of concentration decay distances for unignited hydrogen jets for the same tank pressures and selected leak diameters using the nominal value of the entrainment constant *K* . Detailed plots of radiation and

concentration decay distances for the range of parameters considered are presented in E.9.7 .

Figure E.9.4.1(f) shows a comparison of hydrogen jet flame radiation hazard distances with unignited jet concentration decay distances for a range of tank pressures and leak diameters. Results are shown for the visible flame length and the radiation hazard distance, D_{rad}, for heat flux levels of 1577 W/m^2 and 4732 W/m^2. These radiation hazard distances are compared with unignited jet concentration decay distances from origin to jet centerline mean concentration levels of 0.08, 0.06, 0.04 mole fractions. For the range of pressures studied, the unignited jet concentration decay distance to the generally accepted lower flammability limit of hydrogen in air (0.04 mole fraction) is greater than the radiation jet flame hazard distance (D_{rad}) for exposure at property line (1577 W/m^2).

Table E.9.4.1(a) Hydrogen Jet Flame Radiation Distances for Selected Leak Diameters and Tank Pressures

P_{tank} (bar)	d_j (mm)	X(R_{max}) (m)	R_{max} (m)	D_{rad} (m)	L_{vis} (m)	Heat Flux (W/m^2)
18.25	1.00	0.35	0.10	0.45	0.55	1577
18.25	1.00	0.35	0.059	0.41	0.55	4732
18.25	1.00	0.35	0.02			

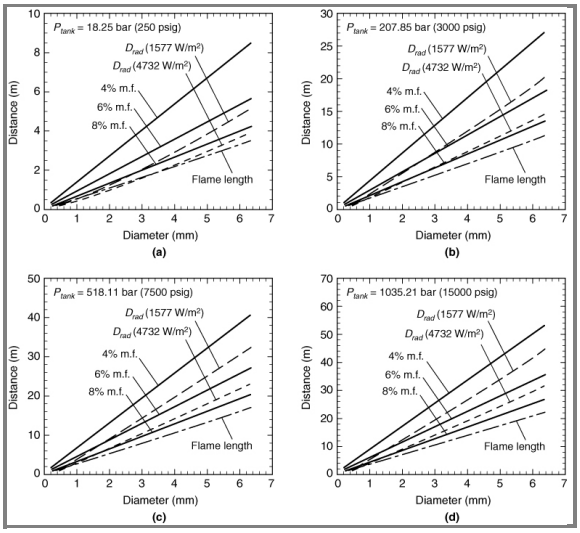
Note: Assuming worst case of no pressure loss in tubing.

Table E.9.4.1(b) Unignited Hydrogen Jet Concentration Decay Distances on Jet Centerline for Selected Leak Diameters, Tank Pressures, and Mole Fractions

P_{tank} (bar)	d_j (mm)	X 2% (m)	X 4% (m)	X 6% (m)	X 8% (m)
18.25	0.25	0.67	0.33	0.22	0.16
18.25	0.50	1.34	0.67	0.44	0.33
18.25	1.00	2.67	1.34	0.89	0.67
18.2					

X2 percent indicates the distance from jet origin to the point where the centerline concentration has decayed to a mean concentration of 2 percent mole fraction.

Figure E.9.4.1(f) Comparison of Simulations of Hydrogen Jet Flame Radiation Hazard Distances with Unignited Hydrogen Jet Centerline Concentration Decay Distances for Various Tank Pressures [18.25 bar (250 psig), 207.85 bar (3000 psig), 518.11 bar (7500 psig), 1035.21 bar (15000 psig)] and Leak Diameters. Dashed lines show the radiation hazard distance, D_{rad} = (X(R_{max}) + R_{max}), for radiation heat flux levels of 1577 W/m^2 and 4732 W/m^2 and the visible flame length. Solid lines show unignited jet concentration decay distances along jet centerline for concentration levels of 4 percent, 6 percent, and 8 percent mole fraction.



E.9.5 – Summary and Conclusions.

The previous sections presented methods by which the radiant heat flux from hydrogen jet flames and the concentration decay of supercritical high-momentum unignited hydrogen jets can be computed. If the jet exit conditions can be computed at the leak (Chernicoff et al., 2005), then these methods can be used to compute hydrogen jet flame radiation and unignited jet concentration decay based on the models.

An uncertainty analysis of the hydrogen jet flame radiation model (207.85 bar case) using an uncertainty of ±10 percent in each of the three experimentally measured correlations (C^*, L^*, X_{rad}), indicates that the radiation distance, D_{rad}, can be computed to approximately ±14 percent to ±18 percent for the jet diameters studied. The flame length can be computed to approximately ±10%. Assuming a ±10 percent uncertainty in the experimentally measured turbulent jet entrainment constant, K, an uncertainty analysis of the unignited jet concentration decay model indicates that concentration decay distances can be computed to ±10 percent. Figure E.9.7(a) through Figure E.9.7(e) give detailed plots of the hydrogen jet flame radiation hazard distances [D_{rad}, $X(R_{max})$, R_{max}] and unignited jet concentration decay distances (including upper and lower bounds) for tank pressures of 18.25 bar (250 psig), 207.85 bar (3000 psig), 518.11 bar (7500 psig), and 1035.21 bar (15,000 psig) over a range of leak diameters from 0.25 mm to 6.35 mm.

E.9.6 – Acknowledgements.

This work was supported by the US Department of Energy, Office of Energy Efficiency and Renewable Energy, Hydrogen, Fuel Cells and Infrastructure Technologies Program.

~~**E.9.7**~~ ~~– Appendix.~~

Figure E.9.7(a) shows simulation results of unignited hydrogen jet concentration decay distances and their uncertainty for the range of leak diameters and tank pressures studied. Figure E.9.7(b) through Figure E.9.7(e) show simulation results of hydrogen jet flame radiation distances and their uncertainty for the range of leak diameters and tank pressures studied.

Figure E.9.7(a) Simulations of Concentration Decay for Turbulent High-Momentum Supercritical Unignited Hydrogen Jets from Tanks at Pressures from 18.25 bar (250 psig) to 1035.21 bar (15000 psig) for Various Diameter Leaks. Results showing axial distance from jet origin to the point where jet concentration reaches 2.0 percent, 4.0 percent, 6.0 percent, and 8.0 percent mole fraction on jet centerline. Solid lines show distances using the nominal value of the turbulent jet entrainment constant, K = 5.40. Dashed lines show upper and lower bounds for distances with ±10 percent uncertainty in the value of K.

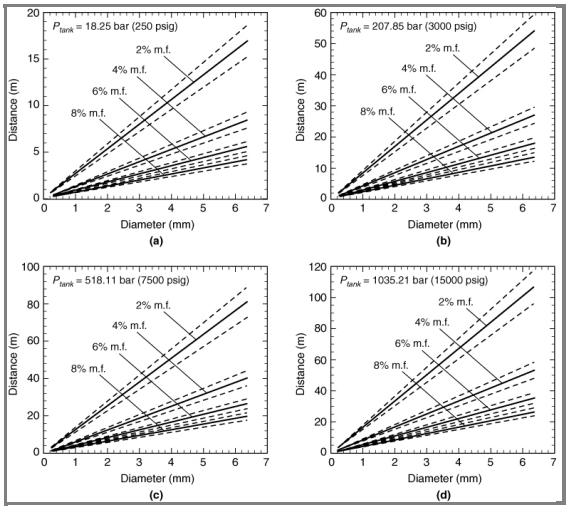
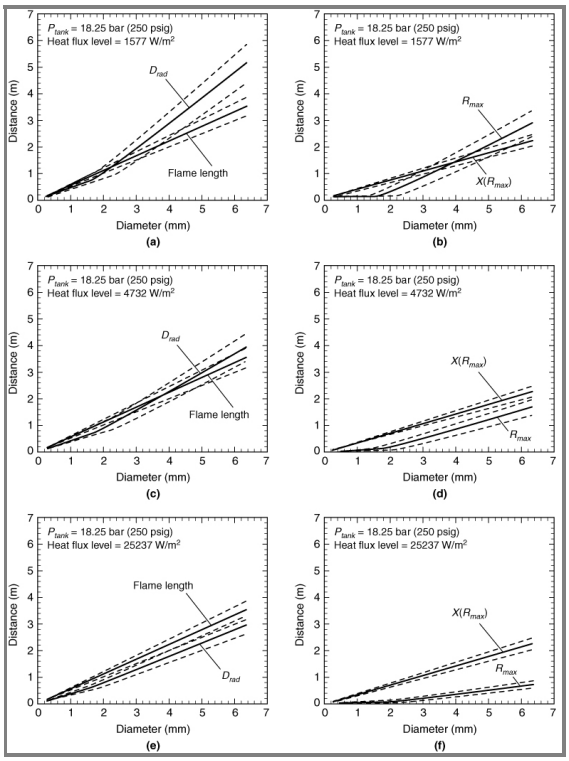


Figure E.9.7(b) Simulations of Hydrogen Jet Flame Radiation from a Tank at Pressure 18.25 bar (250 psig) for Various Diameter Leaks. Results showing maximum radial distance from the flame centerline, R, for a heat flux levels of 1577, 4732, and 25237 W/m^2 and the axial location on centerline, X(R_{max}), where the maximum occurs. Solid lines show distances using nominal values of C*, L*, and X_{rad}. Dashed lines show upper and lower bounds for R_{max} and X(R_{max}) with ±10 percent uncertainty in each of the values of C*, L*, and X_{rad}.



~~Figure E.9.7(c) Simulations of Hydrogen Jet Flame Radiation from a Tank at Pressure 207.85 bar (3000 psig) for Various Diameter Leaks. Results showing maximum radial distance from the flame centerline, R max , for a heat flux levels of 1577, 4732, and 25237 W/m 2 and the axial location on centerline, X(R max), where the maximum occurs. Solid lines show distances using nominal values of C*, L*, and X rad . Dashed lines show upper and lower bounds for R max and X(R max) with ±10 percent uncertainty in each of the values of C*, L*, and X rad .~~

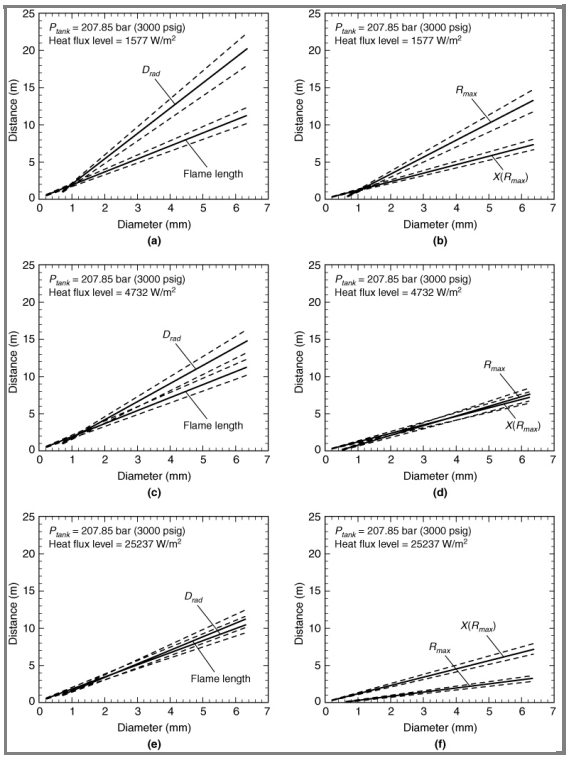


Figure E.9.7(d) Simulations of Hydrogen Jet Flame Radiation from a Tank at Pressure 518.11 bar (7500 psig) for Various Diameter Leaks. Results showing maximum radial distance from the flame centerline, R_{max}, for a heat flux levels of 1577, 4732, and 25237 W/m^2 and the axial location on centerline, $X(R_{max})$, where the maximum occurs. Solid lines show distances using nominal values of C*, L*, and X_{rad}. Dashed lines show upper and lower bounds for R_{max} and $X(R_{max})$ with ±10% uncertainty in each of the values of C*, L*, and X_{rad}.

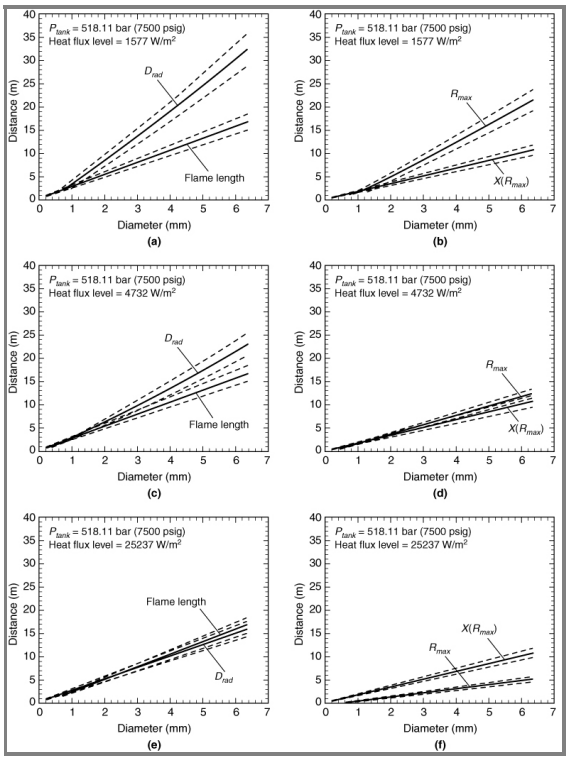
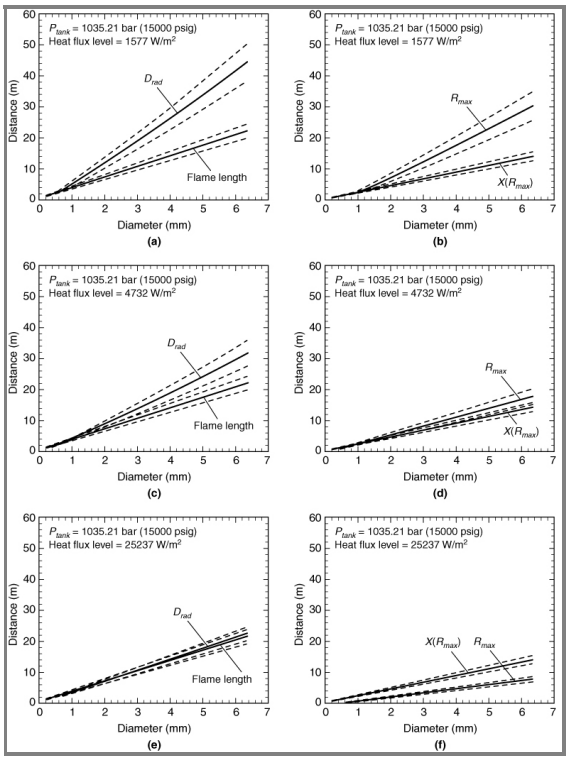


Figure E.9.7(e) Simulations of Hydrogen Jet Flame Radiation from a Tank at Pressure 1035.21 bar (15000 psig) for Various Diameter Leaks. Results showing maximum radial distance from the flame centerline, R_{max}, for a heat flux levels of 1577, 4732, and 25237 W/m^2 and the axial location on centerline, $X(R_{max})$, where the maximum occurs. Solid lines show distances using nominal values of C*, L*, and X_{rad}. Dashed lines show upper and lower bounds for R_{max} and $X(R_{max})$ with ±10 percent uncertainty in each of the values of C*, L*, and X_{rad}.



~~E.9.8~~ ~~– References.~~

(1) NFPA 1, *Fire Code*, 2018 edition.

(2) W. Houf and R. Schefer, "Predicting Radiative Heat Fluxes and Flammability Envelopes from Unintended Releases of Hydrogen," *International Journal of Hydrogen Energy*, Elsevier Publishing, 2007, Vol. 32, pp. 136–151.

(3) J. Floyd, *Siting Requirements for Hydrogen Supplies Serving Fuel Cells in Non-Combustible Enclosures*, Hughes Associates, Inc., 3610 Commerce Drive, Suite 817, Baltimore, MD 21227, HAI Project #3250-000, November 30, 2006.

(4) J. LaChance, *Risk-Informed Separation Distances for Hydrogen Refueling Stations*, Risk and Reliability Department, Sandia National Laboratories, Albuquerque, NM, May 2007. (Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94-AL85000.)

(5) Ibid, p. 11, reference to *Fires in or at Service Stations and Motor Vehicle Repair and Paint Shops*, NFPA, April 2002.

(6) J. LaChance, W. Houf, B. Middleton (all of Sandia National Laboratories), and L. Fluer (of Fluer, Inc.), "Analyses to Support Development of Risk-Informed Separation Distances for NFPA Hydrogen Codes and Standards," SAND 2009-0874, Sandia National Laboratories, Albuquerque, NM 87185, and Livermore, CA 94550, March 2009.

(7) S. E. Rose, S. Flamberg, and F. Leverenz, "Guidance Document for Incorporating Risk Concepts into NFPA Codes and Standards," Fire Protection Research Foundation, March 2007.

(8) "Determination of Safety Distances," European Industrial Gases Association, IGC Doc. 75/07/E, 2007.

(9) C. L. Atwood, J. L. LaChance, H. F. Martz, D. J. Anderson, M. Englehardt, D. Whitehead, and T. Wheeler, "Handbook of Parameter Estimation for Probabilistic Risk Assessment," NUREG/CR-6823, U.S. Nuclear Regulatory Commission, Washington, DC, 2003.

(10) API Recommended Practice 521, *Guide for Pressure Relieving and Depressuring Systems*, 4th edition, March 1997, API Publishing Services, 1220 L. St. N.W., Washington, DC 20005, Table 8, p. 41.

(11) "Predicting 1st and 2nd Degree Skin Burns from Thermal Radiation," *SFPE Engineering Guide*, Society of Fire Protection Engineers, Bethesda, MD 20814, March 2000, p. 8.

(12) ICC, *International Fire Code* ™, 2006 edition, International Code Council, 4051 West Flossmoor Road, Country Club Hills, IL 60478-5795, Table 2209.5.4.3.6(1), p. 210.

(13) V. Babrauskas, "Ignition of Wood: A Review of the State of the Art," Interflam 2001, Interscience Communications Ltd., London, 2001, pp. 71–88.

(14) J. LaChance, J. Phillips, and W. Houf, "Risk Associated with the Use of Barriers in Hydrogen Refueling Stations," National Hydrogen Association Conference & Expo, Long Beach, CA, May 3–6, 2010.

(15) W. Houf, R. Schefer, G. Evans, E. Merilo, and M. Groethe, "Evaluation of Barrier Walls for Mitigation of Unintended Releases of Hydrogen," *International Journal of Hydrogen Energy* , Vol. 35, Issue 10, May 2010, pp. 4758–4775.

(16) R. W. Schefer, G. H. Evans, J. Zhang, A. J. Ruggles, and R. Grief. "Ignitability limits for combustion of unintended hydrogen releases: Experimental and theoretical result," *International Journal of Hydrogen Energy*, Vol. 36, 2011.

(17) W. Houf, R. Schefer, "Analytical experimental investigation of small-scale unintended releases of hydrogen," *International Journal of Hydrogen Energy*, Vol. 33, 2008, pp. 1435-44.

(18) Winters W. S., "A New Approach to Modeling Fluid/Gas Flows in Networks." SAND2001-8422, Sandia National Laboratories, July 2001.

~~**E.9.8.1** – Other References.~~

Birch, A.D., Brown, D.R., Dodson, M.G., and Swaffield, F., "The Structure and Concentration Decay of High Pressure Jets of Natural Gas," *Combustion Science and Technology* 36: 249–261, 1984.

Birch, A.D., Hughes, D.J., Waffield, F., "Velocity Decay of High Pressure Jets," *Combustion Science and Technology* 52: 161–171, 1987.

Britter, R.E., "Dispersion of Two Phase Flashing Releases — FLADIS Field Experiment, The modelling of a pseudo-source for complex releases," Report FM89/2, Cambridge Environmental Research Consultants Ltd., December 1994.

Britter, R.E., "Dispersion of Two Phase Flashing Releases — FLADIS Field Experiment, A further note on modelling flashing releases," Report FM89/3, Cambridge Environmental Research Consultants Ltd., November 1995.

Chen, C. and Rodi, W., "Vertical Turbulent Buoyant Jets — A Review of Experimental Data," Pergamon Press, 1980.

Chenoweth, D.R., "Gas-Transfer Analysis Section H — Real Gas Results via the van der Waals Equation of State and Virial Expansion Extensions of its Limiting Abel-Nobel Form," Sandia Report SAND83-8229, June 1983.

Chernicoff, W., Engblom, L. Schefer, W. Houf, W., and San Marchi, C., "Characterization of Leaks from Compressed Hydrogen Dispensing Systems and Related Components," 16th Annual Hydrogen Conference and Hydrogen Expo USA, March 28–April 1, Washington, DC, 2005.

Coward, H.F, and Jones, G.W., "Limits of Flammability of Gases and Vapors," Bureau of Mines Bulletin 503, 1952.

Delichatsios, M. A., *Combust. Flame* 92: 349–364, 1993.

Houf, W., and Schefer, R., Predicting Radiative Heat Fluxes and Flammability Envelopes from Unintended Releases of Hydrogen, *Inter. Jour. of Hydrogen Energy* 32: 136–151, 2007.

Houf, W., and Schefer, R., Analytical and Experimental Investigation of Small-Scale Unintended Releases of Hydrogen, *Inter. Jour. of Hydrogen Energy* 33: 1435–1444, 2008.

International Code Council (ICC) Ad-Hoc Committee for Hydrogen Gas, October 2003.

2003 International Fire Code, International Code Council, Inc., 2002.

Questar Gas, Material Safety Data Sheet, Natural Gas, April, 1998.

Ruffin, E., Mouilleau, Y., Chaineaux, J. "Large Scale Characterization of the Concentration Field of Supercritical Jets of Hydrogen and Methane," J. Loss Prev. Process Ind., Vol. 9, No. 4, pp. 279–284, 1996.

Schefer, R. W., Houf, W. G., Moen, C. D., Chan, J. P., Maness, M. A., Keller, J. O., Leon, M. V., Tam, R., "Hydrogen Codes and Standards Unintended Release Workshop: Workshop Analysis," Workshop held December 12, 2003 at Sandia National Laboratories, Livermore CA, 2004b.

Schefer, R., Houf, W., Bourne, B., and Colton, J., "Spatial and Radiative Properties of an Open-Flame Hydrogen Plume," *Inter. Jour. of Hydrogen Energy* 31: 133340, 2006.

