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Green Hydrogen Production and Storage:
A Review of Safety Standards and Guidelines with a focus on Safety Instrumented System Applications

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In response to global climate change and the energy crisis, the need for decarbonization is becoming increasingly important for many countries, including Singapore. The transition to a zero-carbon society relies on reducing greenhouse gas emissions. Hydrogen, a clean energy source with relatively high specific energy, has received significant attention in recent years. However, ensuring the safety of hydrogen production and storage is crucial for its widespread adoption. This paper conducts a literature review of hydrogen safety standards and notable incidents, focusing on applying safety instrumented systems to avoid a catastrophic hydrogen disaster. Based on the findings, the paper will discuss the challenges and make recommendations to enhance hydrogen safety, including compliance with international safety standards, establishing risk assessment programs, and regulations and guidelines for safe hydrogen handling and storage. Hydrogen can become an alternative fuel for sustainable development with appropriate safety measures.

Keywords: Hydrogen safety, Hydrogen production, Hydrogen storage, Functional safety, Safety instrumented systems

1. Introduction

Hydrogen is a colorless, odorless, highly flammable gas that can become liquid when stored at -252 degrees Celsius. It has a long history as an energy source and has been used since the 19th century in fuel cells, internal combustion engines, rockets, airships, and more. Compared to traditional fossil fuels, hydrogen offers several benefits, including versatility, cleanliness, zero carbon emissions, greater power and efficiency, and affordability. As such, there is increasing interest in exploring hydrogen's potential as a green and non-polluting energy source. It can be generated from various renewable energy sources and utilized as an alternative energy source in transportation, power generation, and residential sectors.

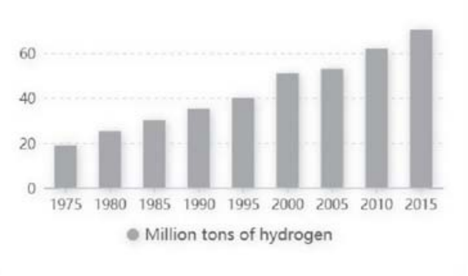

Fig. 1. Global annual demand for hydrogen since 1975 (Birol, 2019, p18).

Since 1975, global demand for hydrogen has tripled and continues to grow, as shown in Figure 1 (Birol, 2019, p18). Many countries are implementing policies to encourage the adoption and utilization of hydrogen. For instance 2018, China announced Wuhan as its first hydrogen city, aiming to establish 100 fuel cell manufacturers and 300 hydrogen filling stations by 2025. In 2019, the European Commission revealed a long-term "Hydrogen Initiative" decarbonization strategy involving 28 countries and approximately 100 companies (Birol, 2019). The UK issued the country's Hydrogen Strategy in 2021, which requires around 7.6 – 13.9 Mt of low-carbon H2 by 2050 (Chen et al., 2023). More recently, on October 25, 2022, Singapore launched its National Hydrogen Energy Strategy to fulfill 50% of its electricity requirements by 2050 (Chen et al., 2023).

Hydrogen is commonly stored and transported either as a compressed gas or a liquid, allowing it to be shipped from low-cost production areas to high-cost production areas over long distances. Hydrogen would diversify energy sources and increase energy security for countries that rely heavily on energy imports (Birol, 2019). In Singapore's current hydrogen life cycle, hydrogen delivery and applications are increasingly common, such as using hydrogen in power plants for heat exchange and as a coolant. As hydrogen deployment expands, Singapore will also need to focus on developing laws and regulations governing hydrogen production and storage to ensure its import needs.

Despite the advantages of using hydrogen as an alternative fuel, it poses some challenges, primarily regarding safety. Hydrogen has properties such as high flammability, small molecule size, and susceptibility to leakage in the gaseous state. In its liquid state, hydrogen requires complex storage conditions, which can lead to associated hazards such as physiological hazards (frostbite, respiratory ailments, and asphyxiation), physical hazards (phase changes, component failures, and embrittlement), and chemical hazards (ignition and burning) (Ordin, 1997).

To ensure the widespread deployment and use of hydrogen and fuel cell technologies, it is crucial to address the safety concerns by minimizing the risks and hazards associated with hydrogen fuels and ensuring that they are comparable to or even lower than conventional fuels.

