Department of **Energy, Mines, Industry Regulation and Safety**
Dangerous Goods Safety

GOVERNMENT OF WESTERN AUSTRALIA

Dangerous Goods Safety Guide

Storage, handling and production of hydrogen

June 2024

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Introduction

This guide is designed to assist all persons who store, handle or produce hydrogen gas and liquid within Western Australia (WA) to understand what is required from a dangerous goods safety perspective.

Hydrogen is a highly flammable gas that is often stored under high pressure. It is vital that hydrogen facilities and installations are correctly designed, built, operated and maintained so that risk is minimised to people, property and the environment.

Background

The use of hydrogen as a fuel is an emerging industry. WA is positioning itself to be a significant global producer, exporter and user of renewable hydrogen. Significant capital expenditure and infrastructure investment has been committed by industry and the State and Commonwealth Governments, which has seen a number of major hydrogen projects being proposed within WA.

The Chief Dangerous Goods Officer considers the use of hydrogen as a fuel to be a new and novel application. Therefore, the assessment of licence applications for hydrogen storage, handling and production will be applied with a high level of rigour proportionate to the complexity of the facility.

The safe storage, transport and handling of gaseous and liquefied hydrogen is controlled by the *Dangerous Goods Safety Act 2004* (DGS Act) and associated regulations.

1 Hydrogen classification and properties

Hydrogen is a colourless, odourless gas at atmospheric conditions. As a gas, hydrogen is lighter than air and will dissipate easily if unconfined.

The physical size of the hydrogen molecule is very small and has a low viscosity making it difficult to contain with threaded and flanged joints. It is so small that it can even slowly disperse through the atomic matrix of solid metal and impact the integrity of the material (causing embrittlement).

Liquid hydrogen has a density approximately 7% to that of water and a boiling point of -253 °C, with a liquid to gas expansion ratio of about 1:850. Due to its low temperature, liquid hydrogen will not disperse as readily as gaseous hydrogen if released to the atmosphere.

When mixed with air, hydrogen has a wide flammability range of 4–75% volume per volume (v/v) compared to liquefied petroleum (LP) gas, which is 2.1–9.5% (v/v), or petrol 1.2–7.4% (v/v). Therefore, it is very important to keep air from mixing with hydrogen within confined spaces.

Hydrogen has a low ignition energy, approximately 13 times lower than LP gas, meaning that it is much easier to inadvertently ignite and requires specialist, intrinsically safe electrical equipment. Hydrogen will heat up when it is depressurised, which can be sufficient to ignite vented hydrogen or inadvertent leaks.

Hydrogen will much more readily detonate with minimal confinement when compared to other flammable gases. It burns with an almost invisible flame, so can be hard to detect.

Hydrogen is a Division 2.1 (flammable gas) dangerous good that can be identified under different UN numbers.

Table 1 Hydrogen UN numbers

UN no.	Proper shipping name
1049	HYDROGEN, COMPRESSED
1966	HYDROGEN, REFRIGERATED LIQUID
3468	HYDROGEN IN A METAL HYDRIDE STORAGE SYSTEM, or HYDROGEN IN A METAL HYDRIDE STORAGE SYSTEM CONTAINED IN EQUIPMENT, or HYDROGEN IN A METAL HYDRIDE STORAGE SYSTEM PACKED WITH EQUIPMENT

For further information on hydrogen safety considerations, refer to SA TR 15916:2021 *Basic considerations for the safety of hydrogen systems* and SA TS 5359:2022 *The storage and handling of hydrogen.*

2 Hydrogen safety under dangerous goods legislation in Western Australia

Under section 8 of the DGS Act, there is a duty placed on persons involved in storing, handling or transporting dangerous goods to minimise risk to as low as reasonably practicable to people, property and the environment.

Dependent upon the amount of hydrogen being stored or handled, and its use, the following legislation is applicable.

Dangerous Goods Safety Act 2004

- Applies to all uses and quantities of hydrogen unless otherwise specified.

  For example, if an operator is considering using hydrogen as a fuel source in quantities of less than 5,000 litres (manifest quantity) the requirements to comply with the DGS Act still apply.

Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007 (DGSH Regulations)

- Licensing is required for a storage and handling facility exceeding 5,000 litres of hydrogen.

  Note that this is the total volume (in litres) of all storage and pipework containing hydrogen (i.e. the water capacity).

- A documented dangerous goods risk assessment is required. For information on what is required for a risk assessment, send an email to ra@demirs.wa.gov.au requesting risk assessment guidance information. You can also refer to Appendix 3.

  See Appendix 2 and Appendix 4 for detailed information requirements for hydrogen storage and handling proposals.

- Hydrogen pipelines that leave a site (e.g. manufacturing or storage facility to an export or import facility) may need to be registered under the DGSH Regulations.

Dangerous Goods Safety (Major Hazard Facilities) Regulations 2007 (MHF Regulations)

- Any facility with a capacity exceeding the critical quantity (5 tonnes of hydrogen) needs to notify the Department of Energy, Mines, Industry Regulation and Safety (the department) by completing the form: *Operator notification that critical quantity of Schedule 1 substances will be exceeded*.
- The department will assess the facility and determine if it will be classed as a major hazard facility.
- An major hazard facility must have a safety report detailing the potential major incidents, safety critical controls and a safety management system, approved by the Chief Dangerous Goods Officer prior to operation, as outlined in *Preparing a safety report for a major hazard facility*.

2.1 Other legislation covering hydrogen

All workplaces in WA, including those governed under DGS laws, must comply with the *Work Health and Safety Act 2020* (WHS Act) and associated regulations, as well as other applicable legislation outlined in Table 2.

Table 2 Applicable legislation by hydrogen use

Hydrogen use	Applicable safety legislation
Transport by road	• DGS Act • Dangerous Goods Safety (Road and Rail Transport of Non-explosives) Regulations 2007 • Australian Dangerous Goods Code – Edition 7.8
Blended in a natural gas transmission pipeline	• Work Health and Safety (Petroleum and Geothermal Energy Operations) Regulations 2022
Fuel for gas appliances (e.g. fuel cells)	• *Gas Standards Act 1972*
Distribution/blending through gas network	• *Gas Standards Act 1972*
Export	• International Maritime Dangerous Goods Code (Australian Maritime Safety Authority)
Gas installations	• *Gas Standards Act 1972*

3 Applying for a dangerous goods site licence

The chemical properties and the novel use of hydrogen as a fuel source requires industry and regulators to scrutinise the appropriateness of safety controls and design standards used to produce, manufacture, store and use hydrogen as well as the ongoing safety of these facilities.

Therefore, the application for a dangerous goods site licence must demonstrate that all reasonably practical measures are in place to minimise the risk to people, property and the environment in relation to dangerous goods.

As a condition of the licence, the operator will be required to develop and comply with a safety management system, which is acceptable to the Chief Dangerous Goods Officer, to ensure the ongoing safe operations of the facility.

Supporting documentation must be sufficiently detailed to demonstrate that the operator has met and will continue to meet their duties under the DGS Act and associated regulations. This includes how hazards associated with dangerous goods are identified and risk assessed, including how the risk is mitigated so far as reasonably practicable.

The application process is often iterative, whereby applicants may be asked to provide additional information to clarify issues. Therefore, sufficient time should be factored in when seeking licence approvals required prior to commissioning.

It is important that applicants liaise with the department early in the preparation and design phase to understand the process, potential turnaround times and the documentation required. For further information, refer to section 3.1 below.

A consultant, accredited by the Chief Dangerous Goods Officer, may be engaged to assist in the preparation and endorsement of an application for a site licence and can be used to examine applications for compliance with the DGS Act and DGSH Regulations. A list of consultants that have been accredited to examine and endorse storage and handling proposals can be found on the department's website.

Given the rigorous assessment required of site licence applications for facilities storing and handling hydrogen, be mindful of the additional processing times for applications, including those prepared by an accredited consultant.

An application for a dangerous goods site licence must be made on the approved form, which is available from the department's website.

Appendices 2, 3 and 4 provide an overview of the detailed information required for submission.

