



Australian Government

Department of Climate Change, Energy,
the Environment and Water

National Hydrogen Regulatory Guidebook: Hydrogen Refuelling

energy and
climate change
ministerial council

Acknowledgement

The Australian Government acknowledges the Traditional Owners of Country throughout Australia and their continuing connection to land, skies, waters and community. We pay our respects to their cultures and their Elders past and present. First Nations knowledge is critical to living sustainably in Australia. The knowledge that Aboriginal and Torres Strait Islander peoples hold as Custodians of Australia's land and natural resources can and should underpin a fair and just clean energy transition.

Disclaimer

The draft National Hydrogen Regulatory Guidebook: Refuelling Facility including its Annexures 1-5 (**Guidebook**) is part of the National Hydrogen Regulatory Review, which is an initiative of the Energy and Climate Change Ministerial Council.

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Executive Summary

Australia's demand for hydrogen fuels is anticipated to grow in the coming decades.

The International Energy Agency and other experts have concluded that hydrogen will play an essential role in achieving both Australia and the world's decarbonisation goals. Renewable hydrogen is a prospective decarbonisation pathway for several major economic sectors, including chemicals (particularly ammonia, a key input to fertilisers), metals (such as iron and alumina), and long haul heavy-duty and commercial transport (hydrogen, ammonia and methanol fuels). Australia can also contribute to global decarbonisation and energy security as an exporter of hydrogen based green fuels.

Recognising the importance of hydrogen, including hydrogen based green fuels, and the economic opportunities it presents, Australia's updated National Hydrogen Strategy (**Strategy**), endorsed by all state and territory governments, was published in 2024. This followed Australia's inaugural Strategy in 2019, one of the first published globally.

Effective regulatory settings are essential for the hydrogen industry to grow—providing assurance to communities and confidence to industries wanting to invest

Australia's Strategy reinforces efficient and fit-for-purpose regulation as the foundation for enabling the hydrogen sector to grow, while retaining community support. Appropriate, transparent and nationally consistent regulatory frameworks will provide confidence, trust and reassurance to the community that the industry is safe and meets its environmental obligations, and brings certainty to businesses wanting to know how their hydrogen project meets their regulatory obligations.

An early focus for governments has been to take stock of existing regulations and ensure there is clarity on how they accommodate hydrogen refuelling facilities. As, although hydrogen is not presently a major transport fuel in Australia or overseas, it is anticipated that as the use of hydrogen fuels grow, renewable hydrogen will be produced, stored and used at different scales and in different locations. This confidence is based on both expert opinion, and that hydrogen based fuels are one of the few prospective decarbonisation solutions available to fuel long haul heavy-duty and commercial transport. Renewable hydrogen also has the advantage of being able to be produced in a decentralised way, at smaller scales and closer to its end use.

The National Hydrogen Regulatory Guidebook is a key part of the roadmap to navigating Australia's hydrogen regulatory frameworks—it clarifies existing regulatory obligations and encourages national consistency in approaches to compliance wherever possible.

This Guidebook has been prepared as a valuable information source for all people involved in the hydrogen industry. It provides both legal and technical information relevant to the coverage of hydrogen refuelling facilities by existing legislation. This is intended for use by project proponents, and their agents or employees, to provide basic technical information regarding hydrogen refuelling

facilities and to assist in the understanding of legal and regulatory frameworks in the context of the practical needs of hydrogen projects.

This Guidebook is drafted to make complex legal and technical information accessible no matter the reader's understanding of hydrogen industry regulation. It comprises three main chapters:

- Chapter 2 provides an overview of the physical properties of hydrogen and common hazards and mitigations associated with a hydrogen refuelling facility. This chapter supports the discussion of regulatory obligations in chapters 3 and 4 by ensuring the reader has a base level of knowledge of hydrogen properties and characteristics, components of a typical hydrogen refuelling facility and associated hazards and mitigations.
- Chapter 3 describes existing regulatory frameworks for safety and how they apply to hydrogen refuelling facilities. This includes the primary and general duties established in work health and safety laws adopted across jurisdictions, and specific detailed obligations established by dangerous goods, gas, electrical and other safety legislation.
- Chapter 4 describes existing regulatory frameworks for environment, cultural heritage and planning and discusses how they may apply to hydrogen refuelling facilities. This includes laws governing First Nations land tenure and cultural heritage, planning and building laws and environmental regulations (e.g. environmental impact assessments, pollution and waste).

To capture more complex learnings and provide value to people already familiar with hydrogen, each of these chapters is supported by detailed annexures. The annexures corresponding to chapters 3 and 4 also including details on the specific requirements for different Australian jurisdictions.

An important supplement to the regulatory guidance chapters of this Guidebook is Annexure 5 (Hydrogen legislation summaries). Where chapters 3 and 4 focus on providing regulatory transparency directly relevant to key compliance activities, the Hydrogen legislation summaries provide greater context through an overview of legislation relevant to hydrogen refuelling facilities discussed in this Guidebook and identifies the appropriate regulators for these schemes.

Analysis and consultation undertaken in developing this Guidebook has reinforced that there are varying degrees of consistency between legislation across jurisdictions. This Guidebook highlights that despite these differences, there are fundamental similarities in regulatory frameworks and objectives, and that common compliance pathways exist even where specific obligations and approval requirements are different. This Guidebook identifies where there may be opportunities for project developers or operators to meet multiple regulatory obligations operating in parallel and to avoid duplication if their projects are operating in more than one jurisdiction.

This Guidebook aims to capture those obligations to be most highly relevant to the emerging hydrogen industry (with relevance determined based on extensive stakeholder engagement and firsthand research and analysis). It is not possible for one document to provide an exhaustive discussion of all laws that may be applicable to hydrogen refuelling facilities, and this Guidebook does not endeavour to do so. Further detail on what is in and out of scope of this Guidebook is set out in the respective chapters below.

This Guidebook has been developed in close collaboration with regulators, industry and other experts around Australia

This Guidebook is a key action of the 2024 National Hydrogen Strategy that will support the safe and sustainable growth of Australia's hydrogen industry. It is the product of the National Hydrogen Regulatory Review—a co-ordinated project of the Commonwealth, state and territory governments. This collaboration is the proactive effort of all governments to ensure that hydrogen regulation meets the needs of Australian communities, industry and regulators across the country. It aims to support industry to ensure that a growing hydrogen industry maintains the high expectations for safety and sustainability enshrined in other areas.

In developing this Guidebook, extensive first-hand research and analysis along with extensive consultation with the public, industry and government was undertaken. This included looking at every Act, Regulation and statutory instrument that could potentially be relevant to hydrogen—resulting in a detailed review of over 800 pieces of legislation, likely the single biggest national analysis of how Australian laws apply to renewable fuels. Consultation was also undertaken with over 200 industry participants and experts and 100 regulators and government policy agencies. This Guidebook was built on this research and learnings, and shares hydrogen regulatory knowledge for the benefit of all stakeholders involved with the hydrogen industry.