This paper aims to conduct a literature review of hydrogen safety standards, with a specific focus on functional safety aspects related to hydrogen production and storage. The review will also include an analysis of notable hydrogen incidents to identify shortcomings and opportunities for enhancing current safety standards. Based on the findings, this paper will provide recommendations in the Singapore context at the end of this paper. By addressing safety concerns and implementing appropriate safety measures, Singapore can pave the way for the widespread adoption and utilization of hydrogen as an alternative fuel.

2. Literature Reviews

This study consists of several components. Firstly, an extensive review of literature, encompassing academic papers, industry reports, government publications, and international standards, to gather information about the existing safety standards and regulations relevant to hydrogen safety. Secondly, various case studies highlighting hydrogen-related accidents are carefully chosen to gain practical insights. Subsequently, a gap analysis is conducted to identify deficiencies in the current regulatory framework. This analysis involves examining the causes and proposing practical strategies to address them. To access relevant literature, platforms such as Google Scholar and the NUS library system were used. Government regulatory websites were also used to gather specific information regarding safety standards and regulations. Lastly, several rounds of unstructured discussions were held with experts in functional safety at the HIMA Asia Pacific in Singapore, incorporating valuable insights and expert opinions into this study.

2.1 Hydrogen Safety Standards (International)

Adherence to internationally recognized standards is critical to produce and store hydrogen safely. These standards provide comprehensive guidelines and technical requirements for designing, constructing, operating, and maintaining hydrogen storage systems. ISO 13985, ISO 16111, ISO 19881, and ISO 19882 are among the international standards that provide technical specifications and safety guidelines for various hydrogen storage systems. These standards cover compressed hydrogen gas storage systems used in vehicles and safety considerations for hydrogen systems in fuel cell vehicles and stationary hydrogen storage systems. ISO 15916 provides explicit guidelines for the use of hydrogen in its gaseous and liquid forms as well as its storage in either of these or other forms (hydrides). It identifies the primary safety concerns, hazards, and risks and describes the properties of hydrogen relevant to safety. Following these standards helps ensure the safe handling, transportation, and use of hydrogen, making it an increasingly viable option for various applications (Kotchourko, 2022).

Liquid hydrogen technology is subject to specific Regulations, Codes, and Standards (RCS), similar to compressed hydrogen technology. For liquid hydrogen, there are two main RCS areas: ISO 13985, which sets safety limits for tanks, materials, and safety valves, and ISO 13984, which aims to prevent accidental leakage and may include provisions related to functional safety. However, it is worth noting that there is no international standard specifically for fixed liquid hydrogen storage, although ISO 21010, which is the relevant standard for cryogenic containers, can be applied. As Kotchourko (2022) pointed out, liquid hydrogen storage technology for vehicles is still in its infancy and requires the development of new regulations.

Manufacturers of hydrogen production equipment such as electrolyzers also need to implement safety measures to ensure safe operation. For example, based on manufacturer's specification, Proton Exchange Membrane (PEM) Electrolyzers require several safety functions to be put in place; these are typically implemented as a functional safety or safety instrumented systems protection layer. To identify the safety requirements for such systems, the company needs to carry out a formal hazards and risk assessment process based on the requirements of existing standards such as IEC 61511-1:2016 Functional Safety: Safety Instrumented Systems for the Process Industry sector (Marta, 2022).

Coupling electrolysis cells and renewable energy is crucial to developing low-carbon emission energy systems. However, traditional electrolysis cells are designed to operate at rated power and are unsuitable for the higher variability of renewable energy sources. Fortunately, ISO 22734 (Hydrogen generators using water electrolysis - Industrial, commercial, and residential applications) is currently undergoing revision to ensure safe operation in combination with variable power sources (Kotchourko, 2022).

In summary, international standards for hydrogen safety are primarily developed under the umbrella of organizations such as the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). The standards related to hydrogen production and storage are outlined in Figure 2.

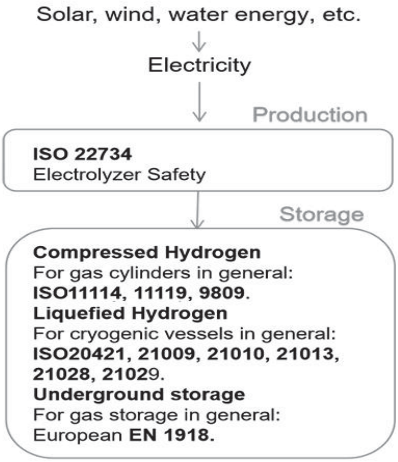

Fig. 2. Simplified two parts of the Hydrogen value chain and the related international standards on hydrogen safety (Kotchourko, 2022).