Schefer, R., Houf, W., Williams, T.C., Bourne, B., and Colton, J., "Characterization of High-Pressure, Underexpanded Hydrogen-Jet Flames," *Inter. Jour. of Hydrogen Energy* 32: 2081–2093, 2007.

Sivathanu, Y. R. and Gore, J. P., *Combust. Flame* 94: 265–270, 1993.

Swain, M., "Hydrogen Properties Testing and Verification," presented at Fuel Cell Summit Meeting, Coral Gables, FL, June 17, 2004.

Turns, S. R. and Myhr, F. H., *Combust. Flame* 87: 319–335, 1991.

Turns, S. R., "An Introduction to Combustion," 2nd edition, McGraw-Hill, 2000.

Winters, W. S., "TOPAZ — A Computer Code for Modeling Heat Transfer and Fluid Flow in Arbitrary Networks of Pipes, Flow Branches, and Vessels," SAND83-8253, Sandia National

~~Laboratories, Livermore, CA, January, 1984.~~

~~Zebetakis, M.G., U.S. Bureau of Mines, Bulletin 627, 1965.~~

Statement of Problem and Substantiation for Public Input

The paper that is included as E.9 is already published as Appendix A in SAND2009-0874. The references that were previously section E.9.8 were actually referring to the entirety of appendix E, thus, E.9 has been replaced with only the references in section E.9.8.

Two references were deleted as these references appear in section E.8, proposed to be deleted in PI-298 since Annex N describes the LH2 exposure distance methodology.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 303-NFPA 2-2024 [Section No. E.1]	

Submitter Information Verification

Submitter Full Name: Ethan Hecht
Organization: Sandia National Laboratories
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 12:03:52 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-103-NFPA 2-2024

Statement: The paper that is included as E.9 is already published as Appendix A in SAND2009-0874. The references that were previously section E.9.8 were actually referring to the entirety of appendix E, thus, E.9 has been replaced with only the references in section E.9.8.

Two references were deleted as these references appear in section E.8, which is being deleted.

Additionally this annex material contained references to the previous 3% leak size and could cause confusion.

Public Input No. 174-NFPA 2-2023 [Chapter K]

Annex K ~~Hydrogen Explosion Control~~ **Determination of Internal Overpressure, External Overpressure and Fireball Size Resulting from Deflagration Venting of Hydrogen/Hydrogen Mixtures Based on NFPA 68 (2018)**

K.4 – References.

American Institute for Chemical Engineers, Center for Chemical Process Safety, *Guidelines for Chemical Process Quantitative Risk Assessment,* 2nd edition, 2000.

American Institute for Chemical Engineers, Center for Chemical Process Safety, *Guidelines for Hazard Evaluation Procedures,* 2nd edition, 1992.

ASME *Boiler and Pressure Vessel Code,* American Society of Mechanical Engineers, 2013.

ASME B31.12, (2011) "Hydrogen Piping and Pipelines," American Society of Mechanical Engineers, 2011.

Baker, W., Cox, P., Westine, P., Kulesz, J., and Strehlow, R. "Explosion Hazards and Evaluation," Elsevier, 1983.

Baker, Q., Doolittle, C., Fitzgerald, G. and Tang, M. "Recent Developments in the Baker-Strehlow VCE Analysis Methodology." 31st Annual AIChE Loss Prevention Symposium, 1997.

CGA P-28, *Risk Management Plan Guidance Document for Bulk Liquid Hydrogen Systems,* Compressed Gas Association, 2009.

Cleaver, R., Humphreys, C., Morgan, J. and Robinson, C. "Development of a model to predict the effects of explosions in compact congested regions." *Journal of Hazardous Materials* v. 53, pp. 35–55, 1997.

Davison, J., Porter, J., Dinan, R., Hammons, M., and Connell, J., "Explosive Testing of Polymer Retrofit Masonry Walls," *Journal of Performance of Constructed Facilities* , v. 12, pp. 100–106, 2004.

Dorofeev, S. "A Flame Speed Correlation for Unconfined Gaseous Explosions." *Process Safety Progress* 26(2): 140–149, 2007a.

Dorofeev, S., "Hydrogen Flames In Tubes: Critical Run-Up Distances." 2nd International Conference on Hydrogen Safety. San Sebastian, Spain, 2007b.

Environmental Protection Agency, "Risk Management Plan Regulation," Code of Federal Regulations (CFR) 40 CFR 68.130, see also http://www.epa.gov/oem/content/rmp/rmp_guidance.htm#General.

Groethe, M. et al., "Large Scale Hydrogen Deflagrations and Detonations," International Conference on Hydrogen Safety, 2005.

Friedrich A. et al. "Experimental Study of Hydrogen-Air Deflagrations in a Flat Layer," 2nd International Conference on Hydrogen Safety, San Sebastian, Spain, 2007.

Hansen, O., Renoult, J., Sherman, M., and Tieszen, S.,"Validation of FLACS-Hydrogen CFD Consequence Prediction Model Against Large Scale H_2 Explosion Experiments in the FLAME Facility," International Conference on Hydrogen Safety, 2005.

Jo, Y.-D. and Park, K-S., "Minimum Amount of Flammable Gas for Explosion within a Confined Space." *Process Safety Progress* 23: 321–329, 2004.

M. Kaneshige and J. E. Shepherd, Detonation database, Technical Report FM97-8, GALCIT, July 1997. See also the electronic hypertext version at http://www.galcit.caltech.edu/detn_db/html/.

Knox, K., Hammons, M., Lewis, T. and Porter, J., "Polymer Materials for Structural Retrofit," Air Force Research Laboratory Report, 2004.

Lee, J. and Berman, M., "Hydrogen Combustion and Its Application to Nuclear Reactor Safety," *Advances In Heat Transfer* , v 29, 1998.

Mays, G. C., and Smith, P. D., *Blast effects on buildings — Design of buildings to optimise resistance to blast loading.* Thos. Telford, London, 1995.

Mercx, W., and van den Berg, A., "The Explosion Blast Prediction Model in the Revised Yellow Book." 31st Annual AIChE Loss Prevention Symposium, 1997.

Molkov, V., Makarov, D. and Schneider, H., "Hydrogen-Air Deflagrations in Open Atmosphere: Large Eddy Simulation of Experimental Data." 1st International Conference on Hydrogen

Safety. Pisa, Italy, 2005.

Ng, H. D., Ju, Y., and Lee, J., "Assessment of Detonation Hazards in High-Pressure Hydrogen Storage from Chemical Sensitivity Analysis," *Intl. Journal of Hydrogen Energy* , 2006.

OECD Nuclear Energy Agency, Flame Acceleration and Deflagration to Detonation Transition in Nuclear Safety, State-of-the-Art Report by a Group of Experts, OECD Nuclear Energy Agency, NEA/CSNI/R(2000)7, August 2000.

Ogle, R., "Explosion Hazard Analysis for an Enclosure Partially Filled With a Flammable Gas." *Process Safety Progress* 18: 170–177, 1999.

Petukhov, V. A., Naboko, I. M., and Fortov, V. E., "Explosion Hazard Of Hydrogen-Air Mixtures In The Large Volumes," 2nd International Conference on Hydrogen Safety, 2007.

Pierorazio, J., Thomas, Q., Baker, Q., and Ketchum, D., "An Update to the Baker-Strehlow-Tang Vapor Cloud Explosion Prediction Methodology Flame Speed Table." *Process Safety Progress* 24: 59–65, 2005.

Schneider, H., "Large Scale Experiments: Deflagration and Deflagration to Detonation within a Partial Confinement Similar to a Lane," 1st Intl. Conference on Hydrogen Safety, Pisa, Italy, 2005.

Shepherd, J. E., "Elastic and Plastic Structural Response of Tubes to Deflagration-to-Detonation Transition," California Institute of Technology Explosion Dynamics Laboratory Report FM2006-00X, 2006.

Sherman, M. and Berman, M., "The Possibility of Local Detonations during Degraded-Core Accidents in the Bellefonte Nuclear Power Plant," *Nuclear Technology* , v 18, pp. 63–77, 1987.

Shirvill, L. C., Royle, M., and Roberts, T. A., "Hydrogen Releases Ignited In A Simulated Vehicle Refuelling Environment," 2nd International Conference on Hydrogen Safety, San Sebastian, Spain, 2007.

Smith, P. D., and Hetherinton, J. G., *Blast and ballastic loading of structures.* Butterworth-Heinemann, Oxford, U.K., 1994.

Tanaka, T. et al.,"Experimental Study on Hydrogen Explosions in a Full-Scale Hydrogen Filling Station Model," 1st Intl. Conference on Hydrogen Safety, Pisa, Italy, 2005.

Tang, M. and Baker, Q., "A New Set of Blast Curves from Vapor Cloud Explosions." 33rd Annual AIChE Loss Prevention Symposium, 1999.

Wabayashi, et al., "A Field Explosion Test of Hydrogen-Air Mixtures," International Conference on Hydrogen Safety, 2005.

Zalosh, R., "Blast Waves and Fireballs Generated by Hydrogen Fuel," 2005.

Zalosh, R.,"Explosion Venting Data and Modeling Literature Review," Fire Protection Research Foundation Report, 2007.

Zlochower, I., and Green, G., "The limiting oxygen concentration and flammability limits of gases and gas mixtures." *Journal of Loss Prevention in the Process Industries* , vol. 22: 499–505, 2009

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only. The following information is intended to provide voluntary guidance related to explosion control for hydrogen. The text is presented in a format similar to what is anticipated to be included in Chapter 9 , which is currently reserved, in the next edition of NFPA 2.

The guidance in Annex K pertains to explosion prevention measures as follows:

(1) *Providing criteria to determine where explosion control measures are needed*

(2) *Providing continuous or emergency ventilation to dilute inadvertently released hydrogen in confined areas*

(3) *Inerting hydrogen contained in process equipment and piping*

(4) *Eliminating potential ignition sources associated with electrical equipment and wiring*

(5) *Avoiding highly obstructed, confined, and partially confined areas containing hydrogen storage vessels, processing equipment, and piping*

(6) *Containing hydrogen deflagrations within equipment and vessels so as to prevent equipment or vessel rupture, and to prevent deflagration propagation to interconnected equipment*

(7) *Conducting explosion risk analyses to identify site-specific potential explosion scenarios and implement appropriate measures to reduce the likelihood of those scenarios actually occurring*

Annex K guidance also covers explosion damage mitigation by deflagration venting and avoiding deflagration-to-detonation transitions.

K.1 – General.

K.1.1 – Applicability.

The storage, use, and handling of GH_2 in any quantity should also comply with the requirements of Chapter 1 and 4 and the applicable requirements of Chapters 5 through 8.

K.1.1.1 –

Vehicles regulated by approved motor vehicle safety standards used for commercial or noncommercial application should not be required to comply with Annex K.

K.2 – Explosion Control.

~~K.2.1~~ –

Explosion control should be provided where there are any of the following conditions:

(1) The amounts of GH 2 or LH 2 in storage or use exceed the quantity thresholds requiring special provisions.

(2) At outdoor or partially confined locations as follows:

(3) Where the amount of GH 2 or LH 2 in storage or use exceed the quantity thresholds requiring special provisions, as specified in Table 6.4.1.1.1 for indoor control areas

(4) Where one or more of the following exist:

(5) A flame acceleration hazard exists due to hydrogen being stored or used along with piping and equipment in a congested space

(6) The area containing the GH 2 or LH 2 is partially enclosed by either three or more walls, or two walls plus a weather cover or ceiling.

An example of a congested space could be small regularly spaced obstacles such as a congested equipment or piping array. The following criteria can help identify congested spaces where flame acceleration hazard would exist:

(1) Three or more rows or tiers of piping, spaced at less than 10 to 12 pipe diameters

(2) Three or more hydrogen process or storage units, spaced at one to five times the smallest process/storage unit dimension

The following references describe analysis methods to account for the effects of flammable gas cloud volume and obstructions on pressures generated from vapor cloud explosions due to large releases of flammable gas: Baker et al. (1997), Cleaver et al. (1997), Dorofeev, (2007a), Mercx and van den Berg (1997), Pierorazio et al. (2005), and Tang and Baker (1999). Note: Unconfined hydrogen explosions only occur with at least 40 kg hydrogen released into an unobstructed open area in such a way that at least 20 kg develops near-stoichiometric concentrations, or with at least 0.50 kg hydrogen into a highly obstructed area. Test data on unconfined hydrogen deflagrations are available in the following references: Groethe et al. (2005), Molkov et al. (2005), and Wabayashi et al. (2005). The experiments of Groethe et al. showed that blast walls constructed to protect equipment and structures behind them are only effective for structures within a distance of two-to-three wall heights on the side of the wall away from the hydrogen explosion.

The threat of a hydrogen explosion in a partially confined area depends on the hydrogen concentration distribution, potential ignition sources, the amount of confinement, the enclosure length/diameter ratio, and the presence of various types of obstructions. Although there are no definitive research results for every quantitative value and combination of these four parameters, there has been extensive research and guidelines on the congestion levels and gas burning velocities that are conducive to hydrocarbon vapor cloud explosions Baker-Strehlow-Tang (2005) and Zalosh (2008) have provided a comprehensive review of the effects of different types and quantities of obstructions on the pressures developed in vented hydrocarbon gas explosions. As an example, these reviews indicate that closely spaced piping at three or more elevations and evenly spaced small equipment represent the type of congestion that allows explosions to develop in open or partially confined areas. Test data and computational models providing data and calculations to assess the effects of certain important ranges of hydrogen concentrations, confinement and obstruction configurations, and ignition source locations in partially confined areas are available in the following references: Friedrich et al. (2007), Schneider (2005), Shirvill and Roberts (2007), and Tanaka et al. (2005).

(1) Indoors or in enclosures if the static volume of GH_2 or LH_2 (STP) contained in a process or transported in piping systems in the enclosure is equal to or greater than 0.004 (0.4 percent) times the enclosure volume and the piping or container or equipment is disconnected during normal operations while at least some hydrogen remains pressurized.

Hydrogen–air deflagrations can occur when a flammable hydrogen-air mixture encounters a capable ignition source in an enclosure. The likelihood of formation of a flammable hydrogen–air mixture depends on the likelihood of releasing hydrogen at a rate and location such that it cannot be readily or rapidly diluted below the lower flammable limit (LFL). Because existing NFPA standards do not contain a systematic and general description of the risk of a hydrogen deflagration occurring, the Hydrogen Technologies Committee has generated the deflagration risk criteria in Section K.4 based on semi-quantitative considerations of the risk of a hydrogen release, and the following quantitative determination of the minimum amount of hydrogen required to produce enclosure damage and injuries once ignited in an enclosure.

The least amount of flammable gas that can produce deflagration pressure damage can be determined from considerations of partial volume deflagrations in which a local flammable mixture exists in an enclosure in which most of the enclosure volume has concentrations below the LFL. The deflagration pressure, P, produced from ignition at atmospheric pressure, P_{atm}, of a local near-stoichiometric mixture of volume, V_{pv}, in an enclosure of volume, V, is given by the following equation *(see Ogle, 1999, and Jo and Park, 2004)*.

$$\frac{P}{P_{atm}} = \left[1 - \left(\frac{V_{pv}}{V}\right) + \left(\frac{V_{pv}}{V}\right)\left(\frac{P_{exp}}{P_{atm}}\right)^{1/\gamma}\right]^{\gamma} \qquad \text{[K.2.1a]}$$

where:

P = deflagration pressure

P_{atm} = atmospheric pressure

V_{pv} = local near-stoichiometric mixture volume

V = enclosure volume

P_{exp} = the deflagration explosion pressure corresponding to a uniform near-stoichiometric gas mixture throughout the enclosure

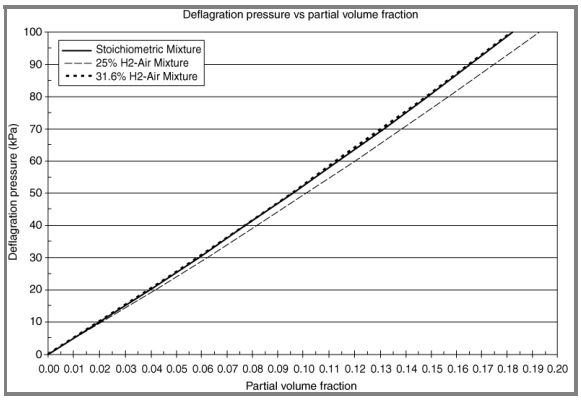
γ = the gas mixture ratio of specific heats

Values of P_{exp}/P_{atm} and γ for stoichiometric hydrogen–air mixtures (i.e., 29.6 percent volume hydrogen in dry air), and for hydrogen–air mixtures with hydrogen concentrations in the range of 25.15 volume percent to 33.5 volume percent have been obtained using the GASEQ software package. Using these values of P_{exp}/P_{atm} and γ, Equation K.2.1a has been used to calculate P (kPa g) as a function of the partial volume fraction V_{pv}/V. Results are shown in Figure K.2.1(a). The curves of P versus partial volume fraction are linear for partial volume fractions less than about 0.08 because Equation K.2.1a can be approximated as follows:

$$\frac{P}{P_{atm}} - 1 \approx \left(\frac{V_{pv}}{V}\right)\left(\frac{P_{exp}}{P_{atm}}\right) \qquad \text{[K.2.1b]}$$

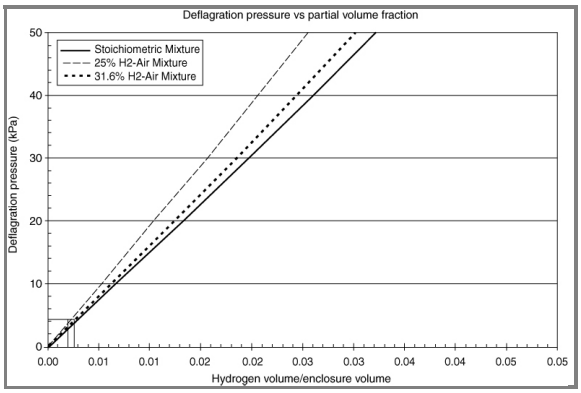
for these small values of V_{pv}/V.

Figure K.2.1(a) Hydrogen Deflagration Pressure Versus Flammable Hydrogen–Air Mixture Partial Volume Fraction for Three Different Hydrogen Concentrations.



The volume of hydrogen in the locally uniform hydrogen–air mixture partial volume is given by $\chi_{H2} V_{pv}$, where χ_{H2} is the volume fraction of hydrogen in the near-stoichiometric hydrogen–air mixture. If the hydrogen concentration distribution in the enclosure is idealized as a sharp discontinuance boundary between the locally uniform flammable gas mixture and the air in the rest of the enclosure, the volume of hydrogen in the enclosure is given by $\chi_{H2} (V_{pv}/V)$. Figure K.2.1(b) is a plot of the deflagration P (kPag) versus $\chi_{H2} (V_{pv}/V)$, which is the ratio of the hydrogen volume to the enclosure volume.

Figure K.2.1(b) Hydrogen Partial Volume Deflagration Pressure Versus Ratio of Hydrogen Volume to Enclosure Volume for Different Hydrogen Partial Volume Concentrations.



The minimum hydrostatic pressure at which limited minor structural damage can occur is approximately 0.4 psig to 0.5 psig (2.8 kPa to 3.5 kPa) according to Tables 2.18a and 2.18b of the American Institute for Chemical Engineers, Center for Chemical Process Safety, *Guidelines for Chemical Process Quantitative Risk Analysis*. Therefore, injuries to any exposed personnel due to broken glass and other debris from minor structural damage can be anticipated at pressures at and above about 4 kPa (0.58 psig). A horizontal line at about 4 kPa in Figure K.2.1(b) intersects the curve for a 25 percent partial volume deflagration at a ratio of hydrogen volume to enclosure volume of about 0.004. The intersection for the stoichiometric mixture concentration occurs at a slightly higher ratio of $\chi_{H2} (V_{pv}/V)$. Therefore, the hydrogen volume that can, in principle, cause minor damage and injuries is 0.4 volume percent — that is, at about 1/10 th LFL if the hydrogen volume was uniformly distributed throughout the enclosure volume.

As an example, consider a hydrogen vehicle repair garage containing a single hydrogen-fueled vehicle with an 80 L fuel tank containing hydrogen at an absolute pressure of 34 MPa. The volume of room temperature hydrogen corresponding to the release of the tank contents through an inadvertently actuated pressure relief device is equal to $(0.080\ m^3\ H_2)(34\ MPa)/(0.101\ MPa) = 26.93\ m^3\ H_2$. The minimum repair garage volume to prevent the ratio of hydrogen volume to enclosure volume from reaching 0.004 is equal to $26.93\ m^3/0.004 =$

~~6733 m ^{3} = 238,000 ft ^{3} . This volume is larger than the volume of a garage with a footprint of 100 ft x 100 ft (30.5 m x 30.5 m) and a ceiling height of 20 ft (6.1 m).~~

~~K.2.2~~ ~~– Explosion Control Methods.~~

~~K.2.2.1~~ ~~– Explosion Protection.~~

~~Where explosion control is recommended by K.2.1 , explosion protection should consist of one or more of the following:~~

(1) ~~Deflagration prevention by gas concentration reduction per K.2.2~~

(2) ~~Deflagration prevention by oxidant concentration reduction per K.2.2.3~~

(3) ~~Deflagration venting per K.2.2.4~~

(4) ~~Deflagration containment per K.2.2.5~~

~~In addition to the explosion control measures, the control of ignition sources will decrease the potential for an explosion. Typical ignition sources include thermal, mechanical, electrical, and electrostatic. The use of ignition control measures to address these sources will not eliminate the potential for spontaneous ignition.~~

~~Electrical ignition sources can be mitigated by utilizing the requirements for electrical equipment and wiring in classified locations in accordance with Article 500 of *NFPA 70* . NFPA 497 provides guidance for establishing classified locations.~~

~~Through the exercise of ingenuity in the layout of electrical installations for hazardous (i.e., classified) locations, it is frequently possible to locate much of the equipment in a reduced level of classification or in an unclassified location and, thus, to reduce the amount of special equipment required. It is important that the authority having jurisdiction (AHJ) be familiar with recorded industrial experience as well as with the standards of the National Fire Protection Association (NFPA), the American Petroleum Institute (API), and the Instrumentation, Systems, and Automation Society (ISA) that can be of use in the classification of various locations, the determination of adequate ventilation, and the protection against static electricity and lightning hazards.~~

~~Electrostatic ignition can be controlled by utilizing the methods identified in NFPA 77.~~

~~Other potential ignition sources including, but not limited to, smoking, open flames, heating, and spark producing equipment should be eliminated or located a safe distance from potential leak sources.~~

~~K.2.2.1.1~~ ~~–~~

~~The explosion protection methods specified in K.2.2.1 can be partially or totally eliminated where supported by an approved hazard analysis.~~

~~The hazard analysis should give consideration to the following:~~

(1) ~~The location of the storage system and associated exposures~~

(2) ~~The potential for deflagration to detonation transition~~

(3) ~~Prevention of pressurized equipment and piping breaches or releases~~

(4) ~~Identification of additional preventive measures~~

(5) ~~Identification of additional mitigation controls~~

(6) ~~Documented test data applicable to the identified scenarios~~

~~K.2.2.1.1.1~~ ~~–~~

~~The hazard analysis should identify and document the applicable explosion hazard scenarios.~~

K.2.2.1.1.2 –

The hazard analysis should be validated by qualified personnel with proven expertise in hazard analysis and should be subject to approval by the AHJ.