3.1 Planning and liaising with the department

For complex or novel projects, or for sites containing large quantities of dangerous goods, it is recommended to engage with a departmental dangerous goods officer (DGO) as early as possible to discuss the proposal and application requirements.

By meeting with a DGO, operators will be able to review and discuss the proposed operations to be conducted at the facility as well as the operator's approach to managing safety. Developing an interaction with the department early in the application process provides the basis for a good working relationship and an understanding of the regulatory requirements.

If an accredited consultant is being used to apply for a site licence, they will have the contact details of the department's DGOs. Otherwise, the department can be contacted by emailing HydrogenSafety@demirs.wa.gov.au or dgsb@demirs.wa.gov.au.

The following flow chart (Figure 1) provides the recommended process for operators considering applying for a dangerous goods site licence to store, handle and produce hydrogen (as a fuel).

It is also the preferred approach when considering storing, handling and producing quantities greater than 1,000 litres.

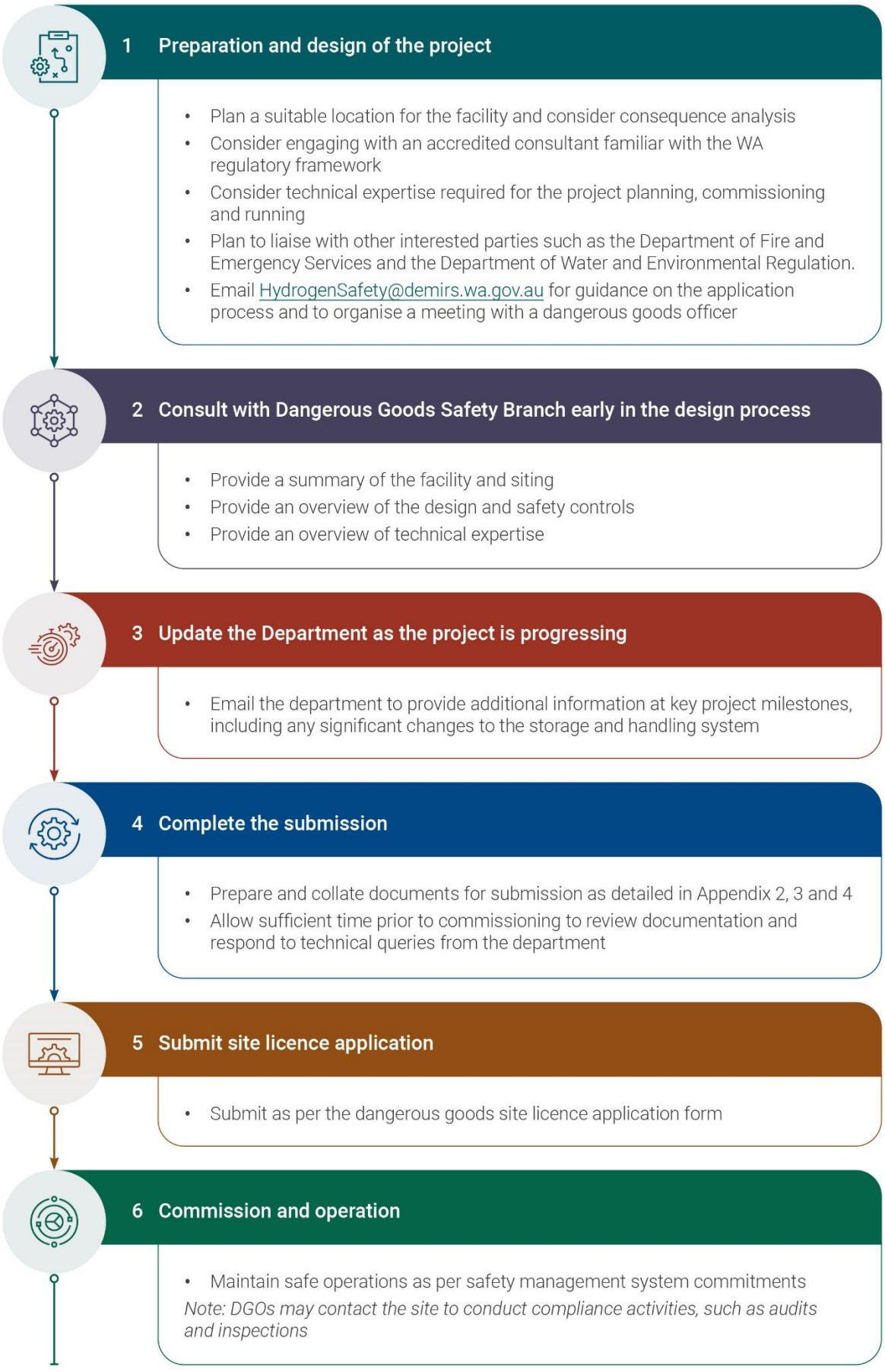

Figure 1 Flowchart of the engagement process for hydrogen site licence applications

4 Hydrogen equipment manufacturers, suppliers and installers

The DGSH Regulations set out a duty of care for manufacturers or suppliers of hydrogen storage or handling systems (e.g. electrolysers, cylinders or tank installations, dispensers and fuel cells) or pipelines. This includes ensuring that the system or pipeline has been designed and built so that, so far as is reasonably practicable, it can be operated with minimal risk to people, property and the environment.

In practical terms, equipment manufacturers need to provide certification to demonstrate that the supplied equipment complies with a relevant Australian standard, Australian/New Zealand standard or ISO standard. In the absence of a relevant AS, AS/NZS or ISO standard, an equivalent international standard may be used.

Installers of hydrogen storage or handling systems or pipelines must also ensure that the system or pipeline has been installed and commissioned so that, so far as is reasonably practicable, risk is minimised to people, property and the environment.

5 Training of people involved in the storage and handling of hydrogen