Australia already safely produces hydrogen, ammonia and other hazardous materials. The capabilities, knowledge, experience and safety practices developed through operating and safely regulating existing industries will be a foundation for managing risks and hazards from the growing hydrogen industry. It is recognised that regulatory frameworks and agency resources will need to be continuously reviewed and adapted as the industry scales up, and so too will governments consider the need to update this Guidebook as technologies and practices develop.

This Guidebook aims to ensure that Australia's hydrogen industry is developed in a way that satisfies safety and environmental obligations. As a national project supported by all jurisdictions, it reinforces that no matter where a hydrogen project is being developed, the expectations for safety and environmental protection are consistent and robust. For industry, this Guidebook seeks to ensure that regulatory expectations are clear and transparent across all jurisdictions. For communities, this Guidebook seeks to give confidence that hydrogen projects under development will be delivered safely and sustainably.

Chapter 1 - Preliminary matters

1.1 Introduction – a national roadmap

Australia’s updated National Hydrogen Strategy, endorsed by the Commonwealth and all states and territories in 2024, underscored the importance of efficient and fit-for-purpose regulation to the sustainable development of the renewable hydrogen industry.¹ The Strategy noted that appropriate, transparent and nationally consistent regulatory frameworks provide confidence, trust and reassurance to the community on safety and environmental standards, and certainty to businesses wanting to know how hydrogen projects can meet regulatory obligations.

The National Hydrogen Regulatory Guidebook is a roadmap to navigating Australia’s existing regulatory frameworks as they apply to hydrogen. A wide range of regulatory obligations exist across the Commonwealth and all states and territories. These are spread across a range of regulators and sectors, including environment, work health and safety, gas and electrical safety, planning and development, building certification, dangerous goods, First Nations land rights, cultural heritage, and airports and airspace, regulatory schemes. This Guidebook clarifies these existing regulatory obligations as they relate to hydrogen refuelling facilities.

This Guidebook recognises that regulatory guidance is valuable in supporting the growth of Australia’s hydrogen industry. It identifies both individual obligations within specific legislation, and groups laws across jurisdictions into regulatory themes to show how legislative schemes intersect.

1.2 Regulatory Authority

This Guidebook provides guidance on existing regulatory obligations. It is not legislative in nature and does not create any additional regulatory obligations. It is emphasised that the obligation of the parties is to comply with the underlying legislative obligations, not this Guidebook. Additionally, this Guidebook is not intended to replace formal regulatory guidance issued by any specific regulator. As such this Guidebook is limited to providing transparency and guidance over obligations and approvals which are legally binding.

1.3 Objectives of this Guidebook

This Guidebook aims to support the development of a renewable hydrogen industry in Australia in a way that is:

- **safe and environmentally sustainable**
- **efficient**, minimising the time and cost associated with regulatory compliance
- **compliant** with all relevant regulatory obligations.

To achieve this objective, this Guidebook focuses on achieving or strengthening the following attributes in Australia’s regulatory frameworks:

¹ This Guidebook is focused on hydrogen produced through the electrolysis pathway. Unless stated otherwise, references to “hydrogen” should be taken to mean hydrogen produced with electrolysis using renewable electricity or electricity drawn from the power grid.

Transparency and streamlined compliance pathways: This Guidebook brings clarity to how Australia’s existing regulatory frameworks apply to the development, construction and operation of hydrogen refuelling facilities across Australia. As a Guidebook, it does not amend existing laws, but it enables streamlined compliance and approval pathways for industry by summarising obligations and showing where certain activities or benchmarks (e.g. standards) can demonstrate compliance for multiple obligations or approvals.

National consistency: This Guidebook cuts through the differences in jurisdictions’ regulatory frameworks to identify areas of commonality. It highlights that despite differences across jurisdictions, there are also similarities in regulatory frameworks and in the objectives of legislation. As a collaboration of all Australian jurisdictions through the Energy and Climate Change Ministerial Council, this Guidebook has sought to identify where there can be common pathways through hydrogen regulatory frameworks. By pursuing a nationally consistent approach wherever possible, this Guidebook can help provide confidence to the community that hydrogen projects must satisfy appropriate safety and environmental protection requirements no matter where they are located.

Efficiency and cost-effectiveness: This Guidebook recognises that minimising duplication of compliance efforts across regulatory frameworks will directly improve efficiency in how a proponent can comply with laws. While proponents remain fully responsible for complying with all applicable laws for their projects, this Guidebook can help reduce the burden (including time and cost) in identifying compliance and approval requirements.

1.4 Context and background for this Guidebook – a co-design process

Through the 2024 Strategy, Australian governments have supported ongoing collaboration to improve the efficiency and effectiveness of regulatory approval processes for safety and environmental protection. This includes continued coordination in reviewing legal frameworks, and working together to consider and evaluate, with the aim of identifying a nationally consistent approach for project proponents to meet their regulatory obligations in relation to:

- hydrogen safety, noting the role of SafeWork Australia and state-based safety agencies
- hydrogen industry development with the aim of developing a nationally consistent approach as far as practicable.

The National Hydrogen Regulatory Review, a project overseen jointly by the Commonwealth, and all states and territories, was established to implement this action. This was a co-design approach that recognised better regulatory outcomes for hydrogen would be achieved through a collaboration of industry, government and the public, and by the sharing of leading-edge knowledge and practice. It involved workshops to understand key issues and bottlenecks, alongside detailed analysis and legal policy work. A national working group comprising representatives across all jurisdictions was established to support the review and provide a forum for collaboration.

The review process identified that there is likely to be an ongoing task to ensure Australia’s regulatory frameworks are fit-for-purpose as the hydrogen industry scales up. While governments will need to monitor the need for new or amended legislation, the review process concluded the most important priority during the current phase of industry development is to clarify how existing

regulatory frameworks across all jurisdictions apply to hydrogen. For this reason, an early effort was to identify archetypal hydrogen projects and describe the key obligations and approval processes relating to these projects.²

This Guidebook is a further major outcome of the review process that builds on these early efforts. This Guidebook is intended to provide more transparency and help address some of the important messages conveyed through stakeholder feedback (chapter 1.4). Development of this Guidebook has been led by a project team comprising experts with extensive legal and regulatory experience based within the Department of Climate Change, Energy, the Environment and Water but working across jurisdictions through a state and territory working group under the governance of the Energy and Climate Change Ministerial Council. This included looking at every Act, Regulation and statutory instrument that could potentially be relevant to hydrogen—resulting in a detailed review of over 800 pieces of legislation, likely the single biggest national analysis of how Australian laws apply to renewable fuels.

Engineering and legal advisors with detailed knowledge of hydrogen matters were engaged to support analysis and policy work and to ensure this Guidebook reflects first-hand experience with hydrogen refuelling facilities.