For hydrogen, reliance upon prevention of ignition by controlling ignition sources is not sufficient by itself due to the low ignition energy of ignitable clouds of GH_2 and the fact that certain releases can self-ignite due to buildup and discharge of static electricity. Therefore, control of ignition sources must be combined with either fuel reduction (typically) by ventilation of the area to lower GH_2 concentration or by deflagration venting, or both, to achieve sufficient defense in depth.

K.2.2.1.1.3 –

When the hazard analysis has determined that there is a potential deflagration-to-detonation transition (DDT), the system parameters should be redesigned to eliminate the hazard.

K.2.2.2 – Deflagration Prevention by Hydrogen Gas Concentration Reduction.

K.2.2.2.1 –

Deflagration prevention by gas concentration reduction can be considered where a mixture of a combustible material and an oxidant is confined to an enclosure and where the concentration of the hydrogen can be maintained below the LFL of hydrogen (i.e., 4.0 volume percent at room temperature and pressure).

See Annex B of NFPA 69, for a discussion of the control of flammable gas mixtures. See also Annex D of NFPA 69, for information on calculating the time required for concentration reduction by ventilation.

K.2.2.2.2 –

Deflagration prevention by hydrogen gas concentration reduction should be in accordance with Chapter 8 of NFPA 69, as supplemented by K.2.2.2.3 .

K.2.2.2.3 –

The factors in K.2.2.2.3.1 and K.2.2.2.3.2 should be considered in the design of a system intended to reduce the combustible concentration below the LFL.

K.2.2.2.3.1 –

If ventilation is used, the outlets from the protected enclosures [should] be located so that hazardous concentrations of the exhausted air cannot enter or be drawn into the fresh air intakes of environmental air–handling systems. [**69:** 8.3.3.1]

K.2.2.2.3.2 –

The ventilation rate for hydrogen dilution should be based on a hydrogen release rate equal to either the storage pressure and an orifice diameter equal to 3 percent of the diameter of the largest hydrogen piping or equipment connection, or a risk-based analysis of release rates for the type of hydrogen piping and equipment in the room or building.

Note: The 3 percent of the pipe diameter requirement is based on the hydrogen leakage rate conditions described in Section E.9.1 .

K.2.2.3 – Oxygen Concentration Reduction Below the 3 Volume Percent Hydrogen Limiting Oxygen Concentration (LOC).

K.2.2.3.1 –

Oxygen concentration reduction can be considered where a mixture of oxidant and hydrogen is confined to an enclosure within which the oxidant concentration can be controlled.

K.2.2.3.2 –

Oxygen concentration reduction should be in accordance with Chapter 7 of NFPA 69, as supplemented by K.2.2.3.3 .

K.2.2.3.3 – Design Considerations.

K.2.2.3.3.1 –

The following factors should be considered in the design of an oxygen concentration reduction system:

(A) –

Limiting Oxidant Concentrations (LOC). [69:7.2.3]

(1) The hydrogen LOC depends on the inert gas used, the flammability test method, and the initial temperature and pressure.

(2) The LOC for nitrogen inerting at standard temperature and pressure is 3.0 percent oxygen.

(3) The LOC for carbon dioxide inerting at standard temperature and pressure is 3.2 percent oxygen.

(4) The LOC value for other inert gases, temperatures, and pressures should be measured according to ASTM E2079, *Standard Test Method for Limiting Oxygen (Oxidant) Concentration for Gases and Vapors* .

(5) The use of oxidants other than oxygen can also require further investigation with respect to the limiting oxidant concentration.

(6) The design concentration should be a fraction of the LOC per 7.7.2.5 and 7.7.2.7 of NFPA 69.

Note: The LOC values for nitrogen and carbon dioxide are the adjusted values for hydrogen from Table C.1(a) of NFPA 69.

K.2.2.4 – Deflagration Venting.

Hydrogen deflagration venting for limiting explosion damage should be in accordance with the requirements of Section 6.10 and with NFPA 68.

K.2.2.5 – Deflagration Containment.

K.2.2.5.1 – Application.

The technique for deflagration pressure containment [can] be considered for specifying the design pressure of a vessel and its appurtenances so they are capable of withstanding the maximum pressures resulting from an internal [hydrogen] deflagration. [**69:** 13.1.1]

K.2.2.5.2 – Deflagration Containment.

Deflagration containment should be in accordance with Chapter 13 of NFPA 69, as supplemented by K.2.2.5.3 .

K.2.2.5.3 – Design Considerations.

The following factors should be considered in the design of a deflagration venting system:

(1) The deflagration containment design basis should be as described in Section 13.3 of NFPA 69.

(2) The value of the hydrogen–air deflagration pressure ratio, *R* , needed for the design basis in Section 13.3 of NFPA 69 is 8.3. Another value of the deflagration pressure ratio, *R*, can be used if a documented analysis of worst-case hydrogen concentrations shows that near-stoichiometric hydrogen–air concentrations cannot occur.

(3) The value of the hydrogen–oxygen deflagration pressure ratio, *R*, needed for the design basis in Section 13.3 of NFPA 69 is 9.6. Another value of the deflagration pressure ratio, *R* , can be used if a documented analysis of worst-case hydrogen concentrations shows that near-stoichiometric hydrogen–oxygen concentrations cannot occur.

(4) Where either deflagration venting or deflagration containment is relied on as an exclusive control measure for explosion protection, a documented risk assessment should be performed to evaluate the potential for a DDT when any of the following conditions exist:

(5) The ratio of the volume of the equipment plus the volume of internal structures within the enclosure to the volume of the enclosure is greater than 0.10.

(6) The ratio of surface area of the equipment plus the surface area of internal structures to the surface area of the enclosure is less than 0.15.

(7) There are uniformly spaced objects or obstacles including piping or equipment that obstruct more than 40 percent of the enclosure cross-section based on the least dimension of the space. Uniformly spaced objects can include piping or equipment arranged in a repetitive manner such that the explosive effects are magnified as the flame propagates around these objects.

(8) The enclosure length-to-diameter ratio is greater than 5.

The potential for DDT in obstructed or elongated enclosures is a complex subject often requiring expert analysis. Some of the contemporary references on this subject include the following:

Dorofeev (2007b), Hansen et al. (2005), Lee and Berman (1997), Pethukov et al. (2007), Sherman and Berman (1988), Zalosh (FPRF report).

K.3 – Explosion Prevention.

K.3.1 – Intentional Release of Hydrogen.

GH $_2$ or LH $_2$ should not be intentionally released from storage or use systems into areas where congested piping systems are present.

K.3.2 – Hydrogen Explosions in Piping, Electrical Conduit, and Ducting.

K.3.2.1 – Piping and Tubing Explosion Hazards and Protection.

K.3.2.1.1 –

An evaluation should be conducted to determine the potential of an adverse reaction where any of the following conditions exist:

(1) The formation of a mixture of hydrogen with atmospheric pressure air within piping that has a design pressure rating of less than 300 psi.

(2) The formation of a mixture of hydrogen with greater than atmospheric pressure air.

(3) Where a hydrogen–oxygen mixture within piping or tubing can occur.

(4) Where piping can be filled with air and is purged with hydrogen.

(5) Where there is potential for degradation of fittings, gaskets, valves, and so forth, due to hydrogen embrittlement.

If the process requires the hydrogen piping or tubing to carry a flammable mixture during any stage of operation, the ability of the piping to withstand a hydrogen explosion should be evaluated and, if necessary, strengthened to prevent pipe failure.

Methods to assess the structural response of piping and tubing to deflagrations and detonations are described by Shepherd (2006).

Hydrogen compatibility and embrittlement information is provided in documents such as SAND2008-1163, *Technical Reference on Hydrogen Compatibility of Materials*.

K.3.2.1.2 –

Corrective actions should be taken to reduce the likelihood of any significant adverse consequences of flammable mixture formation in piping.

K.3.2.1.3 –

Where piping connects two or more process vessels or equipment in which there are explosion hazards, the piping should be equipped with in-line deflagration arresters per 12.2.4, 12.2.5, or 12.2.6 of NFPA 69.

K.3.3 – Electrical Conduit Explosion Hazards and Protection.

Electrical conduit and connectors in electrically classified (Class 1) areas should be installed per *NFPA 70* .

K.3.4 – Hydrogen Explosion Hazards and Protection for Ducting.

K.3.4.1 –

The hydrogen concentration in exhaust ducting during normal operating conditions should not exceed 1 volume percent unless the duct and exhaust system are designed in accordance with NFPA 69.

K.3.4.2 –

Higher hydrogen concentrations can be permitted for oven and furnace ducting if the ducting is designed in accordance with NFPA 86.

K.3.4.3 –

Operations generating flames, sparks, or hot material such as from grinding wheels and welding should not be manifolded into any duct system potentially containing hydrogen.

K.3.4.4 –

Where ferrous materials can enter ducting carrying hydrogen, magnetic separators should be installed.

K.3.4.5 –

Ducting carrying hydrogen should be grounded.

K.3.5 – Inspection of Hydrogen Pressure Vessels and Piping.

~~**K.3.5.1** –~~

~~Hydrogen pressure vessels and piping should be inspected in accordance with the requirements of the code to which they were built. Where such inspection requirements are not provided, the owner of the pressure vessels should implement a mechanical integrity program.~~

~~**K.3.5.1.1** –~~

~~The mechanical integrity program should consider the impact of hydrogen enhanced fatigue crack growth when the pressure vessels are in cyclic service.~~

a paper by Amy Shen and Derek Miller, "Ventdef: A new engineering model for vented gas deflagration based on NFPA 68 (2018)" [1] . Air Products and Chemicals, Inc.1940 Air Products Boulevard Allentown, PA 18106-5500.

s.

K.1 Introduction

In the event of an accidental release of hydrogen inside an enclosure, a flammable gas cloud could form. Explosion of such a flammable cloud could have catastrophic consequences since confined deflagration can lead to much higher overpressures than would be the case for an equivalent explosion in the open atmosphere. Specific measures are usually required to reduce risk to a tolerable level. Forced or natural ventilation is commonly used to reduce flammable gas concentrations inside enclosures, and deflagration vents are commonly used to relieve deflagration over-pressure and mitigate potential equipment damage and risk to people close to the enclosure.

Various engineering models are available in the literature, including NFPA 68. After several significant developments and re-issues of NFPA 68 in recent years, NFPA 68 (2018) [2] is now proven to better address fast-burning fuels such as hydrogen. However, NFPA 68 (2018) recommends considering the worst-case stoichiometric mixture. This usually leads to over-conservative results and has limited applicability for hydrogen and hydrogen mixtures which has high reactivity.

Since NFPA 68 (2018) is based on fundamental combustion parameters, it can easily be modified to other hydrogen concentrations, more representative of expected conditions, resulting in less conservative conclusions. NFPA 68 (2018) modified in this way has been validated against published data across a range of hydrogen concentrations, from tests performed between 2016 and 2018 in Europe, under the project named HySEA [3,4] .

K.2 _ Overview of HySEA Tests

[3,4] . HySEA project aimed to conduct pre-normative research on vented hydrogen deflagrations to provide recommendations for European and international standards on hydrogen explosion venting mitigation systems. 66 vented deflagration tests were successfully performed using standard 20ft shipping containers, with various hydrogen concentrations, levels of internal congestion and deflagration panel size. 42 tests were with ignited homogeneous and quiescent mixtures (14 tests vented through open doors, one test with closed container, and 27 tests vented through openings on the roof). The remaining 24 tests were with ignited inhomogeneous mixtures (17 tests with stratified mixtures and 7 tests with initial turbulence generated by either a fan or a transient jet).

The tests include two venting orientations – roof venting with different vent areas and different opening pressures (blowout panels or plastic sheets), door venting with the door fully open, as shown in Figure X.2(a). Four levels of internal congestion were investigated to study the impact including no obstruction, pipe rack, bottle basket and high congestion. Figure X.2(b) shows the obstacles used in the tests. Internal and external pressure transducers, as well as external high-speed video recorded the tests.

Figure X.2(c) illustrates the positions of the pressure sensors. The internal pressure sensors were positioned at the U-beams along the side walls of the container, in the same distances from the back wall as the eight bolts holding the frame. External overpressures were measured at 5 m, 10 m and 15 m from the door on the container, and about 1.65 m above ground. For experiments with venting through the roof, pressure sensor P10 was moved to a position above the container, about 2.7 m above the container roof and 1.25 m from the back wall of the container.

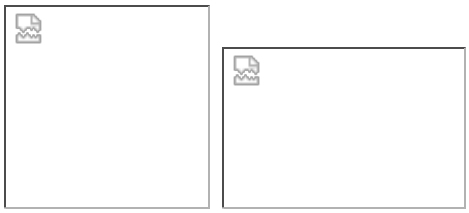


Figure K.2(a) Test Vent Orientations – Roof and Door

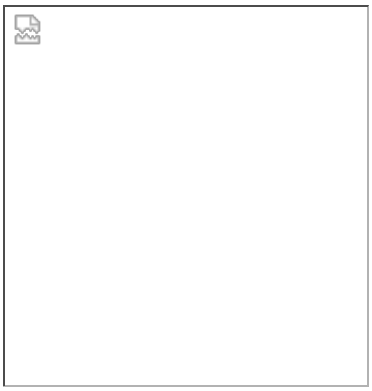


Figure K.2(b) Different Obstacles in the Tests: Bottle Basket, Pipe Rack and High Congestion



Figure K.2(c) Position for Internal (P01-P08) and External (P09-P11) Pressure Sensors

K.3 _ Determination of Internal Overpressure and Impulse Based on NFPA 68 (2018)

Nomenclature. See Table K.3 for specification of the parameters used in the models.

NFPA 68 (2018) model predicts deflagration internal overpressure, duration (and hence impulse) as a function of deflagration vent area. It can also be set up to determine the deflagration vent area required to meet a defined maximum allowable internal over-pressure.

To allow calculation at different flammable gas concentrations, only two simple and logical modifications are required.

(1) Use the laminar burning velocity, S_u, for the specified averaged gas concentration, rather than the conservative stoichiometric value.

(2) Use the maximum closed volume deflagration pressure, P_{max}, for the specific average gas concentration, rather than the conservative stoichiometric value.

Laminar burning velocity is a fundamental combustion property for a specific gas or gas mixture which can be determined experimentally. For example, the laminar burning velocities for different concentrations of H_2/CO mixtures (including pure hydrogen and pure CO) across the range of lower flammability limit (LFL) and upper flammability limit (UFL) are experimentally measured by Chen et al. at normal temperature and pressure [5]. Varghese et al. [6] measured the laminar burning velocities of methane – air mixtures at different concentrations within the LFL and UFL. S_u is affected by different initial gas/mixture temperature and pressure [7], but for enclosure deflagration venting calculation, the enclosure is usually at ambient temperature and atmospheric pressure so S_u and P_{max} at ambient temperature and atmospheric pressure are used. For each specific gas or gas mixture, the maximum closed volume deflagration pressures can be calculated by NASA CEA program [8] for a certain gas concentration in air. Figure X.3(a) and Figure X.3(b) show the variations of S_u and P_{max} versus the gas concentrations in air which are obtained from references [5, 6]. By using the correlations of S_u and P_{max} versus the gas concentration in air and applying them to the equations 7.2.1a & 7.2.1b for non-choked flow or 7.2.2a & 7.2.2b for choked flow in NFPA 68 (2018), a new model based on NFPA 68 “standard” model which considers the actual enclosure gas concentration is developed for calculation of enclosure deflagration venting.



Figure X.3(a) Laminar Burning Velocity S_u versus Gas Concentration in Air for Pure H_2, Different Compositions of Syngas, Pure CO, and Natural Gas (CH_4)



Figure K.3(b) Maximum Closed Volume Deflagration Pressure P_{max} versus Gas Concentration

in Air for Pure H_2, Different Compositions of Syngas, Pure CO, and Natural gas (CH_4)

The values presented here are for: hydro gen, 90% H_2/10% CO, 80% H_2/20% CO, 70% H_2/30% CO, 60% H_2/40% CO, 50% H_2/50% CO, 40% H_2/60% CO, 30% H_2/70% CO, 20% H_2/80% CO, 10% H_2/90% CO, 100% CO, and natural gas (100% CH_4). If any other gas or mixture is of interest, S_u for the new gas or mixture should be obtained from experimental data and the corresponding P_{max} can be calculated by NASA CEA and then be built into the model.

Determination of the appropriate average gas concentration will be application specific. One typical approach is:

(1) Select a representative hole size and determine the leak release rate into the enclosure. If the release rate is significantly greater than the normal process flow rate and the inventory of gas is low, it may be decided to limit the release rate to the normal flowrate.

(2) Based on the air changes per hour, perform a simple mixing calculation, assuming good mixing, to obtain the average concentration in the enclosure

(3) If the enclosure has flammable gas detection with automatic trip isolation, it may be decided to take credit for limited release duration, by calculating the average concentration as a function of time, with the release stopped after a defined time.

K.4 _ Determination of External Overpressure .

Carson et al. [9] provides a method that can be adapted to estimate the ratio of overpressure at any angle to the straight-on overpressure. Figure X.4(b) illustrates the definitions of distance and angle from an external point of interest. The equation can be expressed as:

 [X.4b]

Where

= angle from straight on [degrees]

X = distance to target [m]

D_v = equivalent diameter of vent

c11 = -0.138, c12 = 27.7, c21 = -8.79 E-4, and c22 = -1.36.



Figure K.4(b) External Point of Interest with Distance X and Angle from Vent Centerline

For roof vent tests, the angles of external overpressure sensors located at P09 (X = 5m) and P10 (X = 15m) are 101° and 94°, and X/D is in range of (2-10) depending on test vent area and pressure measurement location. Using Equation [X.4b] , the value of ($P/P_{straight\ on}$) is predicted to be about 0.45 for these tests as shown in Figure X.4(c). The external overpressure test data at P09 and P11 are then compared with correlation predictions at an angle about 100° from straight on as shown in Figure X.4(d). There is more scatter in this data than for the door vent straight on data, but the correlation method works reasonably well.



Figure K.4(c) External Overpressure Correction ($P/P_{straight\text{-}on}$) for Off Center Directions



Figure K.4(d) Comparisons of External Overpressure Test Data (P09 and P11) Against the Correlation Predictions at an Angle about 100° - from Straight on for Roof Vent Tes

K.5 Determination of External Fireball . The empirical correlation for external fireball size in NFPA 68 (2018) only depends on the protected enclosure volume and number of vents. The equation, therefore, does not take into account the vent geometry, flammable gas/air mixture properties, or vent area. Ventdef proposes a new method to calculate the fireball diameter using the theoretical “constant pressure

deflagration expansion ratio", σ.

When the premixed flammable cloud burns, the temperature of the gas will increase. From the ideal gas law:

[X.5a]

If the pressure is fixed, an increase in temperature will result in a reduction in density and an increase in volume. The parameter characterizing the expansion for constant pressure combustion is called "constant pressure deflagration expansion ratio" σ. It is used to predict the maximum volume of the hot combustion gases and can be calculated by NASA CEA program.

For each specific gas or gas mixture, σ is calculated for different gas concentrations in air. For the gases/mixtures considered in the model, the variations of σ versus different gas concentrations in air are shown in Figure X.5(a). Using σ, the volume of the venting fireball can be calculated as

$$V_f = V_u * \sigma \quad [X.5b]$$

Where

V_f = combusted gas volume which equals to the fireball volume [m^3]

V_u = un-combusted gas volume which equals to the enclosure volume [m^3]

σ = theoretical "constant pressure deflagration expansion ratio"

Part of the fireball volume may exist inside the enclosure, or the whole fireball might exit the enclosure pushed by the deflagration overpressure. To be conservative, the total fireball volume V_f is taken as the external fireball volume. Same as NFPA 68 (2018), it is assumed that the external fireball is spherical. Thus, the external fireball diameter can be calculated by:

[X.5c]

Where

D_f = external fireball diameter [m]



Figure K.5(a) "Constant Pressure Deflagration Expansion Ratio", σ, for Pure H_2, Different Compositions of Syngas, Pure CO, and Natural gas (CH_4) Calculated by NASA CEA.

This theoretical model is compared against HySEA test videos, FLACS CFD modeling, NFPA 68 (2018) and EN14994 correlations. A summary of the experimental conditions for tests that modelled in FLACS CFD is shown in Table X.5.

K.6 Validation of Model Predictions versus HySEA Test Data

K.6.1 Validation of Internal Overpressure and Impulse Predictions .

Comparison of model predictions of internal overpressure and impulse are compared with all the 66 HySEA tests reported in reference [4]. NFPA 68 (2018) is based on homogeneous and quiescent mixtures, while HySEA tests include a number of tests that are homogeneous & quiescent and also a

number that have stratified gas (hydrogen rich layer at top of the container) and / or internal releasing turbulent jets. For the latter cases, Ventdef was run using the nominal average concentration in the container.

There are four types of obstructions involved in HySEA tests. Table X.6.1 lists the total external surface area A_{obs} calculated for the four types of obstructions. For some tests, Fike commercial vent panels (nominal static opening pressure P_{stat} 0.1 barg) were used, for others plastic sheets ($0 < P_{stat} < 0.1$ barg) were used. In all the runs of Ventdef, P_{sat} is assumed to be 0.1 bar. The impulse is calculated by $I = 0.5 * P_{red} * t_f$. Ventdef predictions for P_{red}, t_f and I are plotted across the full tested range for the two venting configurations (roof and door) and for each obstruction type. Figure X.6.1(a) to Figure X.6.1(d) show the comparisons of HySEA test results with Ventdef predictions for both roof venting and door venting with different venting areas. Within the range of conditions tested, Ventdef acts quite well at predicting P_{red}, t_f and I for a wide range of conditions that span homogeneous and inhomogeneous, quiescent and non-quiescent, range of obstruction levels up to high congestion. It even worked well for the case without blowout panels where the door was from close (prior to ignition) to open (during the deflagration).