The department expects operators to have a well-designed, managed and implemented training system in place to ensure everyone involved with hydrogen is aware of the risks and has the competencies, qualifications and skills necessary to deliver the specific duties associated with their position and activities.

Appendix 1 Codes of practice and standards

The development of new and novel advancements within the hydrogen fuel sector has been at a rapid pace. Standards Australia is currently preparing documentation for use in Australia covering all aspects of the emerging hydrogen industry.

The following documents have been published and may supplement other suitable standards. However, these are not approved codes of practice.

No.	Document number and title
1	AS 16110.1:2020 *Hydrogen generators using fuel processing technologies, Part 1: Safety* (ISO 16110-1:2007, MOD)
2	AS ISO 16110.2:2020 *Hydrogen generators using fuel processing technologies, Part 2: Test methods for performance*
3	AS ISO 14687:2020 *Hydrogen fuel quality – Product specification*
4	AS 22734:2020 *Hydrogen generators using water electrolysis – Industrial, commercial, and residential applications* (ISO 22734:2019, MOD)
5	SA TS 19883:2020 *Safety of pressure swing adsorption systems for hydrogen separation and purification* (ISO/TS 19883:2017, MOD)
6	AS ISO 16111:2020 *Transportable gas storage devices – Hydrogen absorbed in reversible metal hydride*
7	AS ISO 19881:2020 *Gaseous hydrogen – Land vehicle fuel containers*
8	AS 19880.3:2020 *Gaseous hydrogen – Fuelling stations, Part 3: Valves* (ISO 19880-3:2018, MOD)
9	AS 26142:2020 *Hydrogen detection apparatus – Stationary applications* (ISO 26142:2010 (ED1.0), MOD)
10	AS ISO 19880.8:2021 *Gaseous hydrogen – Fuelling stations, Part 8: Fuel quality control*
11	AS ISO 19880.5:2021 *Gaseous hydrogen – Fuelling stations, Part 5: Dispenser hoses and hose assemblies*
12	SA TR 15916:2021 *Basic considerations for the safety of hydrogen systems* (ISO TR 15916:2015, MOD)
13	AS 62282.3.300:2021 *Fuel cell technologies, Part 3.300: Stationary fuel cell power systems – Installation* (IEC 62282-3-300:2012 (ED.1.0), MOD)
14	AS 62282.3.100:2021 *Fuel cell technologies, Part 3.100: Stationary fuel cell power systems – Safety* (IEC 62282-3-100:2019 (ED.2.0), MOD)
15	AS 62282.2.100:2022 *Fuel cell technologies*, *Part 2.100: Fuel cell modules – Safety* (IEC 62282-2-100:2020 (ED.1.0), MOD)
16	SA TS 5359:2022 *The storage and handling of hydrogen*
17	SA HB 225:2023 Guideline for blending hydrogen into pipelines and gas distribution networks
18	AS 19880.1:2023 Gaseous hydrogen - Fuelling stations, Part 1: General requirements (ISO 19880-1:2020, MOD)