2.2 Hydrogen Safety Standards (Country/Region Specific)

In Europe, guidelines for the design and construction of underground and liquid hydrogen storage facilities, including safety considerations and equipment design, are provided by EIGA 171/12 and EIGA 6/02, respectively. In Australia, AS 22734 aligns with international standards for the requirements of hydrogen gas generation (Salehi et al., 2022). Furthermore, the transportation of hydrogen as a dangerous good is regulated by the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) (Kotchourko, 2022).

China has two sets of hydrogen safety standards: (1) industry-driven voluntary standards and (2) mandatory standards equivalent to national laws. China's national standards, such as GB/T 29412-2012 and GB/T 37562-2019, provide guidelines for technical requirements and safety management of hydrogen purification and water electrolysis systems. Meanwhile, GB/T 26466-2011, GB/T 33292-2016, and GB/T 35544-2017 govern the hydrogen storage (Yang et al. 2019, p5).

In the United States, NFPA 2 and NFPA 55 work in tandem, with NFPA 2 establishing detailed regulations for construction, outdoor storage, and other areas, including electrolysis (Kotchourko, 2022). NFPA 55, on the other hand, provides general provisions for compressed gases and cryogenic liquids but does not explicitly address hydrogen.

In Canada, standards such as ANSI/CSA HGV 4.1-2012 and ANSI/CSA 4.2-2012 provide guidelines for hydrogen dispensing systems, compressed fuel stations, dispensers, and vehicle fuel systems. These regulations apply to all liquid and gas installations, except for those producing more than 21 kg/h of hydrogen, which are excluded, as they are typically used for industrial purposes such as refinery processing or chemical feedstock (Kotchourko, 2022). Table 1 below summarizes some of these standards adopted by various countries.

Table 1. Some safety standards adopted by various countries/regions.

Country	**Standards**	**Related area**	**Specific provisions**
United Kingdom	BS844-BS848	Hydrogen Fuel	Requirements on Storage systems, piping systems, equipment, dispensing systems, and safety.
Europe	EIGA 171/12	Design and construction of underground liquid hydrogen storage facilities.	Equivalent safety distance: 8m from other flammable gas storage, independently from the dimension of the LH2 storage.
Australian	AS 22734	Hydrogen electrolysis	NA

Table 1. Some safety standards adopted by various countries/regions (Continued).

Country	Standards	Related area	Specific provisions
China	GB/T 29412	Hydrogen purification	The absorber element should be made of carbon steel and low alloy steel pipe
	GB/T 37562	Water electrolysis system	NA
	GB/T 26466, GB/T 33292 and GB/T 35544	Hydrogen storage	Stainless steel clad steel plate; Steel strip material is Q345R, 16MnDR or HP345
The US	NFPA2	Construction, outdoor storage, and electrolysis	15-23 m for, respectively, small (150-13250 l) and large (57000-284000 l) LH2 storage
	NFPA 55	Compressed gases and cryogenic fluids	Welded steel-outer vessel
Canada	ANSI/CSA HGV 4.1	Hydrogen dispensing systems	Thermoplastics and elastomers predominantly used for liners (in high-pressure storage cylinders and tanks) and sealing (e.g., O-rings)
	ANSI/CSA 4.2	Compressed fuel stations, dispensers, and vehicle fuel systems	

2.3 Incident Reviews

To identify any gaps or weaknesses in existing functional safety standards, this section reviewed hydrogen-related accidents in the last 30 years. These accidents mainly involved hydrogen production and storage, providing a comprehensive understanding of the risks involved in these stages of the hydrogen value chain.

Norway Hydrogen Explosion - In 1985, a hydrogen explosion occurred at an ammonia plant in Norway. The incident involved releasing 10 to 20 kg of gaseous hydrogen, which formed a combustible gas cloud when mixed with air. After around 20 to 30 seconds, the gas cloud was ignited by a hot bearing, leading to two fatalities (Mjaavatten & Dag, 2005). The time from release to the explosion was only 20-30 seconds, which indicates the order of magnitude of the process safety time (PST), highlighting the importance of rapid response by safety or protection systems and the ineffectiveness of operator-response protection layers.