Table K.6.1 Total external surface area of different obstructions

Obstruction	A_{obs}, m^2
No obstruction	0
Pipe rack	14.4
Bottle basket	23
High Congestion	83



Figure K.6.1(a) Comparison of HySEA Test Data with Ventdef Predictions for Cases with Roof Venting $A_v = 4\ m^2$.



Figure K.6.1(b) Comparison of HySEA Test Data with Ventdef Predictions for Cases with Roof Venting $A_v = 6\ m^2$.



Figure K.6.1(c) Comparison of HySEA Test Data with Ventdef Predictions for Cases with Roof Venting $A_v = 8\ m^2$.



Figure K.6.1(d) Comparison of HySEA Test Data with Ventdef Predictions for Cases with Door Venting $A_v = 5.56\ m^2$.

Figure K.6.1(e) presents the comparison on HySEA test data with Ventdef predictions and CFD results for the cases listed in Table E.5. For P_{red}, Ventdef predictions are slightly higher than the test data for all 6 cases and so does CFD results except for test 10. In CFD simulation, the bottle basket in test 10 is simplified as a block which reduces the value of A_{obs} and thus reduces resulting P_{red}. Both Ventdef and CFD simulations under-predict the blast duration for all the 6 tests. The comparison of impulses has similar trends to P_{red}, except that Ventdef matches quite well with the impulse of test 34 and CFD under-predicts the impulse. In general, Ventdef predicts a bit higher P_{red} and impulse for all the 6 cases which is good to be reasonably conservative.

In terms of these 6 cases, CFD results have somewhat better agreement than Ventdef as a number of the CFD predictions are actually a good match. A thorough comparison between FLACS predictions and all HySEA Phase I tests is done by Lakshmipathy et al. [10] for all HySEA Phase I tests. It was concluded that both the engineering models and FLACS tools tend to overpredict the maximum overpressures measured in the experiments. CFD predictions of P_{red} are a bit different from the values reported by Lakshmipathy et al. [10] which may be due to the simplification of some detailed geometries (steel frames, bolts, etc.) in this work.







Figure K.6.1(e) Comparison of Internal Overpressures, Durations and Impulses on Test Data with Ventdef Predictions and CFD Results for Cases Listed in Table E.5.

K.6.2 Validation of External Overpressure Predictions .

Figure K.6.2(a) summarizes the comparison of external overpressures for test data, Ventdef predictions, and CFD predictions measured at locations of P09 – P11. Ventdef predictions are reasonably conservative for all the three locations except for test 34 (P10 at x = 2.7 m is not measured) in which the measured overpressures at P09 and P11 are a bit higher than Ventdef predictions. Except test 10 and test 26, CFD simulations also tend to reasonably overpredict the overpressures for other tests. In general, among the 6 tests compared, Ventdef and CFD predict similar results for most of the cases.

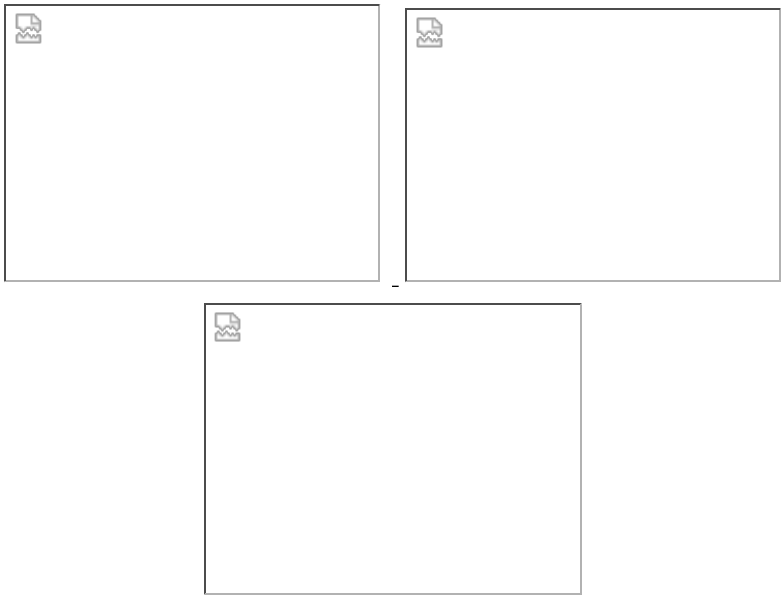


Figure K.6.2(a) Comparison of External Overpressures on Test Data with Ventdef Predictions and CFD Results for Cases Listed in Table E.5.

K.6.3 Validation of External Fireball Predictions .

The explosion events for HySEA tests were recorded with two high-speed video cameras and one video camera [4] . From the high-speed camera videos, fireball dimensions are estimated for the tests listed in Table E.5 with homogeneous mixtures.

For HySEA tests listed in Table E.5, fireball volumes predicted by various methods, such as Ventdef, FLACS CFD modeling, NFPA 68 correlation and EN 14994 equation, are compared with the fireball sizes estimated from the HySEA test videos. All of the fireball volumes including test data, CFD results and Ventdef predictions in this paper are the external fireball only, and do not include the volume in the container and are, therefore, on a common basis.

Taking the fireball volume predicted by Ventdef as the basis, Figure X.6.3(a) shows the comparison of fireball volumes calculated by various methods. Obviously, EN 14994 predicts the maximum fireball volumes across all ranges of H_2 concentrations and NFPA 68 (2018) predictions rank second which is still much higher than the experimental test data and the other two methods. The HySEA test data is a bit smaller than those predicted by Ventdef and FLACS modeling, but the gaps become smaller as the H_2 concentration increases. Based on the comparisons, it can be concluded that FLACS is a bit better than the Ventdef predictions, but both are good and much better than the alternative models which significantly overpredict the fireball sizes.

Many researchers have demonstrated that the non-dimensional vent coefficient K_V has critical impact to the venting deflagration overpressure and flame behavior [11-14] . At different K_V ranges, the flame behaviors can be very different. As shown in Table E.5, the K_V values for HySEA tests cases studied in

this paper vary from 1.29 - 1.83 which are all less than 2. Wang et al. [15] found that with a K_v value of 5.0, the venting fireball expanded to its maximum size over several milliseconds and was then pushed downward by the high-speed vented outflow to form a flame jet. Similar flame jet rather than a fireball is also shown by Colella et al. [16] in the FLACS simulation with a K_v value of 4.33. The "flame jet" may have a much further extent along the venting direction than the fireball diameter. It is to be noted that Ventdef fireball model is currently only validated against the experimental data with $K_v < 2$. This is applicable to most of the industrial enclosure deflagration venting designs where typically most of the roof area will need to be set as the blowout panels.



Figure K.6.3(a) Comparison on Ratios of Fireball Volumes Estimated from HySEA Test Data, NFPA 68 (2018), EN 14994 and FLACS Modeling to Ventdef.

K.6.4 Conclusions .

NFPA 68 (2018), can be modified for different gas concentrations simply by using concentration specific laminar burning velocity and P_{max} values. This approach has been successfully validated against test data over a wide range of conditions that span homogeneous and inhomogeneous, quiescent and non-quiescent, a range of obstruction levels up to high congestion, and different deflagration vent areas.

Moreover, models for calculating the blast overpressure external to the vent and external fireball size are established. The model predictions match the test data reasonably well.

Table K.3 Parameters Used in the Models

Symbol	Units	Description
A_s	m^2	Enclosure internal surface area
A_{obs}	m^2	Total external surface area of equipment and internal structures inside the enclosure
A_v	m^2	Vent area
C_d	-	Vent flow discharge coefficient
G_u	kg/(m².s)	Unburned gas-air mixture sonic flow mass flux
D_f	m	Fireball diameter
D_v	m	Equivalent vent panel diameter
I	barg-ms	Impulse
K_v	-	non-dimensional vent coefficient
n	-	Number of evenly distributed vents

P_o	barg	Enclosure pressure prior to ignition
$P_{external}$	barg	External blast overpressure
P_{max}	barg	Maximum pressure developed in a contained deflagration by ignition of the same gas-air mixture
P_{red}	barg	Maximum pressure developed in a vented enclosure during a vented deflagration
P_{stat}	barg	Nominal deployment or burst pressure of the vent
t_f	s	duration
V_{en}	m^3	Volume of vented enclosure
V_f	m^3	Combusted gas volume which equals to the fireball volume
V_u	m^3	Un-combusted gas volume which equals to the enclosure volume
x	m	External distance from vent to target
S_u	m/s	Fundamental burning velocity of gas-air mixture
ρ_u	kg/m^3	Mass density of unburned gas-air mixture
λ	-	Ratio of gas-air mixture burning velocity accounting for turbulence and flame instability in vented deflagration to the fundamental (laminar) burning velocity
γ_b	-	Ratio of specific heats for burned gas-air mixture
σ	-	Theoretical “constant pressure deflagration expansion ratio”
□	degree	Angle from straight on

Table K.5 Summary of HySEA Tests Modeled in FLACS [3,4]

Test number #	Configuration	Venting direction	Hydrogen conc. (%)	A_v (m^2)	K_v ( )	P_{red} (barg)
10	Bottle basket, doors open	Door	18	5.64	1.83	0.130
26	Frame only, panels	Roof	21	6	1.72	0.245
27	Pipe rack, panels	Roof	21	6	1.72	0.301
19	Pipe rack, roof open	Roof	24	8	1.29	0.136
20	Pipe rack, panels	Roof	24	8	1.29	0.136
34	Pipe rack, roof open	Roof	42	8	1.29	1.076

K.7. Reference

(1) Shen A., Miller D. Ventdef: A new engineering model for vented gas deflagration based on NFPA 68 (2018). Process Safety Progress, Volume 41, Issue 4, pages 738-750, 2022.

(2) NFPA 68. Standard on explosion protection by deflagration venting. 2018.

(3) Skjold T, Lucas M, Hisken H, Atanga G, Lakshmipathy S, Bernard L, Van Wingerden M, van Wingerden K, Wen J, Rao VCM, Sinha A, Carcassi M, Schiavetti M, Pini T, Snoeys J, Hanssen AG, Wang C, Jallais S, Vyazmina E, Miller D & Bauwens CR. Review of the HySEA project. 13th International Symposium on Hazards, Prevention, and Mitigation of Industrial Explosions. Braunschweig, Germany, July 27 – 31, 2020.

(4) Skjold T, Hisken H, Lakshmipathy S, Atanga G, Bernard L, Van Wingerden M, Olsen KL, Holme MN, Turoy NM, Mykleby M, van Wingerden K. Vented hydrogen deflagrations in containers: Effect of congestion for homogeneous and inhomogeneous mixtures. International Journal of Hydrogen Energy 44 (2019) 8819 – 8832.

(5) Chen D, Zhou Q, Zhao Q, Zhang Y, Xu T, Hui S. Experimental study on the laminar flame speed of hydrogen/carbon monoxide/air mixtures. Fuel 88 (2009) 1858 – 1863, 2009.

(6) Varghese RJ, Kolekar H, Kishore V, Kumar S. Measurement of laminar burning velocities of methane-air mixtures simultaneously at elevated pressures and elevated temperatures. Fuel 257 (2019) 116120.

(7) Elia M, Ulinski M, Metghalchi M. Laminar burning velocity of methane-air-diluent mixtures. Transactions of the ASME, Vol. 123, January 2001.

(8) Chemical Equilibrium with Applications (CEA) program, NASA.

(9) Carson RA, Sahni O. Scaling laws for the peak overpressure of a cannon blast. J. Fluids Eng., Feb 2017, 139 (2): 021204

(10) Lakshmipathy S, Skjold T, Hisken H, Atanga G. Consequence models for vented hydrogen deflagrations: CFD vs. engineering models. International Journal of Hydrogen Energy. Volume 44, Issue 17, 2019

(11) Daubech J, Proust C, Gentilhomme O, Jamois C, Mathieu L. Hydrogen-air vented explosions: new experimental data. In: 5th International Conference on Hydrogen Safety. Brussels, Belgium.

(12) Tang Z, Li J, Guo J, Zhang S, Duan Z. Effect of vent size on explosion overpressure and flame behavior during vented hydrogen-air mixture deflagrations. Nuclear Engineering and Design 361 (2020) 110578.

(13) Kumar RK, Skraba T, Greig DR. Vented combustion of hydrogen-air mixtures in large volumes. Nucl. Eng. Des. 99(1987), 205 – 315.

(14) Rocourt X, Awamat S, Sochet I, Jallais S, 2014. Vented hydrogen-air deflagration in a small enclosed volume. Int. J. Hydrogen Energy 39 (35), 20462-20466.

(15) Wang J, Guo J, Yang F, Zhang J & Lu S. Effects of hydrogen concentration on the vented deflagration of hydrogen-air mixtures in a 1-m3 vessel. International Journal of Hydrogen Energy 43 (2018) 21161 – 21168.

(16) Colella F, Ibarreta A, Wolf M, Yen M, O'Hern SC, T. J. Myers. Modeling of explosion venting fireballs.22nd annual international symposium, October 22-24, 2019 .

Additional Proposed Changes

File Name	Description	Approved
Annex_X-reformat_-_for_nwe_Annex_K.docx	reformatted paper for new annex K	

Statement of Problem and Substantiation for Public Input

As the Explosion Control task group made progress on a draft chapter 9, TG member and former chair of NFPA-2 Martin Gresho has stated reasons to delete the current content of annex K. Dave Farese has proposed this new material for annex K. this PC makes that change

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 175-NFPA 2-2023 [Chapter 9]	
Public Input No. 175-NFPA 2-2023 [Chapter 9]	

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: Explosion Control TG
Street Address:
City:
State:
Zip:
Submittal Date: Sat Dec 23 09:30:13 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-76-NFPA 2-2024

Statement: The original Annex K was included in the 2011 (inaugural) Edition of NFPA 2 so that its content could be provided to the public. The previous Annex material was being misused and did not help designers build explosion vents for hydrogen.

Chapter 9 points to the new Annex K to enable the design and use of explosion vents and blow out panels with enclosures that contain hydrogen systems and the new material helps to explain the methodology for designing explosion vents for hydrogen.

Public Input No. 213-NFPA 2-2023 [Chapter K]

Annex K – Hydrogen Explosion Control

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only. The following information is intended to provide voluntary guidance related to explosion control for hydrogen. The text is presented in a format similar to what is anticipated to be included in Chapter 9 , which is currently reserved, in the next edition of NFPA 2.

The guidance in Annex K pertains to explosion prevention measures as follows:

(1) *Providing criteria to determine where explosion control measures are needed*

(2) *Providing continuous or emergency ventilation to dilute inadvertently released hydrogen in confined areas*

(3) *Inerting hydrogen contained in process equipment and piping*

(4) *Eliminating potential ignition sources associated with electrical equipment and wiring*

(5) *Avoiding highly obstructed, confined, and partially confined areas containing hydrogen storage vessels, processing equipment, and piping*

(6) *Containing hydrogen deflagrations within equipment and vessels so as to prevent equipment or vessel rupture, and to prevent deflagration propagation to interconnected equipment*

(7) *Conducting explosion risk analyses to identify site-specific potential explosion scenarios and implement appropriate measures to reduce the likelihood of those scenarios actually occurring*

Annex K guidance also covers explosion damage mitigation by deflagration venting and avoiding deflagration-to-detonation transitions.

K.1 – General.

K.1.1 – Applicability.

The storage, use, and handling of GH_2 in any quantity should also comply with the requirements of Chapter 1 and 4 and the applicable requirements of Chapters 5 through 8 .

K.1.1.1 –

Vehicles regulated by approved motor vehicle safety standards used for commercial or noncommercial application should not be required to comply with Annex K .

K.2 – Explosion Control.

~~K.2.1~~ –

Explosion control should be provided where there are any of the following conditions:

(1) The amounts of GH 2 or LH 2 in storage or use exceed the quantity thresholds requiring special provisions.

(2) At outdoor or partially confined locations as follows:

(3) Where the amount of GH 2 or LH 2 in storage or use exceed the quantity thresholds requiring special provisions, as specified in Table 6.4.1.1.1 for indoor control areas

(4) Where one or more of the following exist:

(5) A flame acceleration hazard exists due to hydrogen being stored or used along with piping and equipment in a congested space

(6) The area containing the GH 2 or LH 2 is partially enclosed by either three or more walls, or two walls plus a weather cover or ceiling.

An example of a congested space could be small regularly spaced obstacles such as a congested equipment or piping array. The following criteria can help identify congested spaces where flame acceleration hazard would exist:

(1) Three or more rows or tiers of piping, spaced at less than 10 to 12 pipe diameters

(2) Three or more hydrogen process or storage units, spaced at one to five times the smallest process/storage unit dimension

The following references describe analysis methods to account for the effects of flammable gas cloud volume and obstructions on pressures generated from vapor cloud explosions due to large releases of flammable gas: Baker et al. (1997), Cleaver et al. (1997), Dorofeev, (2007a), Mercx and van den Berg (1997), Pierorazio et al. (2005), and Tang and Baker (1999). Note: Unconfined hydrogen explosions only occur with at least 40 kg hydrogen released into an unobstructed open area in such a way that at least 20 kg develops near-stoichiometric concentrations, or with at least 0.50 kg hydrogen into a highly obstructed area. Test data on unconfined hydrogen deflagrations are available in the following references: Groethe et al. (2005), Molkov et al. (2005), and Wabayashi et al. (2005). The experiments of Groethe et al. showed that blast walls constructed to protect equipment and structures behind them are only effective for structures within a distance of two-to-three wall heights on the side of the wall away from the hydrogen explosion.

The threat of a hydrogen explosion in a partially confined area depends on the hydrogen concentration distribution, potential ignition sources, the amount of confinement, the enclosure length/diameter ratio, and the presence of various types of obstructions. Although there are no definitive research results for every quantitative value and combination of these four parameters, there has been extensive research and guidelines on the congestion levels and gas burning velocities that are conducive to hydrocarbon vapor cloud explosions Baker-Strehlow-Tang (2005) and Zalosh (2008) have provided a comprehensive review of the effects of different types and quantities of obstructions on the pressures developed in vented hydrocarbon gas explosions. As an example, these reviews indicate that closely spaced piping at three or more elevations and evenly spaced small equipment represent the type of congestion that allows explosions to develop in open or partially confined areas. Test data and computational models providing data and calculations to assess the effects of certain important ranges of hydrogen concentrations, confinement and obstruction configurations, and ignition source locations in partially confined areas are available in the following references: Friedrich et al. (2007), Schneider (2005), Shirvill and Roberts (2007), and Tanaka et al. (2005).

(1) Indoors or in enclosures if the static volume of GH_2 or LH_2 (STP) contained in a process or transported in piping systems in the enclosure is equal to or greater than 0.004 (0.4 percent) times the enclosure volume and the piping or container or equipment is disconnected during normal operations while at least some hydrogen remains pressurized.

Hydrogen–air deflagrations can occur when a flammable hydrogen-air mixture encounters a capable ignition source in an enclosure. The likelihood of formation of a flammable hydrogen–air mixture depends on the likelihood of releasing hydrogen at a rate and location such that it cannot be readily or rapidly diluted below the lower flammable limit (LFL). Because existing NFPA standards do not contain a systematic and general description of the risk of a hydrogen deflagration occurring, the Hydrogen Technologies Committee has generated the deflagration risk criteria in Section K.4 based on semi-quantitative considerations of the risk of a hydrogen release, and the following quantitative determination of the minimum amount of hydrogen required to produce enclosure damage and injuries once ignited in an enclosure.

The least amount of flammable gas that can produce deflagration pressure damage can be determined from considerations of partial volume deflagrations in which a local flammable mixture exists in an enclosure in which most of the enclosure volume has concentrations below the LFL. The deflagration pressure, P, produced from ignition at atmospheric pressure, P_{atm}, of a local near-stoichiometric mixture of volume, V_{pv}, in an enclosure of volume, V, is given by the following equation *(see Ogle, 1999, and Jo and Park, 2004)*.

$$\frac{P}{P_{atm}} = \left[1 - \left(\frac{V_{pv}}{V}\right) + \left(\frac{V_{pv}}{V}\right)\left(\frac{P_{exp}}{P_{atm}}\right)^{1/\gamma}\right]^{\gamma} \qquad \text{[K.2.1a]}$$

where:

P = deflagration pressure

P_{atm} = atmospheric pressure

V_{pv} = local near-stoichiometric mixture volume

V = enclosure volume

P_{exp} = the deflagration explosion pressure corresponding to a uniform near-stoichiometric gas mixture throughout the enclosure

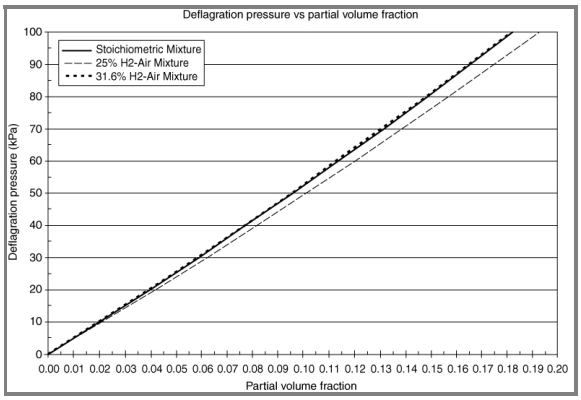
γ = the gas mixture ratio of specific heats

Values of P_{exp}/P_{atm} and γ for stoichiometric hydrogen–air mixtures (i.e., 29.6 percent volume hydrogen in dry air), and for hydrogen–air mixtures with hydrogen concentrations in the range of 25.15 volume percent to 33.5 volume percent have been obtained using the GASEQ software package. Using these values of P_{exp}/P_{atm} and γ, Equation K.2.1a has been used to calculate P (kPa g) as a function of the partial volume fraction V_{pv}/V. Results are shown in Figure K.2.1(a). The curves of P versus partial volume fraction are linear for partial volume fractions less than about 0.08 because Equation K.2.1a can be approximated as follows:

$$\frac{P}{P_{atm}} - 1 \approx \left(\frac{V_{pv}}{V}\right)\left(\frac{P_{exp}}{P_{atm}}\right) \qquad \text{[K.2.1b]}$$

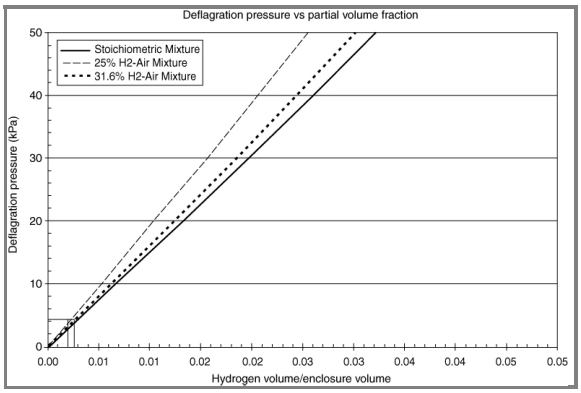
for these small values of V_{pv}/V.