The following codes are considered supplementary guidance. They may inform assessments on failure modes and be useful when undertaking risk assessments or reviewing separation distances from the hydrogen facility to protected places, such as dwellings or offices.

No.	Code and title
1	NFPA 2 *Hydrogen Technologies Code 2020*
2	NFPA 55 *Compressed Gases and Cryogenic Fluids Code 2023*

Appendix 2 Information requirements for all dangerous goods site licence applications involving hydrogen

The following information should be included for all dangerous goods site licence applications for sites involving hydrogen (excluding hydrogen gas storage facilities that are covered by AS 4332 *The storage and handling of gases in cylinders*).

1 Facility and site information

Provide relevant information of the facility and site including an overarching explanation of the operation, including:

- layout of the facility
- location of the facility – include maps, aerial photos and other useful information
- land use zoning for the surrounding area – including separation distances to residential areas, such as schools, child and aged-care facilities
- plant and operation parameters – including design and safety controls.

2 Emergency management

Provide an emergency plan and an overview of any consultation with emergency services. Early engagement with the Department of Fire and Emergency Services (DFES) to understand their response capabilities is strongly recommended.

For sites containing more than 10 times the manifest quantities of dangerous goods, a Fire and Emergency Services Emergency Response Guide is required, and evidence of registration with DFES will need to be submitted as part of the licence application. Contact feserg@dfes.wa.gov.au for any assistance with the registration process.

Guidance on how to prepare a suitable emergency plan to mitigate dangerous goods accidents is provided in AS 3745 *Planning for emergencies in facilities*.

3 Plant layout, site access and security

Detail plant layout at the site, including buildings and hazardous areas. The description should be supported by diagrams showing the plant layout and include separation distances between buildings and storage areas.

Ensure the draft site plan and manifest is available for the proposed installation. Guidance is available in *Manifest and site plan requirements for dangerous goods sites*.

Provide details of the site access and appropriate egress points in the event of an incident, and describe the security provisions in place at the facility to prevent unauthorised access to the site.

4 Design and engineering controls

Include details of the design and engineering controls that will enable ongoing safe operations. Details should include a concise overview and not include a full list of the individual controls in place.

Provide an indication of the content detail for design and control systems, including a description of:

- design philosophy and technology selection – include a summary of key design parameters cross-referencing key technical documents (e.g. approved dangerous goods codes of practice, Australian standards and ISO standards)
- a process overview of the facility – use diagrams to illustrate the process flow, including a piping and instrumentation diagrams (P&ID)
- define the physical, electrical, isolation and instrumentation controls in place for the monitoring and management of the boundary point interfaces (e.g. site interconnections, including where a pipeline links to another facility)
- details of management of possible upstream and downstream impacts (e.g. sudden changes in pressure and the equipment in place to safely manage these changes) including pressure control and relief systems
- the instrumentation and control systems installed
- any functional safety systems in place
- the systems in place for the detection of a fire or gas leak within the facility and the response on detection of a leak or fire
- the emergency shutdown facilities installed.

5 Site management

Provide a summary of how the facility will be operated to ensure its commissioning and ongoing safe operation. Include details of:

- competence and training of on and offsite personnel
- control and management of site activities (e.g. safe operating procedures, permit to work systems)
- planned operation of the facility (e.g. remote operations, onsite personnel numbers and hours)
- the commissioning plan to ensure the safe commissioning of storage and handling systems and correct function of risk controls
- handover plan should the project managers not be the licence holder (e.g. residual risk register)
- integrity management, planned and unplanned maintenance management
- response process during an emergency.