Hydrogenated reduction plant incident - On May 30, 1992, a hydrogen leak was followed by an explosion incident in Kawasaki, Kanagawa, Japan. The incident highlights the importance of proper material selection and maintenance practices for hydrogen production and storage equipment. The use of poorly welded pipeline SUS304 in a chloride atmosphere led to a hydrogen leak and subsequent explosion at a hydrogen reduction plant. Despite a whistle being heard and a leak being detected at 15:30hr, the equipment continued to operate and supply steam to the reduction reactor, causing the reactor to heat up and allowing hydrogen to enter and ultimately ignite 35 minutes later (Yoshinaga & Tamura, n.d.). This incident emphasizes the need to select appropriate materials for construction during design, preventative maintenance, and ensuring the competency of personnel involved in the relevant activities in various life cycle phases, viz. design, engineering, operations, modifications, and decommissioning.

Hydrogen plant gas storage tank explosion and fire - On October 23, 2001, a hydrogen production plant experienced a significant fire and damage caused by an explosive combustion event that began in a high-pressure hydrogen feed pipe. The incident was caused by the failure of welds and connections in the storage groups, which resulted in the release of gaseous hydrogen from the storage banks. Whether the emergency closing valve (ECV) was operational is still being determined. The incident also highlights the importance of preventing contamination of hydrogen cells, which led to an explosive mixture of hydrogen and oxygen inside the high-pressure feed pipes. Additionally, the incident underscores the importance of proper equipment and instrument functioning. The low-pressure purity analyzer failed to detect the low-purity hydrogen due to a failed isolation transformer, which may have prevented early detection of the contamination (Hydrogen tools, 2017).

Japan Oil Company Refinery hydrogen incident- In 1992, an explosion occurred when a large amount of hydrogen gas was released from a pressurized system at the Fuji Oil Plant in Japan (Kempsell et al., 2000). Minutes after the hydrogen leak, crews tried to stop it, but it was too late, and the explosion killed ten people and injured seven. This shows the importance of timely emergency shutdown and control of the hydrogen leak concentration in case of a hydrogen leak.

After reviewing the hydrogen-related accidents in the last 30 years, relevant data has been inferred and compiled in Table 2 to summarize the corresponding process safety times (PST), representing the approximate time it takes for hydrogen gas to ignite after a leakage occurs. The PST varies significantly between accidents, highlighting the importance of adequate safety measures. From a functional safety perspective, setting a time limit for the emergency shutdown (ESD) response is crucial to minimize the potential for catastrophic consequences. (see Table 2).

Table 2. Process safety time of hydrogen incidents.

Incident name	Ignition time of the release
Norway Hydrogen Explosion	20-30 sec
Hydrogenated reduction plant incident	About 35 min
Japan Oil Company Refinery hydrogen incident	few minutes
Hydrogen plant gas storage tank explosion and fire	unknown

2.4 Severity of hydrogen incidents

To appreciate the potential impact of hydrogen incidents with respect to the release scenarios, the modeling test results by DNV were reviewed. The severity of explosions varies depending on the concentration of hydrogen, ranging from 8% to 26% (Tanaka et al., 2007). As shown in Table 3 below, the experiments tested the overpressure of hydrogen-air mixtures at different concentrations in a storage room when ignited. The results indicated that a hydrogen concentration below 15% had minimal impact, while an explosion with a 26% concentration created a high overpressure, exceeding the tolerable limit, leading to a catastrophic outcome (Tanaka et al., 2007). However, it should be noted that hydrogen concentrations below 15% are not entirely safe. For instance, electrolyzer manufacturers have set the lower flammability limit at 8%. Hydrogen has a flammable range of 8-75% when mixed with air, emphasizing the importance of maintaining hydrogen at an appropriate concentration to ensure safety.

Table 3. Results from explosion experiments using homogeneous mixtures in the model storage room/central ignition with spark (Tanaka et al., 2007).

Hydrogen concentration (%)	Maximum measured overpressure (kPa)	
	Inside room	At station boundary
8	Minimal	Not detected
15	0.4-1.3	3.1-3.4
26	>100	28-111

3. Discussion

3.1 Key Learning

The review of safety standards and guidelines for hydrogen production and storage indicated an excellent spectrum of coverage ranging from the user selection of construction materials, predominantly alloy steel in reactor vessels, steel or carbon fiber in transfer feed pipes, and storage tanks. This included the safe handling of liquid hydrogen at -252℃ and hydrogen gas at 103 Kpa, considering the embrittlement effects of hydrogen and the leaky nature of hydrogen molecules. The requirement of a safety instrumented system is predominantly identified by a risk-based approach with guidelines from IEC 61508/61511, requiring SIS as part of designs. This specialist knowledge in the design and installation of hydrogen infrastructure should be better publicized and made readily available for reference instead of being embedded in the standards.