Figure K.2.1(a) Hydrogen Deflagration Pressure Versus Flammable Hydrogen–Air Mixture Partial Volume Fraction for Three Different Hydrogen Concentrations.



The volume of hydrogen in the locally uniform hydrogen–air mixture partial volume is given by $\chi_{H2} V_{pv}$, where χ_{H2} is the volume fraction of hydrogen in the near-stoichiometric hydrogen–air mixture. If the hydrogen concentration distribution in the enclosure is idealized as a sharp discontinuance boundary between the locally uniform flammable gas mixture and the air in the rest of the enclosure, the volume of hydrogen in the enclosure is given by $\chi_{H2} (V_{pv}/V)$. Figure K.2.1(b) is a plot of the deflagration P (kPag) versus $\chi_{H2} (V_{pv}/V)$, which is the ratio of the hydrogen volume to the enclosure volume.

Figure K.2.1(b) Hydrogen Partial Volume Deflagration Pressure Versus Ratio of Hydrogen Volume to Enclosure Volume for Different Hydrogen Partial Volume Concentrations.



The minimum hydrostatic pressure at which limited minor structural damage can occur is approximately 0.4 psig to 0.5 psig (2.8 kPa to 3.5 kPa) according to Tables 2.18a and 2.18b of the American Institute for Chemical Engineers, Center for Chemical Process Safety, *Guidelines for Chemical Process Quantitative Risk Analysis*. Therefore, injuries to any exposed personnel due to broken glass and other debris from minor structural damage can be anticipated at pressures at and above about 4 kPa (0.58 psig). A horizontal line at about 4 kPa in Figure K.2.1(b) intersects the curve for a 25 percent partial volume deflagration at a ratio of hydrogen volume to enclosure volume of about 0.004. The intersection for the stoichiometric mixture concentration occurs at a slightly higher ratio of $\chi_{H2} (V_{pv}/V)$. Therefore, the hydrogen volume that can, in principle, cause minor damage and injuries is 0.4 volume percent — that is, at about 1/10 th LFL if the hydrogen volume was uniformly distributed throughout the enclosure volume.

As an example, consider a hydrogen vehicle repair garage containing a single hydrogen-fueled vehicle with an 80 L fuel tank containing hydrogen at an absolute pressure of 34 MPa. The volume of room temperature hydrogen corresponding to the release of the tank contents through an inadvertently actuated pressure relief device is equal to $(0.080\ m^3\ H_2)(34\ MPa)/(0.101\ MPa) = 26.93\ m^3\ H_2$. The minimum repair garage volume to prevent the ratio of hydrogen volume to enclosure volume from reaching 0.004 is equal to $26.93\ m^3/0.004 =$

6733 m ^{3} = 238,000 ft ^{3} . This volume is larger than the volume of a garage with a footprint of 100 ft x 100 ft (30.5 m x 30.5 m) and a ceiling height of 20 ft (6.1 m).

K.2.2 – Explosion Control Methods.

K.2.2.1 – Explosion Protection.

Where explosion control is recommended by K.2.1 , explosion protection should consist of one or more of the following:

(1) Deflagration prevention by gas concentration reduction per K.2.2

(2) Deflagration prevention by oxidant concentration reduction per K.2.2.3

(3) Deflagration venting per K.2.2.4

(4) Deflagration containment per K.2.2.5

In addition to the explosion control measures, the control of ignition sources will decrease the potential for an explosion. Typical ignition sources include thermal, mechanical, electrical, and electrostatic. The use of ignition control measures to address these sources will not eliminate the potential for spontaneous ignition.

Electrical ignition sources can be mitigated by utilizing the requirements for electrical equipment and wiring in classified locations in accordance with Article 500 of *NFPA 70* . NFPA 497 provides guidance for establishing classified locations.

Through the exercise of ingenuity in the layout of electrical installations for hazardous (i.e., classified) locations, it is frequently possible to locate much of the equipment in a reduced level of classification or in an unclassified location and, thus, to reduce the amount of special equipment required. It is important that the authority having jurisdiction (AHJ) be familiar with recorded industrial experience as well as with the standards of the National Fire Protection Association (NFPA), the American Petroleum Institute (API), and the Instrumentation, Systems, and Automation Society (ISA) that can be of use in the classification of various locations, the determination of adequate ventilation, and the protection against static electricity and lightning hazards.

Electrostatic ignition can be controlled by utilizing the methods identified in NFPA 77.

Other potential ignition sources including, but not limited to, smoking, open flames, heating, and spark producing equipment should be eliminated or located a safe distance from potential leak sources.

K.2.2.1.1 –

The explosion protection methods specified in K.2.2.1 can be partially or totally eliminated where supported by an approved hazard analysis.

The hazard analysis should give consideration to the following:

(1) The location of the storage system and associated exposures

(2) The potential for deflagration to detonation transition

(3) Prevention of pressurized equipment and piping breaches or releases

(4) Identification of additional preventive measures

(5) Identification of additional mitigation controls

(6) Documented test data applicable to the identified scenarios

K.2.2.1.1.1 –

The hazard analysis should identify and document the applicable explosion hazard scenarios.

K.2.2.1.1.2 –

The hazard analysis should be validated by qualified personnel with proven expertise in hazard analysis and should be subject to approval by the AHJ.

For hydrogen, reliance upon prevention of ignition by controlling ignition sources is not sufficient by itself due to the low ignition energy of ignitable clouds of GH_2 and the fact that certain releases can self-ignite due to buildup and discharge of static electricity. Therefore, control of ignition sources must be combined with either fuel reduction (typically) by ventilation of the area to lower GH_2 concentration or by deflagration venting, or both, to achieve sufficient defense in depth.

K.2.2.1.1.3 –

When the hazard analysis has determined that there is a potential deflagration-to-detonation transition (DDT), the system parameters should be redesigned to eliminate the hazard.

K.2.2.2 – Deflagration Prevention by Hydrogen Gas Concentration Reduction.

K.2.2.2.1 –

Deflagration prevention by gas concentration reduction can be considered where a mixture of a combustible material and an oxidant is confined to an enclosure and where the concentration of the hydrogen can be maintained below the LFL of hydrogen (i.e., 4.0 volume percent at room temperature and pressure).

See Annex B of NFPA 69, for a discussion of the control of flammable gas mixtures. See also Annex D of NFPA 69, for information on calculating the time required for concentration reduction by ventilation.

K.2.2.2.2 –

Deflagration prevention by hydrogen gas concentration reduction should be in accordance with Chapter 8 of NFPA 69, as supplemented by K.2.2.2.3 .

K.2.2.2.3 –

The factors in K.2.2.2.3.1 and K.2.2.2.3.2 should be considered in the design of a system intended to reduce the combustible concentration below the LFL.

K.2.2.2.3.1 –

If ventilation is used, the outlets from the protected enclosures [should] be located so that hazardous concentrations of the exhausted air cannot enter or be drawn into the fresh air intakes of environmental air–handling systems. [**69:** 8.3.3.1]

K.2.2.2.3.2 –

The ventilation rate for hydrogen dilution should be based on a hydrogen release rate equal to either the storage pressure and an orifice diameter equal to 3 percent of the diameter of the largest hydrogen piping or equipment connection, or a risk-based analysis of release rates for the type of hydrogen piping and equipment in the room or building.

Note: The 3 percent of the pipe diameter requirement is based on the hydrogen leakage rate conditions described in Section E.9.1 .

K.2.2.3 – Oxygen Concentration Reduction Below the 3 Volume Percent Hydrogen Limiting Oxygen Concentration (LOC).

K.2.2.3.1 –

Oxygen concentration reduction can be considered where a mixture of oxidant and hydrogen is confined to an enclosure within which the oxidant concentration can be controlled.

K.2.2.3.2 –

Oxygen concentration reduction should be in accordance with Chapter 7 of NFPA 69, as supplemented by K.2.2.3.3 .

K.2.2.3.3 – Design Considerations.

K.2.2.3.3.1 –

The following factors should be considered in the design of an oxygen concentration reduction system:

(A) –

Limiting Oxidant Concentrations (LOC). [69:7.2.3]

(1) The hydrogen LOC depends on the inert gas used, the flammability test method, and the initial temperature and pressure.

(2) The LOC for nitrogen inerting at standard temperature and pressure is 3.0 percent oxygen.

(3) The LOC for carbon dioxide inerting at standard temperature and pressure is 3.2 percent oxygen.

(4) The LOC value for other inert gases, temperatures, and pressures should be measured according to ASTM E2079, *Standard Test Method for Limiting Oxygen (Oxidant) Concentration for Gases and Vapors* .

(5) The use of oxidants other than oxygen can also require further investigation with respect to the limiting oxidant concentration.

(6) The design concentration should be a fraction of the LOC per 7.7.2.5 and 7.7.2.7 of NFPA 69.

Note: The LOC values for nitrogen and carbon dioxide are the adjusted values for hydrogen from Table C.1(a) of NFPA 69.

K.2.2.4 – Deflagration Venting.

Hydrogen deflagration venting for limiting explosion damage should be in accordance with the requirements of Section 6.10 and with NFPA 68.

K.2.2.5 – Deflagration Containment.

K.2.2.5.1 – Application.

The technique for deflagration pressure containment [can] be considered for specifying the design pressure of a vessel and its appurtenances so they are capable of withstanding the maximum pressures resulting from an internal [hydrogen] deflagration. [**69:** 13.1.1]

K.2.2.5.2 – Deflagration Containment.

Deflagration containment should be in accordance with Chapter 13 of NFPA 69, as supplemented by K.2.2.5.3 .

K.2.2.5.3 – Design Considerations.

The following factors should be considered in the design of a deflagration venting system:

(1) The deflagration containment design basis should be as described in Section 13.3 of NFPA 69.

(2) The value of the hydrogen–air deflagration pressure ratio, *R* , needed for the design basis in Section 13.3 of NFPA 69 is 8.3. Another value of the deflagration pressure ratio, *R*, can be used if a documented analysis of worst-case hydrogen concentrations shows that near-stoichiometric hydrogen–air concentrations cannot occur.

(3) The value of the hydrogen–oxygen deflagration pressure ratio, *R*, needed for the design basis in Section 13.3 of NFPA 69 is 9.6. Another value of the deflagration pressure ratio, *R* , can be used if a documented analysis of worst-case hydrogen concentrations shows that near-stoichiometric hydrogen–oxygen concentrations cannot occur.

(4) Where either deflagration venting or deflagration containment is relied on as an exclusive control measure for explosion protection, a documented risk assessment should be performed to evaluate the potential for a DDT when any of the following conditions exist:

(5) The ratio of the volume of the equipment plus the volume of internal structures within the enclosure to the volume of the enclosure is greater than 0.10.

(6) The ratio of surface area of the equipment plus the surface area of internal structures to the surface area of the enclosure is less than 0.15.

(7) There are uniformly spaced objects or obstacles including piping or equipment that obstruct more than 40 percent of the enclosure cross-section based on the least dimension of the space. Uniformly spaced objects can include piping or equipment arranged in a repetitive manner such that the explosive effects are magnified as the flame propagates around these objects.

(8) The enclosure length-to-diameter ratio is greater than 5.

The potential for DDT in obstructed or elongated enclosures is a complex subject often requiring expert analysis. Some of the contemporary references on this subject include the following:

Dorofeev (2007b), Hansen et al. (2005), Lee and Berman (1997), Pethukov et al. (2007), Sherman and Berman (1988), Zalosh (FPRF report).

K.3 – Explosion Prevention.

K.3.1 – Intentional Release of Hydrogen.

GH $_2$ or LH $_2$ should not be intentionally released from storage or use systems into areas where congested piping systems are present.

K.3.2 – Hydrogen Explosions in Piping, Electrical Conduit, and Ducting.

K.3.2.1 – Piping and Tubing Explosion Hazards and Protection.

K.3.2.1.1 –

An evaluation should be conducted to determine the potential of an adverse reaction where any of the following conditions exist:

(1) The formation of a mixture of hydrogen with atmospheric pressure air within piping that has a design pressure rating of less than 300 psi.

(2) The formation of a mixture of hydrogen with greater than atmospheric pressure air.

(3) Where a hydrogen–oxygen mixture within piping or tubing can occur.

(4) Where piping can be filled with air and is purged with hydrogen.

(5) Where there is potential for degradation of fittings, gaskets, valves, and so forth, due to hydrogen embrittlement.

If the process requires the hydrogen piping or tubing to carry a flammable mixture during any stage of operation, the ability of the piping to withstand a hydrogen explosion should be evaluated and, if necessary, strengthened to prevent pipe failure.

Methods to assess the structural response of piping and tubing to deflagrations and detonations are described by Shepherd (2006).

Hydrogen compatibility and embrittlement information is provided in documents such as SAND2008-1163, *Technical Reference on Hydrogen Compatibility of Materials*.

K.3.2.1.2 –

Corrective actions should be taken to reduce the likelihood of any significant adverse consequences of flammable mixture formation in piping.

K.3.2.1.3 –

Where piping connects two or more process vessels or equipment in which there are explosion hazards, the piping should be equipped with in-line deflagration arresters per 12.2.4, 12.2.5, or 12.2.6 of NFPA 69.

K.3.3 – Electrical Conduit Explosion Hazards and Protection.

Electrical conduit and connectors in electrically classified (Class 1) areas should be installed per *NFPA 70* .

K.3.4 – Hydrogen Explosion Hazards and Protection for Ducting.

K.3.4.1 –

The hydrogen concentration in exhaust ducting during normal operating conditions should not exceed 1 volume percent unless the duct and exhaust system are designed in accordance with NFPA 69.

K.3.4.2 –

Higher hydrogen concentrations can be permitted for oven and furnace ducting if the ducting is designed in accordance with NFPA 86.

K.3.4.3 –

Operations generating flames, sparks, or hot material such as from grinding wheels and welding should not be manifolded into any duct system potentially containing hydrogen.

K.3.4.4 –

Where ferrous materials can enter ducting carrying hydrogen, magnetic separators should be installed.

K.3.4.5 –

Ducting carrying hydrogen should be grounded.

K.3.5 – Inspection of Hydrogen Pressure Vessels and Piping.

~~**K.3.5.1** –~~

~~Hydrogen pressure vessels and piping should be inspected in accordance with the requirements of the code to which they were built. Where such inspection requirements are not provided, the owner of the pressure vessels should implement a mechanical integrity program.~~

~~**K.3.5.1.1** –~~

~~The mechanical integrity program should consider the impact of hydrogen enhanced fatigue crack growth when the pressure vessels are in cyclic service.~~

~~K.4~~ – ~~References.~~

American Institute for Chemical Engineers, Center for Chemical Process Safety, *Guidelines for Chemical Process Quantitative Risk Assessment,* 2nd edition, 2000.

American Institute for Chemical Engineers, Center for Chemical Process Safety, *Guidelines for Hazard Evaluation Procedures,* 2nd edition, 1992.

ASME *Boiler and Pressure Vessel Code,* American Society of Mechanical Engineers, 2013.

ASME B31.12, (2011) "Hydrogen Piping and Pipelines," American Society of Mechanical Engineers, 2011.

Baker, W., Cox, P., Westine, P., Kulesz, J., and Strehlow, R. "Explosion Hazards and Evaluation," Elsevier, 1983.

Baker, Q., Doolittle, C., Fitzgerald, G. and Tang, M. "Recent Developments in the Baker-Strehlow VCE Analysis Methodology." 31st Annual AIChE Loss Prevention Symposium, 1997.

CGA P-28, *Risk Management Plan Guidance Document for Bulk Liquid Hydrogen Systems,* Compressed Gas Association, 2009.

Cleaver, R., Humphreys, C., Morgan, J. and Robinson, C. "Development of a model to predict the effects of explosions in compact congested regions." *Journal of Hazardous Materials* v. 53, pp. 35–55, 1997.

Davison, J., Porter, J., Dinan, R., Hammons, M., and Connell, J., "Explosive Testing of Polymer Retrofit Masonry Walls," *Journal of Performance of Constructed Facilities* , v. 12, pp. 100–106, 2004.

Dorofeev, S. "A Flame Speed Correlation for Unconfined Gaseous Explosions." *Process Safety Progress* 26(2): 140–149, 2007a.

Dorofeev, S., "Hydrogen Flames In Tubes: Critical Run-Up Distances." 2nd International Conference on Hydrogen Safety. San Sebastian, Spain, 2007b.

Environmental Protection Agency, "Risk Management Plan Regulation," Code of Federal Regulations (CFR) 40 CFR 68.130, see also http://www.epa.gov/oem/content/rmp/rmp_guidance.htm#General.

Groethe, M. et al., "Large Scale Hydrogen Deflagrations and Detonations," International Conference on Hydrogen Safety, 2005.

Friedrich A. et al. "Experimental Study of Hydrogen-Air Deflagrations in a Flat Layer," 2nd International Conference on Hydrogen Safety, San Sebastian, Spain, 2007.

Hansen, O., Renoult, J., Sherman, M., and Tieszen, S.,"Validation of FLACS-Hydrogen CFD Consequence Prediction Model Against Large Scale H_2 Explosion Experiments in the FLAME Facility," International Conference on Hydrogen Safety, 2005.

Jo, Y.-D. and Park, K-S., "Minimum Amount of Flammable Gas for Explosion within a Confined Space." *Process Safety Progress* 23: 321–329, 2004.

M. Kaneshige and J. E. Shepherd, Detonation database, Technical Report FM97-8, GALCIT, July 1997. See also the electronic hypertext version at http://www.galcit.caltech.edu/detn_db/html/.

Knox, K., Hammons, M., Lewis, T. and Porter, J., "Polymer Materials for Structural Retrofit," Air Force Research Laboratory Report, 2004.

Lee, J. and Berman, M., "Hydrogen Combustion and Its Application to Nuclear Reactor Safety," *Advances In Heat Transfer* , v 29, 1998.

Mays, G. C., and Smith, P. D., *Blast effects on buildings — Design of buildings to optimise resistance to blast loading.* Thos. Telford, London, 1995.

Mercx, W., and van den Berg, A., "The Explosion Blast Prediction Model in the Revised Yellow Book." 31st Annual AIChE Loss Prevention Symposium, 1997.

Molkov, V., Makarov, D. and Schneider, H., "Hydrogen-Air Deflagrations in Open Atmosphere: Large Eddy Simulation of Experimental Data." 1st International Conference on Hydrogen Safety. Pisa, Italy, 2005.

Ng, H. D., Ju, Y., and Lee, J., "Assessment of Detonation Hazards in High-Pressure Hydrogen Storage from Chemical Sensitivity Analysis," *Intl. Journal of Hydrogen Energy* , 2006.

OECD Nuclear Energy Agency, Flame Acceleration and Deflagration to Detonation Transition in Nuclear Safety, State-of-the-Art Report by a Group of Experts, OECD Nuclear Energy Agency, NEA/CSNI/R(2000)7, August 2000.

Ogle, R., "Explosion Hazard Analysis for an Enclosure Partially Filled With a Flammable Gas." *Process Safety Progress* 18: 170–177, 1999.

Petukhov, V. A., Naboko, I. M., and Fortov, V. E., "Explosion Hazard Of Hydrogen-Air Mixtures In The Large Volumes," 2nd International Conference on Hydrogen Safety, 2007.

Pierorazio, J., Thomas, Q., Baker, Q., and Ketchum, D., "An Update to the Baker-Strehlow-Tang Vapor Cloud Explosion Prediction Methodology Flame Speed Table." *Process Safety Progress* 24: 59–65, 2005.

Schneider, H., "Large Scale Experiments: Deflagration and Deflagration to Detonation within a Partial Confinement Similar to a Lane," 1st Intl. Conference on Hydrogen Safety, Pisa, Italy, 2005.

Shepherd, J. E., "Elastic and Plastic Structural Response of Tubes to Deflagration-to-Detonation Transition," California Institute of Technology Explosion Dynamics Laboratory Report FM2006-00X, 2006.

Sherman, M. and Berman, M., "The Possibility of Local Detonations during Degraded-Core Accidents in the Bellefonte Nuclear Power Plant," *Nuclear Technology* , v 18, pp. 63–77, 1987.

Shirvill, L. C., Royle, M., and Roberts, T. A., "Hydrogen Releases Ignited In A Simulated Vehicle Refuelling Environment," 2nd International Conference on Hydrogen Safety, San Sebastian, Spain, 2007.

Smith, P. D., and Hetherinton, J. G., *Blast and ballastic loading of structures.* Butterworth-Heinemann, Oxford, U.K., 1994.

Tanaka, T. et al.,"Experimental Study on Hydrogen Explosions in a Full-Scale Hydrogen Filling Station Model," 1st Intl. Conference on Hydrogen Safety, Pisa, Italy, 2005.

Tang, M. and Baker, Q., "A New Set of Blast Curves from Vapor Cloud Explosions." 33rd Annual AIChE Loss Prevention Symposium, 1999.

Wabayashi, et al., "A Field Explosion Test of Hydrogen-Air Mixtures," International Conference on Hydrogen Safety, 2005.

Zalosh, R., "Blast Waves and Fireballs Generated by Hydrogen Fuel," 2005.

Zalosh, R.,"Explosion Venting Data and Modeling Literature Review," Fire Protection Research Foundation Report, 2007.

Zlochower, I., and Green, G., "The limiting oxygen concentration and flammability limits of gases and gas mixtures." *Journal of Loss Prevention in the Process Industries* , vol. 22: 499–505, 2009.

Statement of Problem and Substantiation for Public Input

Substantiation: Annex K must be entirely deleted. Annex K was included in the 2011 (inaugural) Edition of NFPA 2 so that its content could be provided to the public. Also at that time, Chapter 9 was published as Reserved. Now Chapted 9 content has been drafted as a separate PPI and it contains content that is substantially different form that presented in Annex k. The material in Annex K may have value for future development, and will be retained because it has been published, but it now must be removed to avoid conflict with Chapter 9. Additionally, Annex K has been abused as being what NFPA 2 will contain in the future. It is an inappropriate annex.