Appendix 3 Hydrogen risk determination

The Chief Dangerous Goods Officer considers the use of hydrogen as a fuel to be a new and novel application and the assessment of licence applications for hydrogen storage, handling and production will be applied with rigour commensurate to the facility and its installations.

The following summarises what the Chief Dangerous Goods Officer expects for hydrogen risk assessments. This applies to all uses of hydrogen (e.g. refuelling or small storage) and not just quantities at licensed levels.

1. Where the hydrogen storage and handling proposal is covered by an approved code of practice:
    a. conduct a clause by clause compliance check against the code of practice
    b. check to ensure risk controls are adequate to minimise risk as required by the DGSH Regulations – for further information, refer to the *Dangerous goods risk assessment template*.
2. Where the hydrogen storage and handling are not covered by an approved code of practice:
    a. review if it is covered by an Australian or international standard, such as an ISO standard
        i. if an AS or ISO standard is chosen, ensure the scope of the standard covers the hydrogen storage and handling proposal
        ii. document reasons for adopting the standard, then conduct a clause by clause compliance check
        iii. conduct a regulation check against the DGSH Regulations.
    b. if no international standard is available:
        i. refer to Appendix 2 and Appendix 4 for information requirements for hydrogen proposals
        ii. prepare a consequence analysis report based on credible scenarios involving the hydrogen installation to ensure that potential fire and explosions risk to people, property and environment is minimised. Acceptable criteria include:
            - explosion overpressure (7 kPa max); and
            - radiant heat (4.7 kW/m^2 max)
        iii. conduct a first principles risk assessment, to demonstrate that risk from a proposed hydrogen installation can be minimised as required by section 8 of the DGS Act – the risk assessment needs to address the fire and explosion hazards of hydrogen. Risk control measures need to adequately minimise those hazards.
3. If the site has been classified as a major hazard facility, the operator needs to get the site safety report approved by the Chief Dangerous Goods Officer. For further information, refer to the guide: *Development and submission of safety report.*

Appendix 4 Supporting information requirements for hydrogen facilities

Hydrogen facility type	Power generation (hydrogen fuel cells)	Gaseous hydrogen refuelling stations	Hydrogen production and gas/liquid storage	Hydrogen pipelines
Applicable WA laws (see Table glossary below)	DGSA2004 DGSH2007 GSA1972 WHS2020	DGSA2004 DGSH2007 WHS2020	DGSA2004 DGSH2007 MHF2007 may apply WHS2020	DGSA2004 DGSH2007 MHF2007 may apply
Technical guidance on hydrogen safety	Standards Australia Technical Report SA TR 15916:2021 *Basic considerations for the safety of hydrogen systems* Standards Australia Technical Specification SA TS 5359:2022 *The storage and handling of hydrogen*			
Documentation	1. Provide information as detailed in Appendix 2. 2. Equipment vendors to demonstrate, provide evidence or formal certification (dependent on the complexity), that supplied equipment complies with a design standard, for example, electrolysers, fuel cells etc.			
Components	(as applicable)			
Electrolysers	Demonstrate compliance with AS 22734:2020.	Demonstrate compliance with AS 22734:2020.	Demonstrate compliance with AS 22734:2020.	N/A
	Provide evidence the electrolyser (pressure equipment) is a registered plant in WA.			
Other than electrolysers – Steam reforming and other process plants	N/A	N/A	First principles hazard identification and risk assessment (Note 1).	N/A
Compressors/pumps	HAZID/HAZOP – demonstrate design is fit for hydrogen service and risk control is adequate.			
Hydrogen gas storage or process vessels e.g. pressure tank, MEGC, tube-trailers	Facilities comply with relevant pressure vessel standard (Note 2). Conduct consequence analysis (Note 3).	Demonstrate compliance with AS 19880.1:2023.	Facilities comply with relevant pressure vessel standard (Note 2). Conduct consequence analysis (Note 3).	N/A
Pressure reduction	HAZID/HAZOP – demonstrate design is fit for hydrogen service and risk control is adequate.	N/A	HAZID/HAZOP – demonstrate design is fit for hydrogen service and risk control is adequate.	N/A