This Guidebook has been informed by extensive consultation with industry, regulators and other experts. Between 2023 and 2025, a range of meetings were held with regulators across all jurisdictions, both individually and through existing national regulator committees. Similarly, consultation with industry occurred both on an individual basis and through regular updates to bodies such as the Australian Hydrogen Council. Input and written submissions were sought through three open consultation processes:

- Over October-November 2023, co-design workshops were hosted in Sydney, Melbourne and Brisbane, with attendees from all states and territories
- In November 2024, submissions were sought on the Regulator Matrix (now Annexure 5 (Hydrogen legislation summaries)) and technical matters covered within this Guidebook, including properties and hazards of hydrogen and potential mitigation actions relevant to hydrogen refuelling facilities
- In July 2025, submissions were sought on consolidated drafts of this Guidebook.

In total, consultation was undertaken with over 200 industry participants and experts and 100 regulators and government policy agencies.

1.5 Structure of this document

This Guidebook has been designed to be a practical and user-friendly document. It provides guidance on how to navigate Australian regulatory frameworks applying to hydrogen refuelling facilities. It is intended to highlight the core elements for regulatory approvals which, despite

² For example, the application of Commonwealth law to archetypal projects is published online at: <https://www.dcceew.gov.au/energy/hydrogen/regulatory-lists>. Some state and territory governments have also undertaken complementary analyses of laws in their jurisdictions.

regulations that vary significantly between jurisdictions, remain consistent thematically. In this way, it brings together key matters to be addressed in regulatory approvals, even where approval or enforcement of subject matter may occur under different legislation in different jurisdictions.

This Guidebook has been designed to make complex technical and regulatory information accessible to the widest possible range of readers with varying understanding of hydrogen technical matters, Australian laws and regulation practices. It is structured as follows:

- Chapter 2 provides an overview of the physical properties of hydrogen and hazards that need to be managed in planning, constructing and operating a hydrogen refuelling facility. It contextualises the regulatory obligations presented in subsequent chapters by describing the key components of a typical hydrogen refuelling facility and matters relevant to their safe operation.
- Chapter 3 describes existing regulatory frameworks for safety and how they may apply to hydrogen refuelling facilities. This includes the primary and general duties established in Health & Safety Legislation adopted across jurisdictions, and specific detailed obligations established by dangerous goods, gas, electrical and other safety legislation.
- Chapter 4 describes existing regulatory frameworks for cultural heritage, environment and planning and discusses how they may apply to hydrogen refuelling facilities. This includes laws governing First Nations land tenure and cultural heritage, planning and building laws and environmental regulations (e.g. environmental impact assessments, pollution and waste).

Each chapter contains the core information considered to be of greatest relevance to hydrogen production proponents. Each chapter is then supported by a corresponding annexure with greater detail that may be of interest to a smaller subset of readers.

Annexure 5 (Hydrogen legislation summaries) is a stand-alone document³ built to accompany this Guidebook which provides a summary of the main legislation relevant to hydrogen refuelling facilities. It also identifies legislation which applies to similar industries (e.g. natural gas or dangerous goods) but doesn't apply to hydrogen and is included for awareness and completeness.

1.6 Scope of this Guidebook

1.6.1 Scope overview

This Guidebook is one in a series of National Hydrogen Regulatory Guidebooks. It provides guidance on those regulations which we have identified as being of greatest relevance to hydrogen project proponents, looking to establish and operate a hydrogen refuelling facility.

Please note, this Guidebook does not aim to provide a comprehensive account of every law which a hydrogen project proponent is required to consider when establishing and operating a hydrogen refuelling facility.

1.6.2 Operational scope of Guidebook

This Guidebook applies to hydrogen refuelling facilities that dispense hydrogen to light or heavy vehicles. Plant and equipment items commonly found in such facilities, including on-site hydrogen

³ Available on the DCCEE website

storage, that are within scope of this Guidebook are summarised in table 1.1 and described further in chapter 2.

Equipment that is outside the boundary of the facility – including processes either upstream (such as hydrogen production and delivery) or downstream (such as hydrogen use in vehicles) – are not in scope for this Guidebook.

Table 1.1: Plant and equipment and technologies covered by this Guidebook

Unit Operation	In scope	Out of scope
Hydrogen production		<ul style="list-style-type: none"> On-site hydrogen generation (refer to the hydrogen production guidebook)
Hydrogen refuelling	<ul style="list-style-type: none"> Gaseous hydrogen refuelling 	<ul style="list-style-type: none"> Liquid hydrogen refuelling
Gas storage	<ul style="list-style-type: none"> Gaseous hydrogen storage Purge gas storage 	<ul style="list-style-type: none"> Liquid or cryo-compressed hydrogen storage Solid and slurry hydrogen storage e.g. metal hydrides Liquid organic complexes Geological storage, carbon capture and storage Other novel gas storage technologies
Gas compression	<ul style="list-style-type: none"> Hydrogen compressor plant 	
Gas transport		<ul style="list-style-type: none"> Supply and distribution of hydrogen and purge gas via any transport mode (road, rail or pipeline)
Power systems		<ul style="list-style-type: none"> On-site power generation Power supply and conditioning systems Operator control room / switchroom
Liquid systems	<ul style="list-style-type: none"> On-site storage of process water and refrigerants 	
Water systems	<ul style="list-style-type: none"> Process coolers/chillers, cooling/chilled water storage and pumps 	
Other	<ul style="list-style-type: none"> Pressure relief and control valves, gas meters, analysers and detection devices 	<ul style="list-style-type: none"> Hydrogen fuelled vehicles Air ventilation systems Compressed air systems

1.6.3 Regulations not in scope of this Guidebook

As noted above, the focus of this Guidebook is on those regulations identified as being of greatest relevance to hydrogen project proponents. Through consultation with industry and regulators,

supported by expert advice, the focus of this Guidebook is the following legislative obligations: environment, planning and development, building certification, work health and safety, dangerous goods, gas and electrical safety, First Nations land rights, cultural heritage, and airports and airspace. This reflected the findings of analysis and consultation undertaken for this Guidebook which reinforced these frameworks as most important across hydrogen projects' lifecycles.

It was not possible for one Guidebook to discuss all areas of potentially applicable law. The following regulatory themes were identified as having less hydrogen specific application or less immediate need for the current stage of hydrogen industry development and therefore determined to be out of scope. Compliance requirements for these areas are likely to be more similar or more easily determined by reference to an existing analogous industry.

- Water usage approvals / licensing (e.g. ground water / surface water extraction; desalination plant approvals) – noting that water discharge / waste from water purification is in-scope
- End-use appliances consuming hydrogen
- Hydrogen as a fuel for vehicles or vessels
- Climate change-related obligations, such as emissions reporting and carbon credits
- Native vegetation clearing (and general management of forests / trees)
- Biodiversity protection / conservation
- Protected areas, heritage, and management
- Regulation of general construction activities
- Government incentive schemes
- Standard Business regulation, reporting, corporate governance and tax.

1.7 The National Hydrogen Regulatory Guidebook: Hydrogen Production

As noted above, this Guidebook provides guidance only on hydrogen refuelling facilities. The National Hydrogen Regulatory Guidebook: Hydrogen Production provides detailed guidance on hydrogen project facilities.