Submitter Information Verification

Submitter Full Name: Martin Gresho

Organization: FP2Fire, Inc.
Street Address:
City:
State:
Zip:
Submittal Date: Tue Dec 26 16:25:05 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-76-NFPA 2-2024

Statement: The original Annex K was included in the 2011 (inaugural) Edition of NFPA 2 so that its content could be provided to the public. The previous Annex material was being misused and did not help designers build explosion vents for hydrogen.

Chapter 9 points to the new Annex K to enable the design and use of explosion vents and blow out panels with enclosures that contain hydrogen systems and the new material helps to explain the methodology for designing explosion vents for hydrogen.

Annex X Determination of Internal Overpressure, External Overpressure and Fireball Size Resulting from Deflagration Venting of Hydrogen/Hydrogen Mixtures Based on NFPA 68 (2018)

This annex is a paper by Amy Shen and Derek Miller, "Ventdef: A new engineering model for vented gas deflagration based on NFPA 68 (2018)" [1]. Air Products and Chemicals, Inc.1940 Air Products Boulevard Allentown, PA 18106-5500.

X.1 Introduction. In the event of an accidental release of hydrogen inside an enclosure, a flammable gas cloud could form. Explosion of such a flammable cloud could have catastrophic consequences since confined deflagration can lead to much higher overpressures than would be the case for an equivalent explosion in the open atmosphere. Specific measures are usually required to reduce risk to a tolerable level. Forced or natural ventilation is commonly used to reduce flammable gas concentrations inside enclosures, and deflagration vents are commonly used to relieve deflagration over-pressure and mitigate potential equipment damage and risk to people close to the enclosure.

Various engineering models are available in the literature, including NFPA 68. After several significant developments and re-issues of NFPA 68 in recent years, NFPA 68 (2018) [2] is now proven to better address fast-burning fuels such as hydrogen. However, NFPA 68 (2018) recommends considering the worst-case stoichiometric mixture. This usually leads to over-conservative results and has limited applicability for hydrogen and hydrogen mixtures which has high reactivity.

Since NFPA 68 (2018) is based on fundamental combustion parameters, it can easily be modified to other hydrogen concentrations, more representative of expected conditions, resulting in less conservative conclusions. NFPA 68 (2018) modified in this way has been validated against published data across a range of hydrogen concentrations, from tests performed between 2016 and 2018 in Europe, under the project named HySEA[3,4].

X.2 Overview of HySEA Tests [3,4]. HySEA project aimed to conduct pre-normative research on vented hydrogen deflagrations to provide recommendations for European and international standards on hydrogen explosion venting mitigation systems. 66 vented deflagration tests were successfully performed using standard 20ft shipping containers, with various hydrogen concentrations, levels of internal congestion and deflagration panel size. 42 tests were with ignited homogeneous and quiescent mixtures (14 tests vented through open doors, one test with closed container, and 27 tests vented through openings on the roof). The remaining 24 tests were with ignited inhomogeneous mixtures (17 tests with stratified mixtures and 7 tests with initial turbulence generated by either a fan or a transient jet).

The tests include two venting orientations – roof venting with different vent areas and different opening pressures (blowout panels or plastic sheets), door venting with the door fully open, as shown in Figure X.2(a). Four levels of internal congestions were investigated to study the impact including no obstruction, pipe rack, bottle basket and high congestion. Figure X.2(b) shows the obstacles used in the tests. Internal and external pressure transducers, as well as external high-speed video recorded the tests.

Figure X.2(c) illustrates the positions of the pressure sensors. The internal pressure sensors were positioned at the U-beams along the side walls of the container, in the same distances from

the back wall as the eight bolts holding the frame. External overpressures were measured at 5 m, 10 m and 15 m from the door on the container, and about 1.65 m above ground. For experiments with venting through the roof, pressure sensor P10 was moved to a position above the container, about 2.7 m above the container roof and 1.25 m from the back wall of the container.

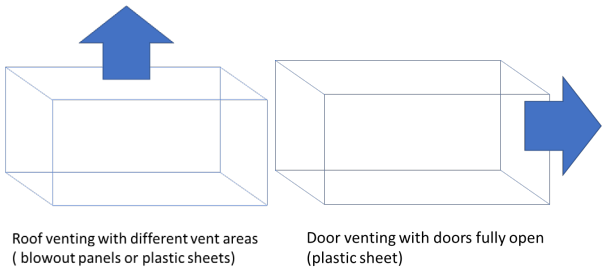


Figure X.2(a) Test Vent Orientations – Roof and Door

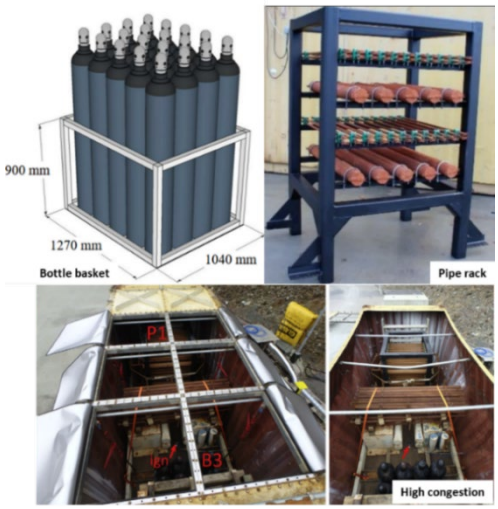


Figure X.2(b) Different Obstacles in the Tests: Bottle Basket, Pipe Rack and High Congestion

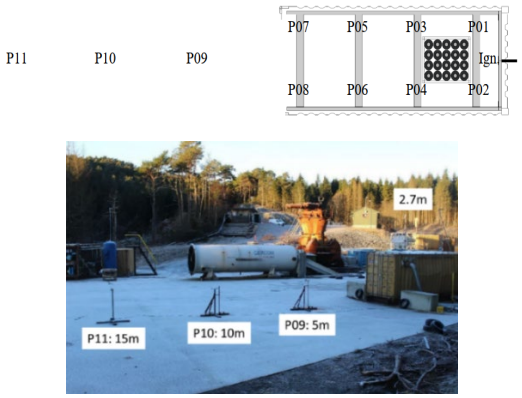


Figure X.2(c) Position for Internal (P01-P08) and External (P09-P11) Pressure Sensors

X.3 Determination of Internal Overpressure and Impulse Based on NFPA 68 (2018). Nomenclature. See Table X.3 for specification of the parameters used in the models.

NFPA 68 (2018) model predicts deflagration internal overpressure, duration (and hence impulse) as a function of deflagration vent area. It can also be set up to determine the

deflagration vent area required to meet a defined maximum allowable internal over-pressure.

To allow calculation at different flammable gas concentrations, only two simple and logical modifications are required.

1) Use the laminar burning velocity, S_u, for the specified averaged gas concentration, rather than the conservative stoichiometric value.
2) Use the maximum closed volume deflagration pressure, P_{max}, for the specific average gas concentration, rather than the conservative stoichiometric value.

Laminar burning velocity is a fundamental combustion property for a specific gas or gas mixture which can be determined experimentally. For example, the laminar burning velocities for different concentrations of H_2/CO mixtures (including pure hydrogen and pure CO) across the range of lower flammability limit (LFL) and upper flammability limit (UFL) are experimentally measured by Chen et al. at normal temperature and pressure [5]. Varghese et al. [6] measured the laminar burning velocities of methane – air mixtures at different concentrations within the LFL and UFL. S_u is affected by different initial gas/mixture temperature and pressure [7], but for enclosure deflagration venting calculation, the enclosure is usually at ambient temperature and atmospheric pressure so S_u and P_{max} at ambient temperature and atmospheric pressure are used. For each specific gas or gas mixture, the maximum closed volume deflagration pressures can be calculated by NASA CEA program [8] for a certain gas concentration in air. Figure X.3(a) and Figure X.3(b) show the variations of S_u and P_{max} versus the gas concentrations in air which are obtained from references [5, 6]. By using the correlations of S_u and P_{max} versus the gas concentration in air and applying them to the equations 7.2.1a & 7.2.1b for non-choked flow or 7.2.2a & 7.2.2b for choked flow in NFPA 68 (2018), a new model based on NFPA 68 "standard" model which considers the actual enclosure gas concentration is developed for calculation of enclosure deflagration venting.

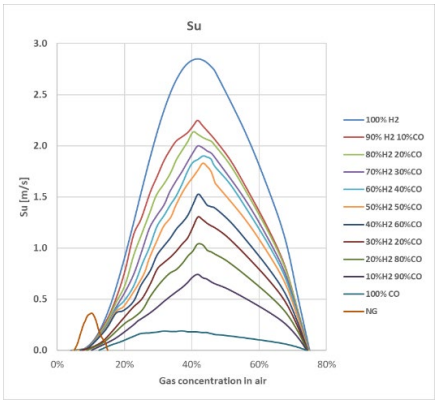


Figure X.3(a) Laminar Burning Velocity S_u versus Gas Concentration in Air for Pure H_2, Different Compositions of Syngas, Pure CO, and Natural Gas (CH_4)

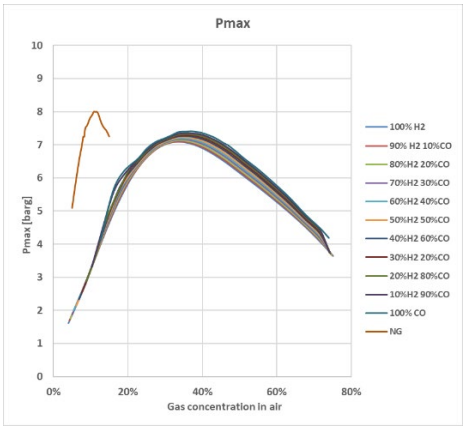


Figure X.3(b) Maximum Closed Volume Deflagration Pressure P_{max} versus Gas Concentration in Air for Pure H_2, Different Compositions of Syngas, Pure CO, and Natural gas (CH_4)

The values presented here are for: hydrogen, 90% H_2/10% CO, 80% H_2/20% CO, 70% H_2/30% CO, 60% H_2/40% CO, 50% H_2/50% CO, 40% H_2/60% CO, 30% H_2/70% CO, 20% H_2/80% CO, 10% H_2/90% CO, 100% CO, and natural gas (100% CH_4). If any other gas or mixture is of interest, S_u for the new gas or mixture should be obtained from experimental data and the corresponding P_{max} can be calculated by NASA CEA and then be built into the model.

Determination of the appropriate average gas concentration will be application specific. One typical approach is:

a) Select a representative hole size and determine the leak release rate into the enclosure. If the release rate is significantly greater than the normal process flow rate and the inventory of gas is low, it may be decided to limit the release rate to the normal flowrate.
b) Based on the air changes per hour, perform a simple mixing calculation, assuming good mixing, to obtain the average concentration in the enclosure
c) If the enclosure has flammable gas detection with automatic trip isolation, it may be decided to take credit for limited release duration, by calculating the average concentration as a function of time, with the release stopped after a defined time.

X.4 Determination of External Overpressure. Besides internal vented deflagration overpressure and impulse, it is also important to be able to predict the external blast when siting flammable enclosures. NFPA 68 does not predict the external overpressure which is a gap in industrial applications. HySEA Phase 1 tests with homogeneous and quiescent mixtures are used to study the relation of external blast overpressure with the distance and angle from the direction of venting. The locations of external overpressure sensors are shown in Figure X.2(c).

For door vent tests, all the 3 pressure sensors (P09, P10, and P11) are located in the direction of deflagration venting ("straight on"). The measured external overpressure data are correlated as a function of the maximum pressure developed in a vented enclosure during deflagration (P_{red}) and x (distance from vent) which fits quite well. The correlation is then used to predict the data measured at P10 above the container for roof vent tests which is also in the direction of deflagration venting. Figure X.4(a) shows a comparison of the external straight on overpressure test data with the correlation predictions. The roof venting test data are a bit scattered, but the correlation also works well. The correlation is:

$$P_{external} = \max(0, \min(P_{red}, (0.012\,x^2 - 0.36x + 3.4) * (-0.0813\,P_{red}^2 + 0.2271\,P_{red} - 0.0021)))$$

[X.4a]

where x is the external distance from vent, in the direction of venting ("straight on").

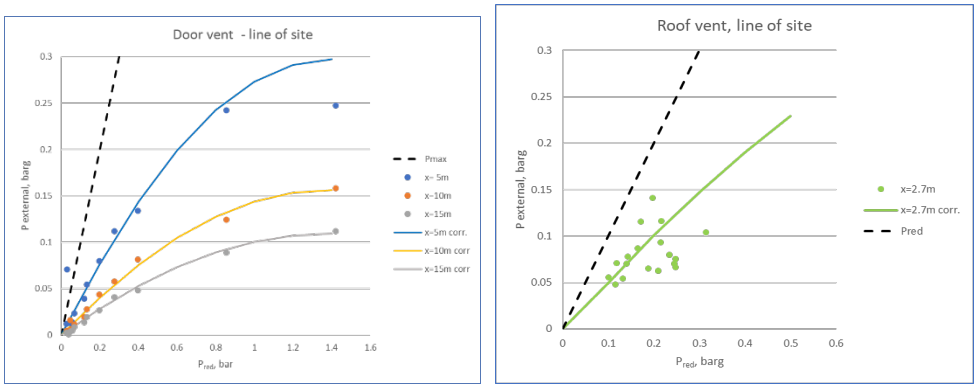


Figure X.4(a) Comparisons of External Straight on Overpressures Test Data with the Correlation Predictions for Phase I Door Vent and Roof Vent Cases.

Carson et al. [9] provides a method that can be adapted to estimate the ratio of overpressure at any angle to the straight-on overpressure. Figure X.4(b) illustrates the definitions of distance and angle from an external point of interest. The equation can be expressed as:

$$\frac{P_{\phi}}{P_{straight\ on}} = \frac{(c11*\phi+c12)(\frac{X}{D_v})^{(c21\phi+c22)}}{c12*(\frac{X}{D_v})^{c22}} \qquad [X.4b]$$

Where

ϕ = angle from straight on [degrees]

X = distance to target [m]

D_v = equivalent diameter of vent

c11 = -0.138, c12 = 27.7, c21 = -8.79 E-4, and c22 = -1.36.

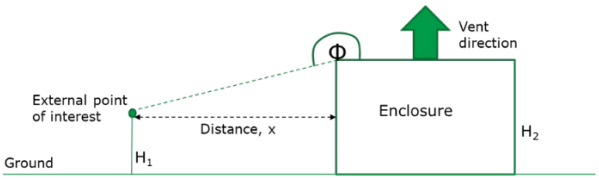


Figure X.4(b) External Point of Interest with Distance X and Angle Φ from Vent Centerline

For roof vent tests, the angles ϕ of external overpressure sensors located at P09 (X = 5m) and P10 (X = 15m) are 101° and 94°, and X/D is in range of (2-10) depending on test vent area and pressure measurement location. Using Equation [X.4b], the value of ($P/P_{straight\ on}$) is predicted to be about 0.45 for these tests as shown in Figure X.4(c). The external overpressure test data at P09 and P11 are then compared with correlation predictions at an angle about 100° from straight on as shown in Figure X.4(d). There is more scatter in this data than for the door vent straight on data, but the correlation method works reasonably well.

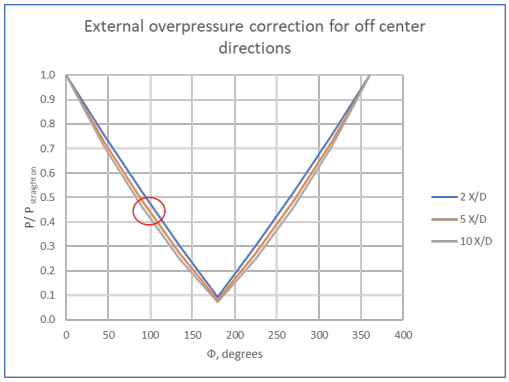


Figure X.4(c) External Overpressure Correction ($P/P_{straight\ on}$) for Off Center Directions

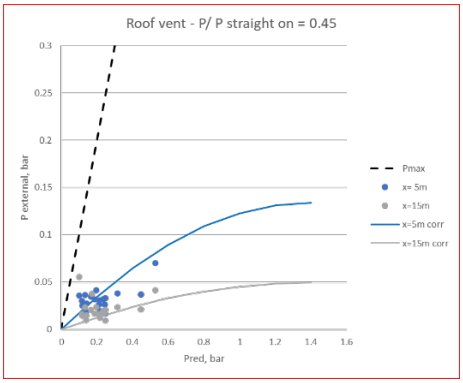


Figure X.4(d) Comparisons of External Overpressure Test Data (P09 and P11) Against the Correlation Predictions at an Angle about 100° from Straight on for Roof Vent Tests

X.5 Determination of External Fireball. The empirical correlation for external fireball size in NFPA 68 (2018) only depends on the protected enclosure volume and number of vents. The equation, therefore, does not take into account the vent geometry, flammable gas/air mixture properties, or vent area. Ventdef proposes a new method to calculate the fireball diameter using the theoretical "constant pressure deflagration expansion ratio", σ.

When the premixed flammable cloud burns, the temperature of the gas will increase. From the ideal gas law:

$$\frac{P}{\rho T} = Constant \qquad [X.5a]$$

If the pressure is fixed, an increase in temperature will result in a reduction in density and an increase in volume. The parameter characterizing the expansion for constant pressure combustion is called "constant pressure deflagration expansion ratio" σ. It is used to predict the maximum volume of the hot combustion gases and can be calculated by NASA CEA program.

For each specific gas or gas mixture, σ is calculated for different gas concentrations in air. For the gases/mixtures considered in the model, the variations of σ versus different gas concentrations in air are shown in Figure X.5(a). Using σ, the volume of the venting fireball can be calculated as

$$V_f = V_u * \sigma \qquad [X.5b]$$

Where

V_f = combusted gas volume which equals to the fireball volume [m^3]

V_u = un-combusted gas volume which equals to the enclosure volume [m^3]

σ = theoretical "constant pressure deflagration expansion ratio"

Part of the fireball volume may exist inside the enclosure, or the whole fireball might exit the enclosure pushed by the deflagration overpressure. To be conservative, the total fireball volume V_f is taken as the external fireball volume. Same as NFPA 68 (2018), it is assumed that the external fireball is spherical. Thus, the external fireball diameter can be calculated by:

$$D_f = (\frac{V_f}{\pi/6})^{1/3} \qquad [X.5c]$$

Where

D_f = external fireball diameter [m]

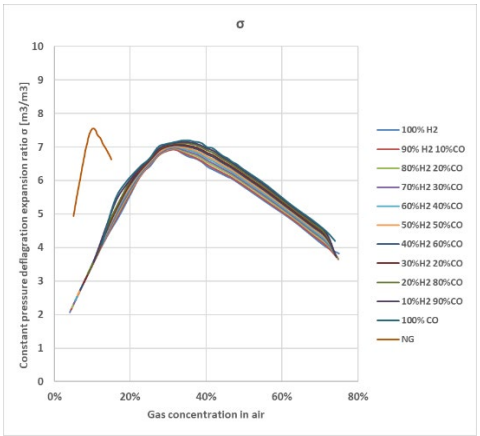


Figure X.5(a) "Constant Pressure Deflagration Expansion Ratio", σ, for Pure H_2, Different Compositions of Syngas, Pure CO, and Natural gas (CH_4) Calculated by NASA CEA.

This theoretical model is compared against HySEA test videos, FLACS CFD modeling, NFPA 68 (2018) and EN14994 correlations. A summary of the experimental conditions for tests that modelled in FLACS CFD is shown in Table X.5.

X.6 Validation of Model Predictions versus HySEA Test Data

X.6.1 Validation of Internal Overpressure and Impulse Predictions. Comparison of model predictions of internal overpressure and impulse are compared with all the 66 HySEA tests reported in reference [4]. NFPA 68 (2018) is based on homogeneous and quiescent mixtures, while HySEA tests include a number of tests that are homogeneous & quiescent and also a number that have stratified gas (hydrogen rich layer at top of the container) and / or internal releasing turbulent jets. For the latter cases, Ventdef was run using the nominal average concentration in the container.

There are four types of obstructions involved in HySEA tests. Table X.6.1 lists the total external surface area A_{obs} calculated for the four types of obstructions. For some tests, Fike commercial vent panels (nominal static opening pressure P_{stat} 0.1 barg) were used, for others plastic sheets ($0 < P_{stat} < 0.1$ barg) were used. In all the runs of Ventdef, P_{sat} is assumed to be 0.1 bar. The impulse is calculated by $I = 0.5 * P_{red} * t_f$. Ventdef predictions for P_{red}, t_f and I are plotted

across the full tested range for the two venting configurations (roof and door) and for each obstruction type. Figure X.6.1(a) to Figure X.6.1(d) show the comparisons of HySEA test results with Ventdef predictions for both roof venting and door venting with different venting areas. Within the range of conditions tested, Ventdef acts quite well at predicting P_{red}, t_f and I for a wide range of conditions that span homogeneous and inhomogeneous, quiescent and non-quiescent, range of obstruction levels up to high congestion. It even worked well for the case without blowout panels where the door was from close (prior to ignition) to open (during the deflagration).

Table X.6.1 Total external surface area of different obstructions

Obstruction	A_{obs}, m^2
No obstruction	0
Pipe rack	14.4
Bottle basket	23
High Congestion	83

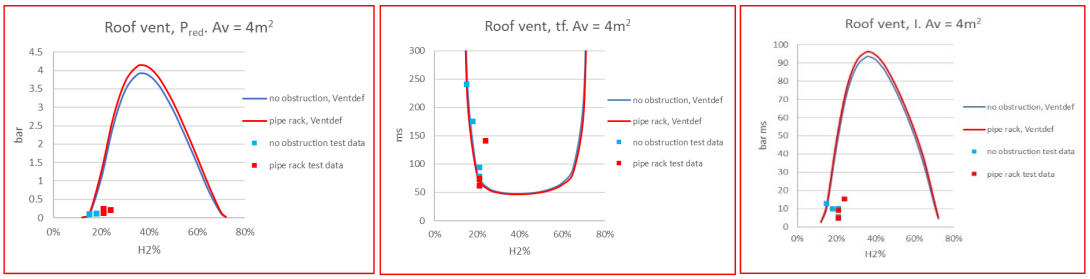


Figure X.6.1(a) Comparison of HySEA Test Data with Ventdef Predictions for Cases with Roof Venting A_v = 4 m^2.