Hydrogen facility type	Power generation (hydrogen fuel cells)	Gaseous hydrogen refuelling stations	Hydrogen production and gas/liquid storage	Hydrogen pipelines
Hydrogen fuel cell – typically housed in an enclosed container structure	Demonstrate fuel cell modules comply with AS 62282.2.100:2022 and stationary fuel cell power systems demonstrate installation complies with AS 62282.3.300:2021. Liaise with Building and Energy.	N/A	N/A	N/A
Refrigeration equipment for hydrogen refuelling stations	N/A	First principles hazard identification and risk assessment (Note 1).	First principles hazard identification and risk assessment (Note 1).	N/A
Hydrogen vehicle dispensers	N/A	Demonstrate compliance with AS 19880.1:2023. Conduct consequence analysis (Note 3).	N/A	N/A
Hydrogen liquefaction equipment, regasification and cryogenic storage	N/A	N/A	First principles hazard identification and risk assessment (Note 1). Facilities comply with relevant pressure vessel standard (Note 2). Conduct consequence analysis (Note 3).	

Hydrogen facility type	Power generation (hydrogen fuel cells)	Gaseous hydrogen refuelling stations	Hydrogen production and gas/liquid storage	Hydrogen pipelines
Product transfer – to tankers, tube trailers	N/A	N/A	First principles hazard identification and risk assessment. (Note 1). Demonstrate compliance with ADG Code transport requirements, including vehicle parking areas. Conduct consequence analysis (Note 3).	N/A
Pipeline (pipe external to a facility)	N/A	N/A	N/A	First principles hazard identification and risk assessment (Note 1). Demonstrate suitability for hydrogen service (Note 5). Conduct consequence analysis (Note 3).
Pipework (piping within a facility)	Demonstrate suitability for hydrogen service (Note 5).	Demonstrate compliance with AS 19880.1:2023.	Demonstrate suitability for hydrogen service (Note 5).	N/A
Expected controls				
Hazardous areas	Compliance with relevant sections of AS/NZS ISO 60079 series relating to hazardous areas.	Demonstrate compliance with AS 19880.1:2023.	Compliance with relevant sections of AS/NZS ISO 60079 series relating to hazardous areas.	Compliance with relevant sections of AS/NZS ISO 60079 series relating to hazardous areas.
Pressure control, pressure relief and emergency venting	Pressure control and relief as per the relevant standards (Note 2). Venting must consider issues (Note 6).			

Hydrogen facility type	Power generation (hydrogen fuel cells)	Gaseous hydrogen refuelling stations	Hydrogen production and gas/liquid storage	Hydrogen pipelines
Fire, gas and leak detection and associated controls	Provide details and describe function/controls in place to ensure safety (Note 4).	Demonstrate compliance with AS 19880.1:2023.	Provide details and describe function/controls in place to ensure safety (Note 4).	Provide details and describe function/controls in place to ensure safety (Note 4).
Spill management	N/A	N/A	Demonstrate where liquid leaks will flow to and how they are controlled.	N/A
Explosion prevention and control	Describe controls in place to prevent explosion (Note 7).	Demonstrate compliance with AS 19880.1:2023.	Describe controls in place to prevent explosion (Note 7).	Describe controls in place to prevent explosion (Note 7).
Safety management system	Summarise the management systems in place which ensure the continued safe operation of the site. The complexity of the system should be appropriate for the complexity of the process. The following elements should be considered: • leadership responsibility • hazard identification and management • record management and document control • safe operating procedures • work control and permit to work • training and competence • contractor management • management of change • procurement • operational readiness and start up • inspection and maintenance systems • incident management • emergency response • site security.			
Facilities located in WA bushfire prone areas Provide evidence that consultation with DFES has occurred to ensure that controls are in place so that the impact of a potential bushfire on the hydrogen installation will not increase the risk to people, property and environment.				

Note 1

First principles hazard identification and risk assessment to demonstrate risk controls are adequate. Various techniques are available. For further information, refer to the *Major hazard facility guide: Development and submission of a safety report*.