The Production Guidebook covers equivalent matters to this Refuelling Guidebook. However, as production involves much greater investment, a larger facility footprint and is more likely to also consider development of greenfield sites than a refuelling facility, that Guidebook also deals with additional matters such as: introducing Australia's regulatory frameworks, first nations land rights and cultural heritage, and community benefit principles.

1.8 First Nations people and hydrogen

Australia's clean energy transition – including the development of Australia's renewable hydrogen industry – requires First Nations peoples' unique and valuable contributions and strong participation to ensure its success.

This Guidebook only applies to hydrogen refuelling facilities. Due to their comparatively small footprint, First Nations and Cultural Heritage have not been addressed. Readers should refer to the National Hydrogen Regulatory Guidebook: Production Facilities for information on these areas.

This Guidebook places a strong emphasis on promoting genuine and best practice engagement by hydrogen project proponents with First Nations peoples. Over the coming decades, many renewable energy projects will need to access First Nations lands and waters for development. First Nations

peoples are stewards and custodians of Country, including the land, waters, skies and seas. This connection is ongoing and enduring. Strong, respectful, and genuine partnerships with First Nations people will be essential to progressing the renewable energy transition and achieving better outcomes.

This Guidebook and governments' wider actions to build Australia's hydrogen industry complement the First Nations Clean Energy Strategy (FNCES) that was endorsed by all governments in 2024. Developed with extensive input from First Nations peoples, the FNCES provides a national clean energy framework for governments, industries and communities and is relevant to all types of clean energy, including renewable hydrogen. It is a national framework to guide investment, influence policy, and support First Nations people to self-determine how they participate in, and benefit from, Australia's clean energy transition. Facilitating community benefits supports First Nations communities and traditional owners to participate in, and share in the benefits of, the transition to net zero.

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Chapter 2 - Technical matters relevant to hydrogen refuelling facilities

2.1 Context

This chapter 2 of this Guidebook provides technical information to assist understanding of the applicability of legislation to hydrogen refuelling facilities in Australia.

This chapter is structured as follows:

- Chapter 2.2 to 2.4 outlines the physical properties and characteristics of hydrogen
- Chapter 2.5 describes the key plant and equipment items that comprise typical configurations of hydrogen refuelling facilities, their function, operation and key design considerations
- Chapter 2.6 describes operational hazards and risks that can be present in hydrogen refuelling facilities, both on a whole-of-facility basis and for the individual plant and equipment items described in chapter 2.5
- Chapter 2.7 to 2.8 outlines safety practices and mitigations that operators can adopt to manage the hazards, including local and international standards that are relevant to safe design and operation.

Chapter 2 provides a basic level of technical knowledge necessary to engage and comply with regulatory obligations associated with a hydrogen refuelling facility. This includes a non-exhaustive list of hydrogen properties and hazards that need to be managed in a typical hydrogen refuelling facility. Where a Commonwealth, or state or territory entity has published guidance on specific hydrogen matters, proponents should also refer to those guides⁴.

2.2 Acronyms and Abbreviations (see also Annexure 1 - Technical Glossary)

AC	alternating current
AS	Australian Standard
BESS	battery energy supply system
DC	direct current
ESD	Emergency Shutdown System
FMEA	Failure Modes and Effects Analysis
HAZID	Hazard identification
HAZOP	Hazard and Operability Study
HIC	hydrogen induced cracking
HRF / HRS	Hydrogen refuelling facility/ Hydrogen refuelling facility
HV	high-voltage: a nominal voltage exceeding 1,000 V AC or exceeding 1,500 V DC
IEC	International Electrotechnical Commission
IGBT	insulated gate bipolar transistor (type of DC rectifier)
ISO	International Standardisation Organisation
LDL	lower detonation limit
LFL	lower flammability limit
MADP	maximum allowable design pressure

⁴ For example, see:

Queensland: Hydrogen Safety Code of Practice

Western Australia: Storage, handling and production of hydrogen: Guide

MUE	Material Unwanted Event
NTP	Normal Temperature and Pressure (T=20 °C 293.15 °K), 1 atm (101.325 kPa)
OEM	Original Equipment Manufacturer
P&ID	Piping and Instrumentation Diagram
PFD	Process Flow Diagram
PFD	Probability of Failure on Demand
PEM	Proton Exchange Membrane or Polymer Electrolyte Membrane
PPE	Personal Protective Equipment
PRA	Probabilistic Risk Assessment
RMS	Root Mean Square
SDS	Safety Data Sheet
SIL	Safety Integrity Level
SLD	Single Line Diagram
SOE	Solid Oxide Electrolyser
STP	Standard Temperature and Pressure (T=0 °C 273.15 °K), 1 atm (101.325 kPa)
TDS	total dissolved solids
UDL	upper detonation limit
UFL	upper flammability limit
WTP	Water treatment plant
WWTP	Waste water treatment plant

2.3 Hydrogen properties

Hydrogen has some distinctive and unique properties and characteristics that warrant special attention—these are summarised in table 2.1 . A deep understanding of these properties and characteristics is necessary to ensure the safe, reliable and compliant design, commissioning, operation and maintenance of all hydrogen refuelling facilities. It enables operational risks and hazards for a broad range of process and ambient conditions and plant operating modes to be well defined and responsibly managed and mitigated.

The coverage of this Guidebook is restricted to the use of hydrogen in its gaseous state and its diffusion through solids. Liquid, slush and hydride forms of hydrogen are not covered.

2.4 Units (see also Annexure 1 - Technical Glossary)

Unit	Unit Name	Type of Measure
A	ampere	SI unit of current
bar	bar	unit of pressure
°C	degree celsius	unit of temperature
dB	decibel	SI unit of sound
g	gram	unit of mass
h	hour	SI unit of time
Hz	hertz	SI unit of frequency
J	joule	SI unit of energy
°K	degree kelvin	SI unit of temperature
kg	kilogram	SI unit of mass
kg/m/h or cPoise or cStoke, Pa.s	kilogram per metre per hour, centipoise, centistoke, pascal second	units of viscosity

Unit	Unit Name	Type of Measure
l	litre	unit of volume
lx	lux	unit of illumination
m	metre	unit of length
m ²	metre squared	unit of area
m ³	metre cubed	SI unit of volume
mol	mole	unit of mass
% mol, % vol., % wt., mg/l	percent mole, percent volume, percent weight, milligram per litre	units of concentration or composition
N	newton	SI unit of force
N.m	newton metre	unit of torque
Pa	pascal	SI unit of pressure, stress or constraint
ppm vol, ppm mol, ppm wt.	parts per million volume/mole/weight basis	units of composition - impurities
s	second	SI unit of time
S/m, mS/cm, μ S/cm	siemen per metre, milli siemen per centimetre, micro siemen per centimetre	units of electrical conductivity
t	tonne	unit of mass
V	volt	SI unit of voltage
W	watt	SI unit of power

Table 2.1: Summary of hydrogen properties⁵ (see also Annexure 1 - Technical Glossary)