The review of incidents and field experiments also showed that the PSTs could be in the order of 20-30 seconds when there is a loss of containment, and keeping the concentration as low as possible is critical, hence requiring an SIS-based ESD to be able to respond in such quick order to prevent avoid a more than 15% explosive concentration depending on the orifice of release and specific process parameters.

The immaturity of liquid hydrogen storage technology, particularly in vehicles, poses a significant challenge to the broader adoption of hydrogen as a fuel source. Liquid hydrogen storage requires shallow temperatures and specialized insulation to minimize heat transfer, and due to hydrogen's low density, a large volume of storage space is required to store a significant amount of hydrogen. Although there is no specific international standard for hydrogen storage, general standards for compressed gases and liquids still apply to liquid hydrogen storage.

However, there are detailed regulations governing the production of hydrogen using electrolytic cells, ensuring safe and sustainable production. Additionally, renewable energy sources in hydrogen production present a promising avenue toward a sustainable future.

3.2 The Singapore Approach

Given the increasing demand for hydrogen, the Singapore government has recognized the need for a dedicated team to establish regulations and ensure hydrogen safety. Currently, there are no specific regulations related to hydrogen technology in Singapore. Therefore, creating new regulations is a priority to ensure the safe handling, transport, and storage of hydrogen. This is particularly important as Singapore seeks to promote the adoption of hydrogen as a key fuel source in its sustainable energy transition while ensuring public safety. Developing regulations would ensure safety and encourage innovation and growth in the hydrogen industry, attracting investors and companies to invest in this emerging technology.

In Singapore, it is required of all significant hazard installations (MHIs), including those that may be involved in activities related to hydrogen production and storage, to comply with the existing Safety Case regulatory framework. This includes the requirements to perform risk assessments, identify significant hazard and accident scenarios, and implement protection layers for risk reduction to a level that is As Low As Reasonably Practicable (ALARP). Based on the incidents reviewed and the prompt response required to mitigate hydrogen release scenarios, a Functional Safety-based Safety Instrumented System is expected to be a crucial control measure.

3.3 Future Research/Study

The review has shown that the process safety time for a hydrogen leak can vary between 20 seconds to half an hour, depending on various factors such as equipment type, leak rate, hydrogen concentration threshold, and safety instrumented system (SIS) response time. However, the critical factor is how long it takes for the hydrogen concentration to reach a catastrophic level (e.g., 15% or more). Future studies can be conducted to evaluate the limiting hydrogen concentration in the event of a release to keep the impact minimal.

This also highlights the importance of having a reliable SIS, such as emergency shutdown systems with fast response times, which can be activated within a predefined response time (based on process safety time requirements) for detecting an incident. Such a fast-rapid SIS is crucial to avoid or prevent any loss of containment to below 15% or lower to mitigate the potential impact of hydrogen incidents. The ability to rapidly shut down hydrogen systems in an accident is vital in ensuring safety in industries that use hydrogen, such as the chemical and energy sectors. This emphasizes the significance of investing in SIS and protocols that mitigate risks associated with hydrogen use and expand safety in the hydrogen industry. Ultimately, the effective implementation of emergency shutdown systems can prevent accidents and ensure the sustainable growth and success of the hydrogen industry.

4. Recommendations

Based on the reviews, this paper identifies several focus areas for the hydrogen industry to enhance hydrogen production and storage safety.

4.1 Compliance & Adherence

The arrays of safety standards and guidelines provided an excellent spectrum of coverage in dealing with hydrogen. The hydrogen industries should continue to adopt and adhere to these safety standards while ensuring compliance with local regulations. Although Singapore currently has no large-scale hydrogen production facilities, storage and transportation of hydrogen are essential aspects of Singapore’s National Hydrogen Energy Strategy. Green hydrogen imports, and thus compliance with safety standards, are critical. It is also crucial for the Singapore government to monitor the progress of liquid hydrogen storage technology and improve regulations in this regard.

4.2 Special Focus on Effective SIS Required

To keep pace with the emerging hydrogen technology, it is recommended to implement a comprehensive risk assessment program to identify potential hazards and appropriate preventative measures. This can be introduced as an enhanced risk and safety management in the current Safety Case regime for all the MHIs. In addition, to consider the analysis and assessment of SIS sufficiency, considering the order of PST and SIS response time when handling hydrogen. This is particularly true as strong safety measures are necessary for both onboard hydrogen storage systems and the hydrogen electrolysis. These systems ' proper design, installation, and maintenance are essential to ensure safe and efficient hydrogen production and storage.