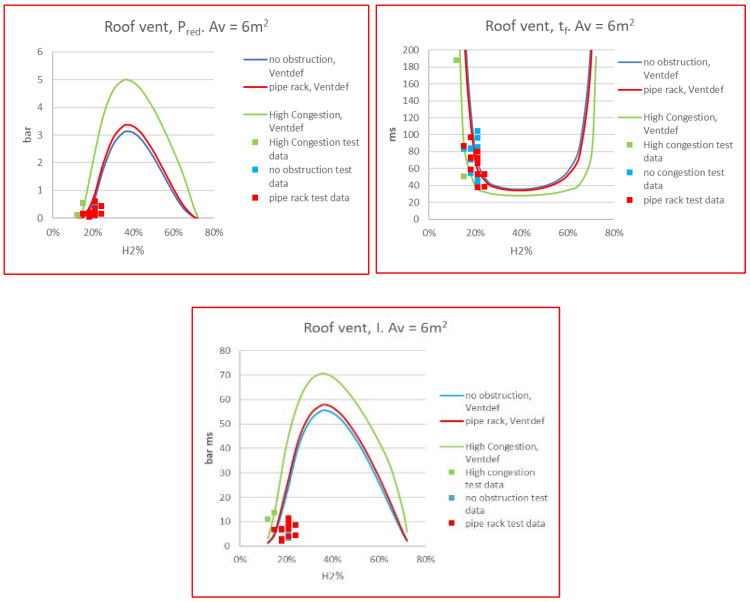


Figure X.6.1(b) Comparison of HySEA Test Data with Ventdef Predictions for Cases with Roof Venting A_v = 6 m^2.

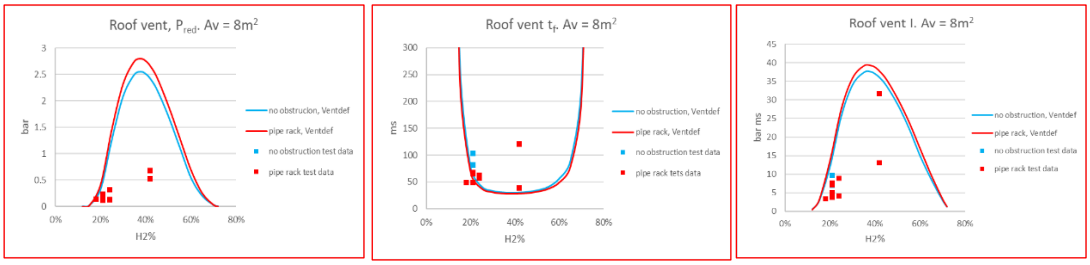


Figure X.6.1(c) Comparison of HySEA Test Data with Ventdef Predictions for Cases with Roof Venting A_v = 8 m².

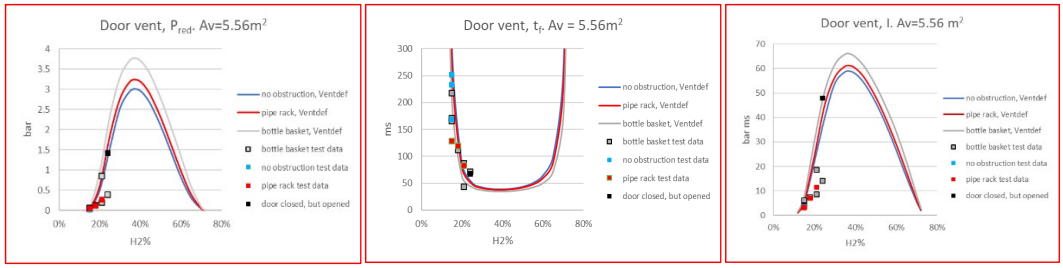
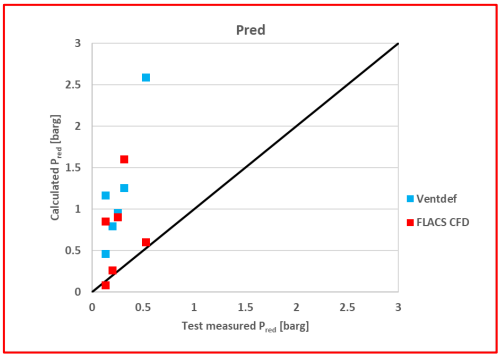


Figure X.6.1(d) Comparison of HySEA Test Data with Ventdef Predictions for Cases with Door Venting A_v = 5.56 m².

Figure X.6.1(e) presents the comparison on HySEA test data with Ventdef predictions and CFD results for the cases listed in Table E.5. For P_{red}, Ventdef predictions are slightly higher than the test data for all 6 cases and so does CFD results except for test 10. In CFD simulation, the bottle basket in test 10 is simplified as a block which reduces the value of A_{obs} and thus reduces resulting P_{red}. Both Ventdef and CFD simulations under-predict the blast duration for all the 6 tests. The comparison of impulses has similar trends to P_{red}, except that Ventdef matches quite well with the impulse of test 34 and CFD under-predicts the impulse. In general, Ventdef predicts a bit higher P_{red} and impulse for all the 6 cases which is good to be reasonably conservative.

In terms of these 6 cases, CFD results have somewhat better agreement than Ventdef as a number of the CFD predictions are actually a good match. A thorough comparison between FLACS predictions and all HySEA Phase I tests is done by Lakshmipathy et al. [10] for all HySEA Phase I tests. It was concluded that both the engineering models and FLACS tools tend to overpredict the maximum overpressures measured in the experiments. CFD predictions of P_{red} are a bit different from the values reported by Lakshmipathy et al. [10] which may be due to the simplification of some detailed geometries (steel frames, bolts, etc.) in this work.



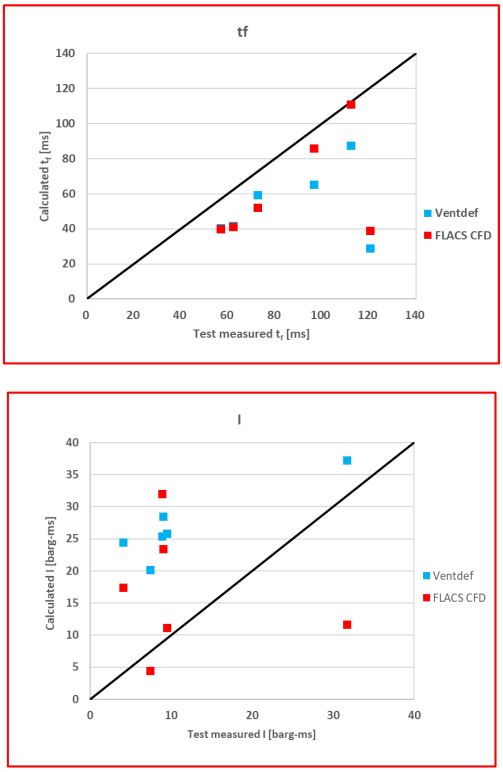
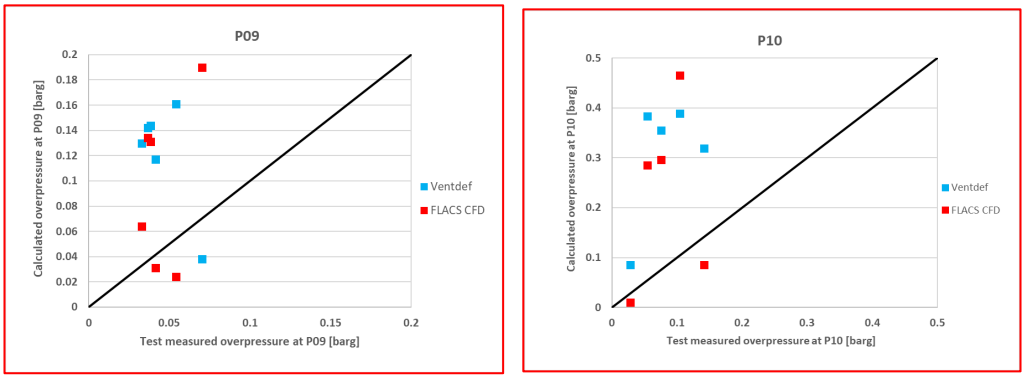


Figure X.6.1(e) Comparison of Internal Overpressures, Durations and Impulses on Test Data with Ventdef Predictions and CFD Results for Cases Listed in Table E.5.

X.6.2 Validation of External Overpressure Predictions. Figure X.6.2(a) summarizes the comparison of external overpressures for test data, Ventdef predictions, and CFD predictions measured at locations of P09 – P11. Ventdef predictions are reasonably conservative for all the three locations except for test 34 (P10 at x = 2.7 m is not measured) in which the measured overpressures at P09 and P11 are a bit higher than Ventdef predictions. Except test 10 and test 26, CFD simulations also tend to reasonably overpredict the overpressures for other tests. In general, among the 6 tests compared, Ventdef and CFD predict similar results for most of the cases.



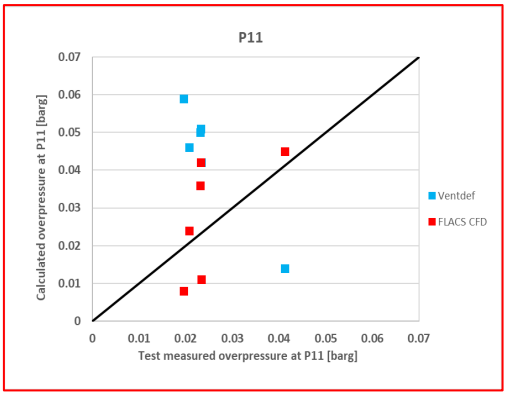


Figure X.6.2(a) Comparison of External Overpressures on Test Data with Ventdef Predictions and CFD Results for Cases Listed in Table E.5.

X.6.3 Validation of External Fireball Predictions. The explosion events for HySEA tests were recorded with two high-speed video cameras and one video camera [4]. From the high-speed camera videos, fireball dimensions are estimated for the tests listed in Table E.5 with homogeneous mixtures.

For HySEA tests listed in Table E.5, fireball volumes predicted by various methods, such as Ventdef, FLACS CFD modeling, NFPA 68 correlation and EN 14994 equation, are compared with the fireball sizes estimated from the HySEA test videos. All of the fireball volumes including test data, CFD results and Ventdef predictions in this paper are the external fireball only, and do not include the volume in the container and are, therefore, on a common basis.

Taking the fireball volume predicted by Ventdef as the basis, Figure X.6.3(a) shows the comparison of fireball volumes calculated by various methods. Obviously, EN 14994 predicts the maximum fireball volumes across all ranges of H_2 concentrations and NFPA 68 (2018) predictions rank second which is still much higher than the experimental test data and the other two methods. The HySEA test data is a bit smaller than those predicted by Ventdef and FLACS modeling, but the gaps become smaller as the H_2 concentration increases. Based on the comparisons, it can be concluded that FLACS is a bit better than the Ventdef predictions, but both are good and much better than the alternative models which significantly overpredict the fireball sizes.

Many researchers have demonstrated that the non-dimensional vent coefficient K_v has critical impact to the venting deflagration overpressure and flame behavior [11-14]. At different K_v ranges, the flame behaviors can be very different. As shown in Table E.5, the K_v values for HySEA tests cases studied in this paper vary from 1.29 - 1.83 which are all less than 2. Wang et al. [15] found that with a K_v value of 5.0, the venting fireball expanded to its maximum size over several milliseconds and was then pushed downward by the high-speed vented outflow to form a flame jet. Similar flame jet rather than a fireball is also shown by Colella et al. [16] in the FLACS simulation with a K_v value of 4.33. The “flame jet” may have a much further extent along the venting direction than the fireball diameter. It is to be noted that Ventdef fireball model is currently only validated against the experimental data with $K_v < 2$. This is applicable to most of the industrial enclosure deflagration venting designs where typically most of the roof area will need to be set as the blowout panels.

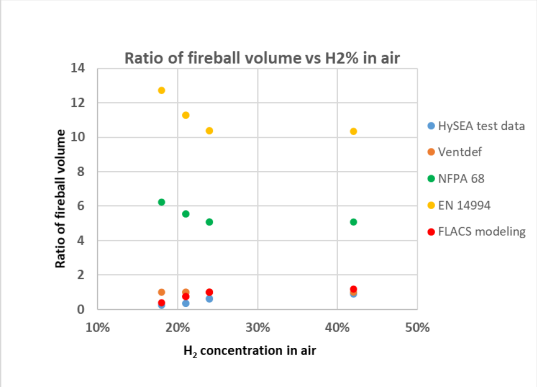


Figure X.6.3(a) Comparison on Ratios of Fireball Volumes Estimated from HySEA Test Data, NFPA 68 (2018), EN 14994 and FLACS Modeling to Ventdef.

X.6.4 Conclusions. NFPA 68 (2018), can be modified for different gas concentrations simply by using concentration specific laminar burning velocity and P_{max} values. This approach has been successfully validated against test data over a wide range of conditions that span homogeneous and inhomogeneous, quiescent and non-quiescent, a range of obstruction levels up to high congestion, and different deflagration vent areas.

Moreover, models for calculating the blast overpressure external to the vent and external fireball size are established. The model predictions match the test data reasonably well.

Table X.3 Parameters Used in the Models

Symbol	Units	Description
A_s	m^2	Enclosure internal surface area
A_{obs}	m^2	Total external surface area of equipment and internal structures inside the enclosure
A_v	m^2	Vent area
C_d	-	Vent flow discharge coefficient
G_u	kg/(m².s)	Unburned gas-air mixture sonic flow mass flux
D_f	m	Fireball diameter
D_v	m	Equivalent vent panel diameter
I	barg-ms	Impulse
K_v	-	non-dimensional vent coefficient

n	-	Number of evenly distributed vents
P_o	barg	Enclosure pressure prior to ignition
$P_{external}$	barg	External blast overpressure
P_{max}	barg	Maximum pressure developed in a contained deflagration by ignition of the same gas-air mixture
P_{red}	barg	Maximum pressure developed in a vented enclosure during a vented deflagration
P_{stat}	barg	Nominal deployment or burst pressure of the vent
t_f	s	duration
V_{en}	m^3	Volume of vented enclosure
V_f	m^3	Combusted gas volume which equals to the fireball volume
V_u	m^3	Un-combusted gas volume which equals to the enclosure volume
x	m	External distance from vent to target
S_u	m/s	Fundamental burning velocity of gas-air mixture
r_u	kg/m^3	Mass density of unburned gas-air mixture
λ	-	Ratio of gas-air mixture burning velocity accounting for turbulence and flame instability in vented deflagration to the fundamental (laminar) burning velocity
g_b	-	Ratio of specific heats for burned gas-air mixture
σ	-	Theoretical “constant pressure deflagration expansion ratio”
ϕ	degree	Angle from straight on

Table X.5 Summary of HySEA Tests Modeled in FLACS [3, 4]

Test number #	Configuration	Venting direction	Hydrogen conc. (%)	A_v (m^2)	K_v $(=\frac{V_{en}^{2/3}}{A_v})$	P_{red} (barg)
10	Bottle basket, doors open	Door	18	5.64	1.83	0.130
26	Frame only, panels	Roof	21	6	1.72	0.245
27	Pipe rack, panels	Roof	21	6	1.72	0.301

19	Pipe rack, roof open	Roof	24	8	1.29	0.136
20	Pipe rack, panels	Roof	24	8	1.29	0.136
34	Pipe rack, roof open	Roof	42	8	1.29	1.076

Reference

[1] Shen A., Miller D. Ventdef: A new engineering model for vented gas deflagration based on NFPA 68 (2018). Process Safety Progress, Volume 41, Issue 4, pages 738-750, 2022.

[2] NFPA 68. Standard on explosion protection by deflagration venting. 2018.

[3] Skjold T, Lucas M, Hisken H, Atanga G, Lakshmipathy S, Bernard L, Van Wingerden M, van Wingerden K, Wen J, Rao VCM, Sinha A, Carcassi M, Schiavetti M, Pini T, Snoeys J, Hanssen AG, Wang C, Jallais S, Vyazmina E, Miller D & Bauwens CR. Review of the HySEA project. 13th International Symposium on Hazards, Prevention, and Mitigation of Industrial Explosions. Braunschweig, Germany, July 27 – 31, 2020.

[4] Skjold T, Hisken H, Lakshmipathy S, Atanga G, Bernard L, Van Wingerden M, Olsen KL, Holme MN, Turoy NM, Mykleby M, van Wingerden K. Vented hydrogen deflagrations in containers: Effect of congestion for homogeneous and inhomogeneous mixtures. International Journal of Hydrogen Energy 44 (2019) 8819 – 8832.

[5] Chen D, Zhou Q, Zhao Q, Zhang Y, Xu T, Hui S. Experimental study on the laminar flame speed of hydrogen/carbon monoxide/air mixtures. Fuel 88 (2009) 1858 – 1863, 2009.

[6] Varghese RJ, Kolekar H, Kishore V, Kumar S. Measurement of laminar burning velocities of methane-air mixtures simultaneously at elevated pressures and elevated temperatures. Fuel 257 (2019) 116120.

[7] Elia M, Ulinski M, Metghalchi M. Laminar burning velocity of methane-air-diluent mixtures. Transactions of the ASME, Vol. 123, January 2001.

[8] Chemical Equilibrium with Applications (CEA) program, NASA.

[9] Carson RA, Sahni O. Scaling laws for the peak overpressure of a cannon blast. J. Fluids Eng., Feb 2017, 139 (2): 021204

[10] Lakshmipathy S, Skjold T, Hisken H, Atanga G. Consequence models for vented hydrogen deflagrations: CFD vs. engineering models. International Journal of Hydrogen Energy. Volume 44, Issue 17, 2019

[11] Daubech J, Proust C, Gentilhomme O, Jamois C, Mathieu L. Hydrogen-air vented explosions: new experimental data. In: 5th International Conference on Hydrogen Safety. Brussels, Belgium.

[12] Tang Z, Li J, Guo J, Zhang S, Duan Z. Effect of vent size on explosion overpressure and flame behavior during vented hydrogen-air mixture deflagrations. Nuclear Engineering and Design 361 (2020) 110578.

[13] Kumar RK, Skraba T, Greig DR. Vented combustion of hydrogen-air mixtures in large volumes. Nucl. Eng. Des. 99(1987), 205 – 315.

[14] Rocourt X, Awamat S, Sochet I, Jallais S, 2014. Vented hydrogen-air deflagration in a small enclosed volume. Int. J. Hydrogen Energy 39 (35), 20462-20466.

[15] Wang J, Guo J, Yang F, Zhang J & Lu S. Effects of hydrogen concentration on the vented deflagration of hydrogen-air mixtures in a 1-m3 vessel. International Journal of Hydrogen Energy 43 (2018) 21161 – 21168.

[16] Colella F, Ibarreta A, Wolf M, Yen M, O'Hern SC, T. J. Myers. Modeling of explosion venting fireballs.22nd annual

international symposium, October 22-24, 2019.

Public Input No. 8-NFPA 2-2023 [Section No. K.2.2.2.3.2]

K.2.2.2.3.2

The ventilation rate for hydrogen dilution should be based on a hydrogen release rate equal to either the storage pressure and an orifice diameter equal to 3 percent of the ~~diameter~~ flow area of the largest hydrogen piping or equipment connection, or a risk-based analysis of release rates for the type of hydrogen piping and equipment in the room or building.

Note: The 3 percent of the pipe ~~diameter requirement~~ flow area requirement is based on the hydrogen leakage rate conditions described in Section E.9.1.

Statement of Problem and Substantiation for Public Input

There appears to be incorrect information in the code/annex. Annex E makes reference a percentage of flow areas but Annex K references a percentage of pipe diameter. I believe that the intent was to reference flow area throughout the code and annex.

Submitter Information Verification

Submitter Full Name: William Hoffman
Organization: Black and Veatch
Street Address:
City:
State:
Zip:
Submittal Date: Sat Jul 01 11:17:50 EDT 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-76-NFPA 2-2024

Statement: The original Annex K was included in the 2011 (inaugural) Edition of NFPA 2 so that its content could be provided to the public. The previous Annex material was being misused and did not help designers build explosion vents for hydrogen.

Chapter 9 points to the new Annex K to enable the design and use of explosion vents and blow out panels with enclosures that contain hydrogen systems and the new material helps to explain the methodology for designing explosion vents for hydrogen.

Public Input No. 70-NFPA 2-2023 [Section No. L.4]

L.4 ~~Number of Gas~~ Gas Detectors to Effectively Detect Hydrogen at Fueling Locations .

In assessing the number of gas detectors required to detect a hydrogen release at a fueling location , the following should be considered:

(1) ~~A minimum of~~ one gas detector should be deployed ~~per dispenser~~ in each dispenser .

(2) If a canopy is used to protect the dispensing operation, ~~the~~ a minimum of one gas detector should be placed directly above the ~~dispenser~~ dispensers .

(3) Additional gas detectors can be placed along the length of the canopy to increase the probability of detecting a release.

Statement of Problem and Substantiation for Public Input

This section was specifically targeted for the fueling island but seemed to be titled for more general applications. As revised, this is now an example of how to consider sensing for hydrogen leaks from a hydrogen fueling area.

Submitter Information Verification

Submitter Full Name: Robert Boyd
Organization: Boyd Hydrogen LLC
Affiliation: TG review of content for Chapter 9
Street Address:
City:
State:
Zip:
Submittal Date: Fri Nov 17 05:54:36 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-36-NFPA 2-2024
Statement: The section is specific for hydrogen fueling locations and that is being added to provide specificity to the application.

Public Input No. 299-NFPA 2-2024 [Chapter N]

Annex N Explanation of Methodology Utilized to Develop Liquid Hydrogen Separation Distances

This annex summarizes the methodology criteria used to develop bulk outdoor liquid hydrogen separation distances; a more detailed description of this work is available in the Sandia National Laboratories technical report Ehrhart et al. SAND2023-12548 (February 2023).

N.1 Separation Distance Tables History.

An evaluation of bulk gaseous hydrogen system separation distances was performed by a joint task group that comprised members of the NFPA Technical Committee on Hydrogen Technology and the Technical Committee on Industrial and Medical Gases during a 2005-to-2010-time frame. This evaluation resulted in significant changes to the bulk gaseous hydrogen setback distance tables, using quantitative risk assessments to inform decisions on a new basis for the tables. Specifically, the tables were changed to be based on the pressure and pipe size of the system, rather than the total quantity stored. Additionally, exposures were grouped so that similar exposure types could be considered with the same criteria, rather than establishing different setback distances for each exposure. These changes were applied to the first edition of NFPA 2 in 2011 and the 2010 edition of NFPA 55. The criteria used in the setback distance table calculations, table format, and exposures have continued to evolve and were revised for the 2020 editions of NFPA 2 and NFPA 55.