Property	Value	Description	Associated hazard/s
Size	Radius of hydrogen atom = 31 pm	The smallest sized of all elements indicating that hydrogen will readily leak or permeate unless it is effectively contained. It will slowly diffuse through the atomic matrix of many solid materials (e.g. metallic pipework, vessel walls, instruments) that can lead to varying levels of material degradation and loss of system functionality due to embrittlement, cracking and high temperature hydrogen attack.	Uncontrolled or undetected hydrogen leakage Refer to chapter 2.7.1.2
Mass	H, hydrogen atom: 1.00784 u (g/mole) or 1.67356 x 10 ⁻²⁴ g H ₂ , diatomic molecule: 2.01568 u (g/mole) or 3.34712 x 10 ⁻²⁴ g	Hydrogen has the lowest molar mass of all elements, a high diffusivity in air, high buoyancy and low viscosity compared to other gases, indicating that it will rapidly dissipate when released to the atmosphere. Hydrogen is significantly lighter than air and, if not confined, will readily dissipate away from the source of a hydrogen leak.	Uncontrolled or undetected hydrogen leakage Refer to chapter 2.7.1.2
Diffusion Coefficient	0.668 x 10 ⁻⁴ m ² /s (in excess of air) @ 1 atm, 0°C 0.756 x 10 ⁻⁴ m ² /s (in excess of air) @ 1 atm, 20°C	Along with a low mass, high buoyancy and low viscosity, hydrogen has a very high diffusivity in air compared to other gases (methane: 0.21 x 10 ⁻⁴ m ² /s, carbon dioxide 0.16 x 10 ⁻⁴ m ² /s, water vapour 0.242 x 10 ⁻⁴ m ² /s all @ 1 atm, 20°C) indicating that a hydrogen release will readily mix with and rapidly diffuse through air.	Uncontrolled or undetected hydrogen leakage, ignition and combustion Refer to chapters 2.7.1.2 and 2.7.1.3

⁵ There is some variability in the precision and consistency of quoted values for the physical properties of hydrogen in the literature. In striving towards national consistency, the hydrogen properties listed in SA TR 15916: Basic considerations for the safety of hydrogen systems are utilized in preference to other data sources.

Viscosity	0.84 x 10 ⁻⁵ Pa.s @ 0°C to 1.84 x 10 ⁻⁵ Pa.s @ 600 °C at normal pressure	Absolute (dynamic) viscosity is a measure of a fluid's internal resistance to flow and is highly dependent on temperature and less so pressure dependent. Hydrogen gas has a low viscosity compared with other gases indicating a propensity for high gas flow velocities and difficulty in containment and prevention of leakage e.g. through standard threaded and flanged joints. Absolute viscosity for other gases: methane 1.03 x 10 ⁻⁵ to 2.53 x 10 ⁻⁵ Pa.s, air 1.73 x 10 ⁻⁵ to 3.94 x 10 ⁻⁵ Pa.s and oxygen 1.95 x 10 ⁻⁵ to 4.47 x 10 ⁻⁵ Pa.s.	Uncontrolled or undetected hydrogen leakage, ignition and combustion Refer to chapters 2.7.1.2 and 2.7.1.3
Odour		No smell or odour, increasing the difficulty of hydrogen detection to human senses.	Reduced safety level due to difficulty in hydrogen detection. Refer to chapters 2.7.4.1 and 2.8.3.9
Colour		No visible colour of gaseous hydrogen at NTP to human senses increases the difficulty of hydrogen detection. Hydrogen burns with a faint flame at night and a very faint, almost invisible flame during the day. A flame of pure hydrogen is visually imperceptible under artificial light or daylight that increases the difficulty in the detection of a hydrogen fire. The visually elusive nature and potential hazards caused by the ignition of hydrogen pose additional significant detection and safety challenges and requires unique and hydrogen-specific fire protection and fire-fighting procedures.	Reduced safety level due to difficulty in hydrogen detection. Refer to chapters 2.7.4.1 and 2.8.3.9

Taste		No taste to human senses increases the difficulty of hydrogen detection.	Reduced safety level due to difficulty in hydrogen detection. Refer to chapters 2.7.4.1 and 2.8.3.9
Gravimetric Density and heating/calorific value	33.3 kWh/kg for gaseous hydrogen at NTP @ Lower Heating/Calorific Value of hydrogen (120.07 MJ/kg or 242 kJ/mol) 39 kWh/kg at NTP for gaseous hydrogen @ Higher Heating/Calorific Value of hydrogen (141.8 MJ/kg or 286 kJ/mol)	The gravimetric (mass-related) energy density of hydrogen otherwise expressed as a heating value or calorific value or heat of combustion is the highest for all common fuels. Other higher heating values (HHV) are: methane 55.5 MJ/kg, diesel 44.80 MJ/kg, natural gas 52.2 MJ/kg, ammonia 22.5 MJ/kg, propane 50.35 MJ/kg, petrol 44-46 MJ/kg. This indicates a high amount of available thermal energy upon the complete combustion of a specific mass of fuel. The build-up of temperature, pressure and thermal energy (heat) released into product gases during hydrogen combustion and the intensity of impacts in the case of a hydrogen incident is directly proportional to the gravimetric density and the heating value of hydrogen and accordingly is significantly greater than for an equivalent mass of other gases.	Heat and radiative effects Refer to chapter 2.7.1.4

<p>Volumetric Density for gaseous hydrogen</p>	<p>For hydrogen in air:</p> <p>0.08890 kg/m³ @ Standard Temperature and Pressure (STP) 0.08375 kg/m³ @ Normal Temperature and Pressure (NTP) 0.00279 kWh/l @ NTP 0.010044 MJ/l @ NTP</p> <p>For compressed gaseous hydrogen @ 350 bar and 20°C: 23.8 kg/m³ or 2.844 MJ/l</p> <p>For compressed gaseous hydrogen @ 700 bar and 20°C: 39.8 kg/m³ or 4.788 MJ/l</p>	<p>Despite having a very high gravimetric density, the volumetric density of hydrogen is extremely low compared to other fuels and gases. For example:</p> <p style="padding-left: 40px;">Air: 1.2051 kg/m³ @ NTP and 1.2932 kg/ m³ @ STP Oxygen: 1.3311 kg/ m³ @ NTP and 1.42902 kg/ m³ @ STP Natural gas: 0.7 – 0.9 kg/ m³ @ STP</p> <p>Hydrogen is compressed, liquefied or stored in solid media to achieve a practical hydrogen storage volume for both stationary and mobile/vehicular applications. The volumetric density for petrol @ 34.2 MJ/l and 35.8 MJ/l for diesel are significantly higher than that for compressed hydrogen storage at a hydrogen refuelling facility i.e. 2.844 MJ/l @ 350 bar and 4.788 MJ/l @ 700 bar.</p>	<p>Uncontrolled or undetected hydrogen leakage, ignition and combustion</p> <p>Refer to chapters 2.7.1.2 and 2.7.1.3 and 2.7.1.4</p>
<p>Minimum ignition energy</p>	<p>0.017 mJ</p>	<p>An extremely low minimum ignition energy indicates that hydrogen requires only an extremely small amount of energy to ignite (e.g. a very small spark, a hot surface, a very low level of friction or static electricity) and significantly less than for common fuels (e.g. natural gas: 0.29 mJ, propane: 0.26 mJ, petrol: 0.24 mJ). The ignition energy of hydrogen is dependent on the hydrogen concentration in the air. At low concentrations of hydrogen in air, the ignition energy required to initiate combustion of hydrogen is closer to that of other fuels.</p>	<p>Hydrogen ignition</p> <p>Refer to chapter 2.7.1.3</p>