Note 2

Demonstrate gas storage facilities comply with the relevant pressure vessel standard. This will typically be AS 1210, AS 2030 but may include those approved under ADG Code if applicable.

Note 3

Conduct consequence analysis to confirm that the proposed location of these facilities is safe from worst case credible hydrogen incidents. The principle is to ensure there is sufficient separation distance to minimise the risks. A worst case credible scenario is one that assumes all active controls fail and they rely on passive inherent controls.

The consequence modelling should consider the following HIPAP 4 criteria (refer to Appendix 1 Table, standards no. 6 and 7):

- explosion overpressure (7 kPa max); and
- radiant heat (4.7 kW/m^2 max).

The modelling should be done on recognised impact modelling software to the agreed impact criteria. The results should demonstrate:

- the impact to people on and off the site (e.g. distance to protected places)
- impact on dangerous goods and materials a hydrogen leak can interact dangerously with
- knock on potential (escalation, pipeline and pipework in particular)
- land use zoning (including residential and sensitive use areas e.g. aged care, schools).

The modelling should focus on the jet flame length as the radiant heat from the hydrogen flame is minimal.

For small compressed gas cylinder/small storage applications, AS 4332 or AS/NZS 1596 or AS/NZS 3961 can provide information on comparative separation distances.

For pipelines, demonstrate adequate external interference protection, that it is correctly located to minimise risk, particularly important if the pipeline is to be co-located in existing pipeline easement with other dangerous goods.

Note 4

Detailed description of hydrogen fire/gas/leak detection equipment and how these leaks will be controlled. This should include information detailing how leaks will be stopped – describe if the hydrogen system will be shut down manually, remotely or automatically.

Note 5

Demonstrate pipeline/pipework/hose design, construction, integrity and maintenance of the pipeline(s) are adequate to minimise risk. Demonstrate the design is suitable for hydrogen service – material compatibility, operating temperature and pressure.

Note 6

Design of any venting to assume that the gas ignites and the flame or explosion impact is considered in the risk assessment. Vents utilised should be designed to cope with ignition and associated consequences. Release into any area must consider minimising confinement but if this is not practicable, the risk assessment should include other controls to mitigate.

Note 7

Describe controls in place to prevent explosive gas mixtures (including post maintenance activities). Describe how confinement is minimised and if this is not practicable the risk assessment should include other controls to mitigate confinement (which may include forced ventilation or explosion relief).

For fuel cells NFPA 55, has recommended a dilution to 25% of the lower flammable limit as an adequate control.

Table glossary

Term	Description / title
HAZID	Hazard identification study
HAZOP	Hazard and operability study
AS 22734:2020	*Hydrogen generators using water electrolysis – Industrial, commercial, and residential applications* (ISO 22734:2019, MOD)
AS 19880.1:2023	*Gaseous hydrogen — Fueling stations — Part 1: General requirements* (ISO 19880-1:2020, MOD)
AS 62282.2.100:2022	*Fuel cell technologies*, *Part 2.100: Fuel cell modules – Safety* (IEC 62282-2-100-2020 (ED.1.0) MOD)
AS 62282.3.100:2021	*Fuel cell technologies, Part 3.100: Stationary fuel cell power systems – Safety*
AS 62282.3.300:2021	*Fuel cell technologies, Part 3.300: Stationary fuel cell power systems – Installation*
SA TR 15916:2021	*Basic considerations for the safety of hydrogen system*
SA TS 5359:2022	*The storage and handling of hydrogen*
DGSA2004	*Dangerous Goods Safety Act 2004*
DGSH2007	Dangerous Goods Safety (Storage and Handling of non-explosives) Regulations 2007
MHF2007	Dangerous Goods Safety (Major Hazard Facilities) Regulations 2007
GSA1972	*Gas Standards Act 1972*
WHS2020	*Work Health and Safety Act 2020*
AS4332:1995	*The storage and handling of gases in cylinders*
AS/NZS1596:2014	*The storage and handling of LP Gas*
AS/NZS3961:2005	*The storage and handling of liquefied natural gas*
AS1210:2010	*Pressure Vessels*
AS 2030.1:2009	*Gas cylinders – General requirements*