4.3 Enhance Risk & Safety Management

The current Safety Case regime can focus on hydrogen safety by concentrating on the operational specifications of SIS devices, such as valves, enclosures, and detection systems. This approach can ensure safety measures are in place while allowing for the gradual adoption of hydrogen technology. To ensure safety when deploying hydrogen technology, it is essential to regulate operational specifications and establish effective communication systems and emergency response procedures. This should be accompanied by proper material selection and maintenance practices to prevent leaks and explosions. Additionally, conducting regular inspections and tests on equipment and instruments is crucial to ensure their proper functioning. Finally, it is essential to provide comprehensive training and education to workers and emergency responders to ensure they are equipped to handle hydrogen safely and mitigate potential hazards.

5. Conclusion

In summary, to enhance hydrogen safety in Singapore, it is critical to ensure compliance with international safety standards, implement a comprehensive risk assessment program, establish strong safety measures for onboard hydrogen storage systems and electrolysis, develop effective communication and emergency response procedures, prioritize material selection and maintenance practices, and provide training and education for workers and emergency responders. These recommendations, derived from existing research, should be interpreted within the evolving context of Singapore's constantly updated status quo, which may introduce bias. To enhance the validity of the recommendations, a statistical approach can be employed to further analyze incident data and refine the suggested measures. Such an approach also enables the identification of patterns and relationships among different risk variables that may not have been adequately addressed in the existing studies. Furthermore, while this review primarily focuses on the technical aspects of hydrogen safety, it is crucial to acknowledge that economic, environmental, and social considerations are equally important and should be thoroughly assessed before embarking on the use of hydrogen.

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References

Birol, Fatih. "The Future of Hydrogen: Seizing Today’s Opportunities." *IEA Report prepared for the G* 20 (2019).

Chen, Peggy Shu-Ling, Hongjun Fan, Hossein Enshaei, Wei Zhang, Wenming Shi, Nagi Abdussamie, Takashi Miwa, Zhuohua Qu, and Zaili Yang. "A Review on Ports’ Readiness to Facilitate International Hydrogen Trade." *International Journal of Hydrogen Energy* (2023).

Hydrogen tools. (2017). Retrieved from https://h2tools.org/lessons/hydrogen-plant-explosion-and-fire.

Kempsell, ID, MJ Wakem, MP Fairelough, and JM Ingram. "Hydrogen Explosions-an Example of Hazard Avoidance and Control." Paper presented at the Institution of Chemical Engineers symposium series, 2000.

Kotchourko, Alexei, and Thomas Jordan. *Hydrogen Safety for Energy Applications: Engineering Design, Risk Assessment, and Codes and Standards.* Butterworth-Heinemann, 2022.

Marta zietek@seshydrogen com Ziętek, “H2 Safety #2: Electrolyzer,” Ses Hydrogen, February 10 2022. Retrieved from https://seshydrogen.com/en/h2-safety-2-electrolyzer/.

Mjaavatten, A, and Dag Bjerketvedt. "A Hydrogen-Air Explosion in a Process Plant: A Case History." (2005).

Ordin, Paul M. "Safety Standard for Hydrogen and Hydrogen Systems Guidelines for Hydrogen System Design, Materials Selection, Operations, Storage and Transportation." (1997).

Salehi, Fatemeh, Rouzbeh Abbassi, Mohsen Asadnia, Billy Chan, and Longfei Chen. "Overview of Safety Practices in Sustainable Hydrogen Economy–an Australian Perspective." *International Journal of Hydrogen Energy* (2022).

Tanaka, Toshimitsu, T Azuma, JA Evans, PM Cronin, DM Johnson, and RP Cleaver. "Experimental Study on Hydrogen Explosions in a Full-Scale Hydrogen Filling Station Model." *International Journal of Hydrogen Energy* 32, no. 13 (2007): 2162-70.

Yang, Yanmei, Geng Wang, Sinan Zhang, Lan Zhang, and Ling Lin. "Review of Hydrogen Standards for China." Paper presented at the E3S Web of Conferences, 2019.

Yoshinaga, J., & Tamura, M. Retrieved from https://www.shippai.org/fkd/en/cfen/CC1000025.html.