Flammability limits	<p>Lower Flammability Limit (LFL): 4.1 % vol.% in air</p> <p>Upper Flammability Limit (UFL): 75% vol. % in air</p> <p>Lower Flammability Limit (LFL): 4.0 % vol.% in oxygen</p> <p>Upper Flammability Limit (UFL): 94% vol. % in oxygen</p>	<p>A low minimum flammability limit compared to other fuels increases the probability of hydrogen ignition. Owing to its low LFL, hydrogen ignites in air more readily than the majority of other fuels.</p> <p>Hydrogen also has a significantly wider flammability range in air compared to other fuels e.g. natural gas (5 – 15 vol. %), LPG (2.1–10.1 vol. %), petrol (1.2–7.6 vol. %) and diesel (0.6 – 6.0 vol. %). Flammability limits are dependent on system temperature and pressure.</p> <p>The formation of an explosive hydrogen-air mixture is highly unlikely under normal operating conditions as the hydrogen will generally rapidly disperse away from the point of release. The probability of reaching a 4 % concentration of hydrogen in air is increased if operating plant equipment within a building or enclosure. Hydrogen in air will not reach the HFL if handled in an adequately ventilated facility.</p>	<p>Uncontrolled or undetected hydrogen leakage, ignition and deflagration</p> <p>Refer to chapter 2.7.1.2 and 2.7.1.3 and 2.7.1.4.1</p>
Detonation limits	<p>Lower detonation limit (LDL): 18.3 vol.%</p> <p>Upper detonation limit (UDL): 59.0 vol. %</p>	<p>Hydrogen is potentially explosive and will detonate across a wider range of concentrations in air 15–59% vol. % @ STP compared to other fuels. Detonation limits are dependent on system temperature and the nature and dimensions of the confinement. The limits are extended with higher energy ignition sources. The review of combustion literature provides examples of detonations occurring as low as 11 vol. % and possibly lower. There is no standard measurement procedure for the determination of detonation limits, unlike for flammability limits.</p>	<p>Uncontrolled or undetected hydrogen leakage, ignition and detonation</p> <p>Refer to chapter 2.7.1.2 and 2.7.1.3 and 2.7.1.4.1</p>
Autoignition temperature	585 °C (858 °K) in air	<p>The autoignition temperature is the lowest temperature at which hydrogen will spontaneously ignite in the absence of an ignition source. Along with the flammability limits and ignition energy, the auto ignition temperature of hydrogen is used to characterize the circumstances</p>	<p>Hydrogen ignition</p> <p>Refer to chapter 2.7.1.3</p>

		under which hydrogen combustion can occur. Ignition temperatures are dependent on hydrogen concentration and pressure and the surface treatment of containers. The minimum autoignition temperature for hydrogen in air is generally higher than for other flammable gases and vapours (e.g. ammonia: 498 °C, methane: 537 °C, propane: 450 °C, methanol: 385 °C, petrol: 280 to 471 °C and benzene 498 °C).	
Flame temperature	<p>Adiabatic flame temperature</p> <p>2,045°C (2,318 °K) in air</p> <p>2,660°C (2,993 °K) in oxygen</p> <p>Non-adiabatic (with heat losses):</p> <p>1,800°C to 2,200°C in air</p>	<p>The flame or burning temperature is the temperature of complete combustion. It provides a measure of the heat intensity of a flame and is dependent on the source and concentration of an oxidant (e.g. air or pure oxygen). Adiabatic flame temperatures represent the theoretical maximum temperatures achieved under ideal conditions i.e. no heat loss and constant pressure. In practice, actual flame temperatures are lower than these adiabatic values due to heat loss.</p> <p>The flame temperature of hydrogen in either air or oxygen is higher than for the majority of other fuels. LPG: 1,980°C (in air), CNG: 1,960°C (in air), butane: 1,970°C (in air), methane: 2,810°C (in oxygen), 1,957°C (in air), natural gas: 2,770°C (in oxygen) and propane: 2,820°C (in oxygen), 1,980°C (in air).</p>	<p>Heat and radiative effects</p> <p>Refer to chapter 2.7.1.4</p>
Burning or flame velocity (maximum)	<p>2.55 m/s in air @ 29.4% vol. of hydrogen</p> <p>3.25 m/s in air @ 40.1% vol. of hydrogen</p> <p>11.75 m/s in pure oxygen</p>	<p>A very fast laminar burning velocity in air compared with other fuels (methane: 0.05-0.37 m/s, propane: 0.18 - 0.40 m/s). Burning velocities are dependent on pressure, temperature and mixture composition. The high burning velocity of hydrogen indicates its high explosive potential and short burn period for an equivalent mass of conventional fuels and increased difficulty of confining or arresting hydrogen flames and explosions. A hydrogen jet fire will have approximately one third of the duration compared to a methane / natural gas jet fire.</p>	<p>Uncontrolled or undetected hydrogen leakage, ignition and deflagration or detonation</p> <p>Refer to chapter 2.7.1.2 and 2.7.1.3 and 2.7.1.4.1</p>

Thermal Conductivity	0.1805 W/m.K (at NTP) 8.813 x 10 ⁻⁵ g/cm-s (at NTP)	The highest thermal conductivity of any gas or vapour and much higher than all other common gases (for which the thermal conductivity lies between 0.01 and 0.03 W/m.K @ 20°C). The design of all gaseous hydrogen storage, handling and transport systems and process streams must therefore account for the rapid transfer of heat via conduction of gaseous hydrogen.	Heat and radiative effects Refer to chapter 2.7.1.4
Reverse Joule-Thomson Effect	200 °K (-73°C)	Under most operating conditions hydrogen displays a Reverse Joule-Thomson Effect. At room temperature and atmospheric pressure, hydrogen warms up when it expands through a throttle or valve. That's because its inversion temperature the point below which it cools upon expansion is around 200 K (-73 °C). Only hydrogen and helium display a reverse effect at normal operating conditions.	Hydrogen ignition Refer to chapter 2.7.1.3

2.5 Summary of plant and equipment of a nominal hydrogen refuelling facility

This section provides a summary of the function and operation of plant and equipment items that are commonly found in refuelling hydrogen facilities (see chapter 1.6.2, table 1. 1 for complete list).

Annexure 2 provides more detailed technical information regarding these plant items.