For the 2020 editions of NFPA 2 and NFPA 55, a joint task group again considered revisions for the bulk liquid hydrogen storage setback distance tables. It ultimately was decided that the work was not ready for the 2020 editions but did result in Section I.8 in NFPA 2, which identified a proposed path forward. This proposed methodology highlighted the use of a representative liquid hydrogen storage system, such as that given in CGA P-28, *OSHA Process Safety Management and EPA Risk Management Plan Guidance Document for Bulk Liquid Hydrogen Systems*, and the use of risk assessments on that system to inform revisions to the setback distance tables. Of particular concern to the task group was the transfer of liquid hydrogen from a transfer truck to a bulk liquid hydrogen tank.

N.2 Separation Distance Methodology for Bulk Liquid Hydrogen Storage.

The joint task group of the NFPA technical committees for Hydrogen Technology and Industrial and Medical Gases reviewed the current liquid hydrogen setback distances and considered how a similar methodology to that used for bulk gaseous hydrogen setback distances could be applied to bulk liquid hydrogen setback distances. In a similar way that the bulk gaseous hydrogen setback distances were chosen, a leak size was chosen that was informed by various risk assessment methods; this leak size would serve as a proxy for those more detailed and variable risk assessments and allow consequence-based distances to be calculated based on selected physical criteria. As in the bulk gaseous hydrogen setback table, the exposures were grouped, and applicable physical harm criteria were chosen for each exposure group. Finally, as in the bulk gaseous hydrogen setback table, setback distances were calculated for bulk liquid hydrogen storage based on the chosen leak size and the chosen harm criteria based on variable pipe sizes and system pressures, rather than the quantity of liquid hydrogen stored.

While the overall process for bulk liquid hydrogen setback distances is similar to and informed by the previous methodology for the bulk gaseous hydrogen setback distances, there are some notable differences. The leak size, models, and criteria have all been revised from the previous methodology and are described in more detail in Sections N.3 through N.6. One difference is the elimination of a 1.5 (50 percent) safety factor that had been applied to the calculations of the bulk gaseous hydrogen setback distance values; as described below, the task group and Technical Committee on Hydrogen Technology instead selected a more conservative (5 percent instead of 1 percent) leak size with no safety factor. Revisions to the model include those specific to the behavior of liquid hydrogen, as well as the use of a harm criterion for peak overpressure from delayed ignition of hydrogen leaks. This is a scenario that could be considered in a future analysis for revision of the bulk hydrogen gas table. The models used are part of a free and open-source software, and the details of the methodology and calculations for setback distances are publicly available for review and future revisions [1]. Finally, a more exhaustive report will be publicly available through Sandia National Laboratories that contains significantly more detail, discussion, and justification of the choices selected by the task group and technical committee than is summarized in this annex. The intention is to ensure that the methodology and models used for the calculation of the revised setback distances are well-documented, retrievable, repeatable, revisable, and independently verified.

N.3 Justification of Fractional Leak Size.

A fractional leak size is based on the internal flow area of the interconnecting piping. Using a fractional leak size allows for setback distances to vary with both pipe size and fluid pressure, which are significant contributors to overall system risk. In this way, the fractional hole size can serve as a proxy for more in-depth risk assessments by taking pipe size and fluid pressure into account, while also not requiring the variability and system-specific nature of a full risk assessment. The 5 percent leak size area selected by the task group and technical committee was informed by a number of factors, not calculated from a single equation. Therefore, these setback distances are said to be risk-informed rather than risk-based, as they are informed by risk assessments, but the distances themselves are not based solely on a risk assessment and risk criteria. The fractional leak size is the ratio of the cross-sectional area from a circular leak orifice to the cross-sectional area of the inside of the pipe.

First, members of the task group shared operating experiences that indicated that full-bore liquid hydrogen leaks are infrequent and that leak sizes as a fraction of the pipe size seem reasonable for setback distance calculation. Furthermore, members of the task group reviewed commercially available bayonet connectors for use in liquid hydrogen transfer operations (a scenario identified previously as of specific interest) and found that even complete O-ring failure would be expected to yield leak sizes of approximately 5 percent of flow area.

Secondly, a risk assessment was performed using the Hydrogen Plus Other Alternative Fuels Risk Assessment Models (HyRAM+) software tool kit with a representative liquid hydrogen storage system as described in CGA P-28. The specifics of the HyRAM+ risk assessment will be described in detail in an upcoming report, but the process takes into account system pipe size and pressure, the leak frequencies for different fractional leak sizes, the likelihood of whether or not the leak is detected and isolated, and the probability of ignition (either immediate or delayed). The likelihood of fatality due to these different outcomes for a position of interest is then calculated. This risk assessment was performed for multiple pipe sizes and multiple locations to determine the distance from the leak at which a risk criterion (2e-5 fatalities per year, based on the criteria used for the gaseous hydrogen setbacks) was met. Consequence-based models, which are also part of HyRAM+, were then used with the selected exposure group criteria to estimate an equivalent hole size that would lead to the same distance as determined by the full quantitative risk assessment. This led to an equivalent fractional hole size based on the system pipe size. A number of significant inputs to the risk assessment were then varied in a sensitivity study, including system pressure, system temperature, detection and isolation credit, different inputs to the thermal heat flux and overpressure harm models, and different fatality probability models. Almost all of these sensitivity cases resulted in equivalent fractional hole sizes that were <10 percent of flow area, and most were <5 percent of flow area. Based on this assessment, the task group concluded that a 5 percent fractional hole size was a representative and conservative choice for the leak size.

N.4 Justification of Models Used for Distance Calculations.

HyRAM+ contains various models for hydrogen dispersion, combustion, and flame behaviors. The first step in these calculations is determining the mass flow as a function of the hole size and the condition of the fluid feeding the leak. Liquid hydrogen leaks are complex, as the flow through a leak could be subcooled liquid, saturated liquid, or a two-phase mixture of liquid and gas. If the hydrogen is a subcooled or saturated liquid and remains liquid as it flows through the leak, the density of the fluid, and therefore the mass flux, will be at a maximum (for a given pressure). This assumption that the liquid would remain a liquid as it travels through the leak is mathematically captured by a metastable liquid model (MLM) [2]. While this type of flow can be possible for a severely subcooled fluid, or a leak directly on a vacuum insulated tank, it is much more likely that there will be piping and equipment (e.g., valves) between the leak point and the storage tank. As the fluid flows through this piping and other equipment, there will be energy transfer (and pressure loss) and it is unlikely that the flow rates predicted by the MLM can be achieved. In fact, in two example experiments where researchers were attempting to maximize liquid flow from a liquid hydrogen storage system, two-phase hydrogen flowed out the release point [3, 4]. These experiments also measured the significant pressure drop that occurred along the piping system, finding the tank pressure to be significantly higher than the pressure immediately upstream of the release. For these reasons, a homogenous equilibrium model (HEM) was selected to calculate the mass flow rate through the orifice [2]. In this model, it is assumed that a saturated liquid (at the tank pressure) flows through the leak isentropically while conserving energy. Rather than requiring a challenging calculation of the two-phase speed of sound (as was previously done in HyRAM+ 4.0), a new implementation of the HEM model has been developed. In this implementation, the maximum mass flux is iteratively found for a flow where entropy and energy are conserved from the upstream (tank) conditions to the throat (leak) conditions. This implementation results in exactly the speed of sound for compressed gas flows (where the speed of sound is well characterized) and works for these saturated liquid flows that become two-phase in the orifice. These calculations were verified by Air Products as well as Chart Industries. These calculated flow rates generally overpredict (with the exception of one case) the flow rates as measured in experiments [3, 4] when using the storage tank pressure, as is done in the calculation of separation distances shown in the separation distances Table 8.3.2.3.1.6(a). Even when using the pressures measured just upstream of the leak point rather than the tank pressures, the HEM model generally overpredicted the flow rates measured during these experiments. This model for the leak is conservative (i.e., it will give higher mass flow rates than can be achieved) since: 1) The pressure at a leak point will always be lower than the tank pressure used in the calculation; and 2) The leak is not likely to be isentropic, resulting in lower flows than predicted.

The dispersion model is the same as that described in the HyRAM+ technical reference manual [1]. Results from this model were compared to predictions by an internal Air Products model and Phast model. The distances to an 8 percent concentration endpoint were 20 percent to 90 percent longer for the HyRAM+ model when compared to the Air Products and Phast models. Reasons for the discrepancy include: 1) The Air Products and Phast models included effects from the ground; and 2) increased entrainment caused by wind. Both were not accounted for in the HyRAM+ model. The HyRAM+ predictions of these dispersion distances are conservative.

The diffusion flame model described in the HyRAM+ technical reference manual [1] was modified (from version 4.0) to include the effect of a 5 m/sec (20 ft/sec) wind on the momentum of the flame. For these liquid hydrogen flows, the velocities out of the leak were fairly low, and therefore buoyancy was having a large impact on the flame trajectory. By including the effect of wind, the flame tilted back towards the ground, extending the distances to a given heat flux level. Once again, the HyRAM+ flame model, and subsequent heat flux from this model, was compared against an Air Products model. The distances to different heat flux levels predicted by HyRAM+ were 60 percent to 85 percent of the distances predicted by the Air Products model. Differences include ground effects on radiation in the Air Products models as well as the way entrainment and flame shape due to wind are calculated.

Several different unconfined overpressure models are described in the HyRAM+ technical reference manual [1]. A modified version of the Baker Strehlow Tang (BST) model, as suggested by Jallais et al. [6] was used for this liquid hydrogen separation distance analysis. Rather than calculating the flammable mass using the flammability limits, the model calculates the flammable mass included in the cloud from 10 volume percent to 75 volume percent. The flame speed is based on the mass flow rate: 100 m/sec (300 ft/sec) for mass flow rates less

than 0.5 kg/sec (1 lb/sec), 140 m/sec (460 ft/sec) for mass flow rates between 0.5 kg/sec (1 lb/sec) and 1 kg/sec (2 lb/sec), and 240 m/sec (787 ft/sec) for mass flow rates between 1 kg/sec (2 lb/sec) and 10 kg/sec (20 lb/sec). This model was compared to an ignited release described by DNV-GL and the model overpredicted the measured overpressures by three to ten times, depending on the location. The somewhat large discrepancy is due to additional mixing and unsteadiness due to wind in the experiments and uncertainty around the origin of the pressure wave. The model is expected to result in conservative estimates of distances to overpressures (i.e., larger distances than experimentally observed). However, the distances required to meet the overpressure criteria were not the bounding condition for the separation distances.

N.5 Justification of Harm Criteria for Exposure Groups.

Similar to the bulk gaseous hydrogen setback distance values, different physical values are used as the acceptance criteria for the different exposure groups for the bulk liquid hydrogen setback distance values. Again, similar to the bulk gaseous hydrogen setback distance values, these criteria include unignited concentration, heat flux from a jet flame, and the visible flame length. In addition, peak overpressure criteria have been selected for the exposure groups for the liquid hydrogen analysis. While overpressure hazards were considered in the bulk gaseous hydrogen setback distance analysis, ultimately, they were not included as setback distance criteria. This can be considered for inclusion in the gaseous analysis in the next code cycle for NFPA 2. For the calculation of setback distance values, the distance to each criterion for the given exposure group was calculated, and the maximum distance was used for a given pipe size and pressure.

Exposure Group 1 considers the lot line, air intakes, building openings like doors or windows, and ignition sources. The distances specified minimize the probability of ignition for a leak, harm to the public, and damage to buildings. This exposure group, therefore, utilizes a concentration criterion of 8 percent by volume as the limit for sustained ignition, similar to the bulk gaseous hydrogen setback distances. This exposure group also utilizes a heat flux criterion of 4.732 kW/m^2 (1,501 BTU/hr/ft^2) again similar to the current gaseous hydrogen setback distances. Exposure Group 1 also adds a peak overpressure criterion of 6.895 kPa (1,000 psi), based on the ability of this level of overpressure to break glass or cause minor injuries to people [5]. For the majority of the calculations, the distance to the 8 percent by volume concentration was the largest of the three considered criteria.

Exposure Group 2 includes exposed persons not servicing the system, parked cars, other hazardous material storage, and buildings of combustible construction. The distances specified minimize harm to persons interacting with/aware of a somewhat elevated risk of being near a fuel source, the risk of fire spread to combustibles, and the risk of significant damage to buildings. This exposure group utilizes a heat flux criterion of 9 kW/m^2 (3,000 BTU/hr/ft^2), based on more serious consequences to people. This is the heat flux fatality limit for a person outdoors without PPE according to the 2019 edition of NFPA 59A [7]. This exposure group also uses a peak overpressure criterion of 13.790 kPa (2 psi), based on a very small (<1 percent) fatality possibility for a person outdoors and the possibility of some structural damage to buildings [5]. For all of the calculations, the distance to the 9kW/m^2 heat flux was the larger of the two considered criteria.

Exposure Group 3 includes buildings of nonflammable construction, slow-burning combustibles, and other hazardous material piping. The distances specified minimize the chance of escalation of the event. This exposure group utilizes a heat flux criterion of 20 kW/m^2 (6,000 BTU/hr/ft^2), which is similar to the current bulk gaseous hydrogen heat flux limit. The visible flame length of a jet flame is the second criterion, in order to protect against possible flame propagation. Finally, a peak overpressure criterion of 20.7 kPa (3 psi) is used to minimize the likelihood of pipe breakage or tank rupture [5]. For the majority of the calculations, the distance to the 20 kW/m^2 heat flux was the largest of the three considered criteria.

N.6 Justification of Mitigations for Distance Reductions.

The 2020 editions of NFPA 2 and NFPA 55 had allowances for passive mitigations to reduce bulk liquid hydrogen setback distances. Setback distances to certain exposures could be reduced by two-thirds for insulated portions of the system, and setback distances to certain exposures could be reduced to zero (eliminated) with the use of a fire-rated barrier wall. These mitigations are largely kept in place for the new setback distance values. One change in the setback distance reduction provided by barrier walls is for air intakes. Previously, the distance to air intakes could not be reduced, even by barrier walls that were applied to other Group 1 exposures. Based on consequence-based modeling from the original gaseous hydrogen work [8], as well as verification by modeling by task group members specific to liquid hydrogen releases, the task group and technical committee decided that this was too conservative and did not account for the safety benefit offered by a wall. Instead, a reduction in the separation distance by half but no less than 4.6 m (15 ft) is allowed, based on the distance to air intakes that is already specified for non-bulk gaseous hydrogen systems.

Another difference in mitigations is the addition of a required active mitigation for public-access systems. For systems located on facilities that the public has access to, such as public vehicle refueling stations, the task group and technical committee determined that to have roughly equivalent risk, an additional requirement was necessary due to the prevalence of untrained members of the public so nearby to bulk hydrogen storage. Requirements for an automatic emergency shutdown system have been added to reduce system risk by limiting the exposure time of exposed persons to dangerous levels of heat flux, reduce fire propagation by limiting the exposure time of buildings or combustibles to the flame, and reduce the likelihood of ignition by limiting the time a leak occurs. However, it is challenging to establish a single specific value for the reduction of a consequence-based setback distance due to the reduction in exposure time fatality probability or ignition probability. Therefore, the same setback distance values will be used for both public and nonpublic facilities, but the additional active mitigation of an automatic retention valve is required for public facilities to account for the increased risk at those sites.

N.7 References.

(1) Ethan S. Hecht and Brian D. Ehrhart. “Hydrogen Plus Other Alternative Fuels Risk Assessment Models (HyRAM+) Version 4.0 Technical Reference Manual.” Sandia National Laboratories SAND2021-14813, November 2021.

(2) Tom Spicer and Derek Miller. “Quantifying the Mass Discharge Rate of Flashing Two Phase Releases Through Simple Holes to the Atmosphere” *Process Safety Progress* 37 (3): 382-396, 2018.

(3) DNV-GL “Liquid Hydrogen Safety Data Report: Outdoor leakage studies.” Report number 853182. 2020.

(4) Kieran Lyons, Simon Coldrick, and Graham Atkinson. “Summary of experimental series E3.5 (Rainout) results.” *FCH JU Pre-normative Research for Safe use of Liquid Hydrogen.* Deliverable D3.6. 2020.

(5) Ethan S. Hecht and Brian D. Ehrhart. “Analysis to support revised distances between bulk liquid hydrogen systems and exposures.” Proceedings of the 2021 International Conference on Hydrogen Safety. SAND2021-7705C. 2021.

(6) Simon Jallais, Elena Vyazmina, Derek Miller, and J. Kelly Thomas. “Hydrogen jet vapor cloud explosion: A model for predicting blast size and application to risk assessment.” *Process Safety Progress* 37: 397-410, 2018.

(7) NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)* National Fire Protection Association, 2019.

(8) W. Houf, R. Schefer, and G. Evans. “Analysis of Barriers for Mitigation of Unintended Releases of Hydrogen.” Presented at 2008 Annual Hydrogen Conference and Hydrogen Expo USA March 30 – April 3, Sacramento, CA.

Statement of Problem and Substantiation for Public Input

This adds a reference to a publicly available document for additional details to the previously revised

bulk outdoor liquid hydrogen separation distances

Submitter Information Verification

Submitter Full Name: Brian Ehrhart
Organization: Sandia National Laboratories
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jan 04 11:36:15 EST 2024
Committee: HYD-AAA

Committee Statement

Resolution: FR-104-NFPA 2-2024
Statement: This adds a reference to a publicly available document for additional details to the previously revised bulk outdoor liquid hydrogen separation distances

Public Input No. 23-NFPA 2-2023 [Section No. O.1.2.11]

O.1.2.11 CSA Group Publications.

CSA Group [corporate office:] 178 Rexdale Blvd., Toronto, ON M9W 1R3, Canada.

~~ANSI~~ CSA /~~CSA FC 1~~ ANSI FC 1 * CSA C22.2 No. 62282-3-100 , *Fuel cell technologies – Part 3-100: Stationary fuel cell power systems – Safety,* ~~2014 (reaffirmed 2018)~~ 2021 .

ANSI/CSA FC 3, *American National Standard/CSA American Standard for Portable Fuel Cell Power Systems*, 2004 (reaffirmed ~~2017~~ 2021).

ANSI/CSA HGV 4.1, *Standard for hydrogen-dispensing systems*, 2020.

ANSI/CSA HGV 4.2, *Hoses for Compressed Hydrogen Fuel Stations, Dispensers and Vehicle Fuel Systems*, 2013 (reaffirmed 2019).

CSA/ANSI HGV 4.3, *Test Methods for Hydrogen Fueling Parameter Evaluation*, 2019.

ANSI/CSA HGV 4.4, *Breakaway Devices for Compressed Hydrogen Dispensing Hoses and Systems*, 2013 (reaffirmed 2018).

ANSI/CSA HGV 4.6, *Manually Operated Valves for Use in Gaseous Hydrogen Vehicle Fueling Stations*, 2013 (reaffirmed 2018).

ANSI/CSA HGV 4.7, *Automatic Valves for Use in Gaseous Hydrogen Vehicle Fueling Stations*, 2013 (reaffirmed 2018).

ANSI/CSA HGV 4.8, *Hydrogen Gas Vehicle Fueling Station Compressor Guidelines*, 2012 (reaffirmed 2018).

CSA/ANSI HGV 4.9, *Hydrogen Fueling Stations*, 2020.

ANSI/CSA HGV 4.10, *Fittings for Compressed Hydrogen Gas and Hydrogen Rich Gas Mixtures*, 2012 (reaffirmed 2019).

CSA HPIT 2, *Dispensing Systems and Components for Fueling Hydrogen Powered Industrial Trucks*, 2017.

ANSI/CSA NGV 5.1, *Residential Fueling Appliances,* 2015.

Statement of Problem and Substantiation for Public Input

New binational edition has been published which is an adoption of the newest edition of IEC 62282-3-100.This is the first edition of CSA/ANSI FC 1 • CSA C22.2 No. 62282-3-100, Fuel cell technologies — Part 3-100: Stationary fuel cell power systems — Safety, which is an adoption with Canadian and U.S. deviations of the identically titled IEC (International Electrotechnical Commission) Standard 62282-3-100 (second edition, 2019-02). It replaces ANSI/CSA FC 1-2014 (adopted IEC 62282-3-100:2012, with U.S. deviations).

ANSI/CSA America FC 3:2004 was reaffirmed in 2021.

Submitter Information Verification

Submitter Full Name: Mark Duda
Organization: CSA Group
Street Address:
City:
State:

Zip:

Submittal Date: Tue Aug 15 10:20:09 EDT 2023

Committee: HYD-AAA

Committee Statement

Resolution: FR-216-NFPA 2-2024

Statement: References titles and editions have been revised per the NFPA Manual of Style. New references have been added as needed.

Public Input No. 219-NFPA 2-2023 [Section No. O.1.2.20]

O.1.2.20 UL Publications.

Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 508, ~~*Standard for*~~ *Industrial Control Equipment,* 2018, revised 2021.

UL 1626, *Residential Sprinklers for Fire Protection Service,* 2008.

UL 1998, ~~*Standard for*~~ *Software in Programmable Components*, 2013.

UL 2267, *Fuel Cell Power Systems for Installation in Industrial Electric Trucks*, 2020.

UL 60730-1, *Automatic Electrical Controls — Part 1: General Requirements*, ~~2016~~ 2021 .

UL 60947-1, ~~*Standard for*~~ *Low-Voltage Switchgear and Controlgear — Part 1: General Rules*, ~~2013~~ 2022 .

UL 61010-1, *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements*, ~~2019~~ 2012, revised 2023 .

Statement of Problem and Substantiation for Public Input

Update the standards to the most current publication date and remove "Standard for" to reflect UL short title for consistency.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 218-NFPA 2-2023 [Section No. 2.3.12]	

Submitter Information Verification

Submitter Full Name: Kelly Nicolello
Organization: UL Solutions
Street Address:
City:
State:
Zip:
Submittal Date: Fri Dec 29 11:43:56 EST 2023
Committee: HYD-AAA

Committee Statement

Resolution: FR-216-NFPA 2-2024
Statement: References titles and editions have been revised per the NFPA Manual of Style. New references have been added as needed.