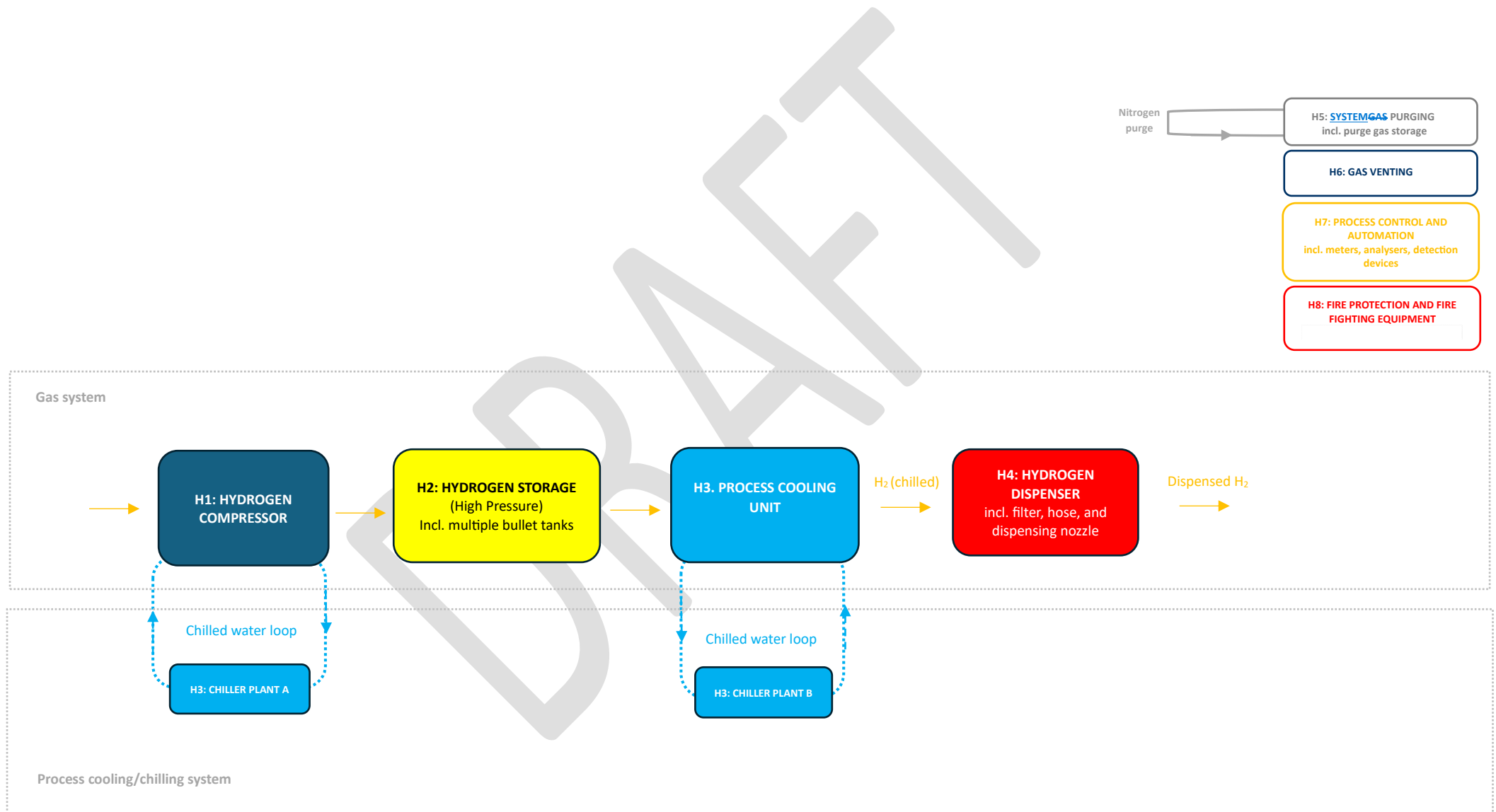
2.5.1 Plant diagrams for nominal hydrogen refuelling facilities

Figure 2.1 provides a simplistic, generic diagram of nominal hydrogen refuelling plant configurations / layouts. They provide an indicative or commonly used configuration/layout for the integration of key plant and equipment items but do not include all plant and equipment items. Chapter 2.5.2 provides a brief summary of the key plant and equipment items that comprise this common facility configuration, and focusses on items which typically carry the most significant hazard, risk and safety implications.

The configuration/layout of hydrogen refuelling facilities varies on the basis of OEM and technology specifications, plant footprint, the co-location and interdependency with other adjacent facilities and economic and environmental considerations. Facilities will also differ on the basis of the technologies deployed.

The key plant items for a nominal refuelling plant, denoted H1 – H8, are listed in table 2.2. Standard mechanical and electrical equipment that has been utilised across process industries for many years and for which there exists adequate regulatory coverage are not the key focus of this Guidebook and therefore not included in the diagrams.

Figure 2.1 Schematic representation of a generic hydrogen refuelling plant



2.5.2 Technical aspects of plant and equipment of a nominal hydrogen refuelling facility

This section provides a summary of the function and operation of plant and equipment items that are commonly found in hydrogen refuelling facilities servicing light or heavy duty vehicles (see chapter 1.6.2, table 1.1 for complete list). Annexure 3 provides more detailed technical information regarding these plant items.

2.5.3 Plant overview for a nominal hydrogen refuelling facility

Figure 2.1 (above) provides a simplistic, generic diagram of a nominal hydrogen refuelling facility. It provides an indicative or commonly used configuration/layout for the integration of key plant and equipment items but does not include all plant and equipment items. Chapter 2.6.2 provides a brief summary of the key plant and equipment items that comprise a hydrogen refuelling facility of the most technologically mature and commercially available hydrogen refuelling technologies. This Guidebook focusses on plant and equipment items with the most significant hazard, risk and safety implications.

The configuration/layout of hydrogen refuelling facilities may vary based on OEM and technology selection, plant footprint, the co-location and interdependency with other adjacent facilities and economic and environmental considerations. Plants will also differ on the basis of the technologies deployed for process cooling and chilling, hydrogen storage and compression and inclusion of a dedicated, on-site electrolyser or other hydrogen production plant for hydrogen supply.

The key plant items for hydrogen refuelling facilities, denoted H1 – H8, are listed in table 2.2. Standard mechanical and electrical equipment that have been utilised across process industries for many years and for which there exists adequate existing regulatory coverage are not the key focus of this Guidebook and therefore not included in the diagrams. These common plant items include process pumps, fans, switchboards, control rooms, instrumentation and controls, meters, analysers, detection devices, valves, condensate traps, chemical and water stores, drainage systems and air ventilation systems. While important at a whole-of-facility level (and therefore relevant to the safety measures discussed in chapter 2), summary descriptions of these plant and equipment are not included here.

The upstream plant boundaries or battery limits for the hydrogen refuelling facility are the hydrogen supply stream into low and/or high pressure hydrogen storage vessels.

Table 2.2: List of key plant items for a nominal hydrogen refuelling facility

Nominal Plant Item	Summary description	Additional detail
H1: HYDROGEN COMPRESSOR	2.6.2.1	Annexure 2, 2.2.1
H2: HYDROGEN STORAGE	2.6.2.2	Annexure 2, 2.2.2
H3: PROCESS COOLERS/CHILLERS	2.6.2.3	Annexure 2, 2.2.3
H4: HYDROGEN DISPENSER	2.6.2.4	Annexure 2, 2.2.4
H5: SYSTEM PURGING	2.6.2.5	Annexure 2, 2.2.5
H6: GAS VENTING	2.6.2.6	Annexure 2, 2.2.6
H7: PROCESS CONTROL AND AUTOMATION	2.6.2.7	Annexure 2, 2.2.7
H8: FIRE PROTECTION AND FIREFIGHTING EQUIPMENT	2.6.2.8	Annexure 2, 2.2.8

2.5.4 Key plant and equipment items of a nominal hydrogen refuelling facility

2.5.4.1 Plant Item H1: HYDROGEN COMPRESSOR

A hydrogen compressor is a mechanical device that safely and reliably increases the pressure of hydrogen by reducing its volume and results in compressed hydrogen with a higher volumetric density. A desired flow rate of hydrogen can be achieved with the use of a variable speed drive (VSD) that varies the flow rate based on the suction pressure of the hydrogen supplied from a hydrogen storage vessel.

A hydrogen compressor package will feature multi-stage, reciprocating compressors that are powered by electrical motors. Two-stage positive displacement diaphragm compressors are commonly used to achieve the high grade of hydrogen at a hydrogen refuelling facility. Reciprocating piston compressors are also commercially available as either oil-lubricated or non-oil lubricated types. Non-lubricated compressors avoid oil contamination of the hydrogen stream and are therefore preferred for high pressure, high purity applications.

The heat of compression generated during hydrogen compression is removed via intercoolers, that are normally of the shell-and-tube type of heat exchangers. The final cooling stage is supplied by the compressor aftercooler/scrubber, that reduces the temperature of gas exiting the compressor.

Hydrogen refuelling plants should utilise two or more sets of compressors given the critical role of hydrogen compression to the hydrogen filling process.

2.5.4.2 Plant item H2: HYDROGEN STORAGE

Depending on the refuelling facility's design and fuelling requirements (delivery pressure, number and type of vehicles to be refuelled), one or more (or a "bank") of bullet tanks are used to store hydrogen at a hydrogen refuelling facility. They reliably and safely store high pressure hydrogen within the specified operating conditions (volume, pressure and temperature) with no leakage. Plant item H2 is a representation of a combined configuration of these tanks.

The storage system bank is normally operated with either two or three stages of "cascade filling" that ensures the supply of hydrogen at a pressure that is sufficient to fill the on-board hydrogen storage tank of the hydrogen vehicles (service pressure). The number of tanks varies and is largely dependent on the type of hydrogen vehicles that the facility is designed to service. A high pressure tank is operated at close to 400 bar to fill hydrogen vehicles at 350 bar. Similarly, a high pressure tank will be operated at close to 900 bar to fill hydrogen vehicles at a 700 bar facility. Many hydrogen refuelling facilities provide dual pressure dispensing at both 350 and 700 bar for the filling of both light and heavy duty vehicles. Some hydrogen refuelling facilities will include a third storage tank that is operated at an intermediate pressure e.g. 500 bar for a 700 bar facility.

The storage system includes pressure gauges, a hydrogen and purge gas vent systems and isolation valves to enable the facility to be shut down for maintenance or inspection. The storage is controlled by specially designed valves, fittings and electrical controls designed to regulate pressure and interact with the dispenser and hydrogen vehicle as needed. A fail-safe emergency isolation valve shall interrupt the hydrogen flow to the compressor in case of an off-specification event and must be located as close as possible to the high pressure storage system.

2.5.4.3 Plant Item H3: PROCESS COOLERS / CHILLERS

This plant item covers all process cooling and chiller systems of the hydrogen refuelling facility inclusive of the pre-cooling unit. Refrigeration or “chiller” packages provide chilled water to cool the hydrogen gas.

The chiller functions are:

- Chiller A: Removes the heat generated throughout the compression process to ensure the compressor (including after-cooler) is maintained within ideal temperature and pressure design limits.
- Chiller B: A pre-cooling and chiller unit generates chilled water to enable the controlled cooling of the hydrogen to approximately -40°C to ensure fast and efficient transfer of hydrogen to the on-board vehicle tank.

The continuous monitoring and control of heat across the facility serves to minimize the time for filling and avoids the overheating or overfilling of the vehicle’s on-board gaseous hydrogen storage tank. The process cooling unit and chillers are standard process equipment items that are commonly used across many commercial and industrial plants.

Components of the chilled water systems include: chiller unit/refrigeration package, chilled water circulation pumps, an expansion vessel and insulated piping.

While the chiller plants are essential components of a hydrogen refuelling facility, they are not particular or unique to such facilities. There is experience across industry and regulatory agencies in considering the hazards, risks and safety implications of most components of the process cooling and chilling plants. As such, this Guidebook acknowledges the essential role that these systems play at a facility-level, but does not focus on operational hazards and safety measures for these systems at a plant and equipment level.

2.5.4.4 Plant Item H4: HYDROGEN DISPENSER

The function of the hydrogen dispenser is to safely and reliably transfer hydrogen from the refuelling facility to the hydrogen vehicle at a set service pressure in accordance with a specified hydrogen fuelling protocol.

To dispense hydrogen, the user connects a dispensing nozzle to the vehicle and then presses the vehicle fill button on a bowser. The hydrogen is transferred from the chiller plant, through a hose, the nozzle and into the hydrogen storage tank of the vehicle. The dispensing nozzle is fitted with a barrel that fits tightly onto the vehicle receptacle.

The filling process is an automated one, governed by a hydrogen fuel controller that communicates between the hydrogen compressor and a pressure control valve (PCV). The pressure ramp rate and mass flow rate of hydrogen that is delivered to the vehicle tank is controlled by and dependent on the service pressure and the temperature of hydrogen in the vehicle tank.

The vehicle and the hydrogen refueller use a standard based protocol to communicate with one another and perform pre-fill safety checks, including a connection seal check. Only after all the checks are completed will the refueller start the fuelling stage. The plant control and automation system for the facility constantly monitors the filling process.

At the completion of the refuelling process, the user lifts a handgrip latch that unlocks the nozzle enabling it to be returned to the holder. The hydrogen fuel controller will then disable the vehicle from any further filling.

2.5.4.5 Plant Item H5: SYSTEM PURGING

The circulation of an inert gas such as nitrogen is commonly utilized to purge/flush the piping systems to remove any excess water, impurities and contaminants that may accumulate within the piping systems of a hydrogen refuelling facility. The circulation of an inert gas such as nitrogen is commonly utilized to perform the purge for gaseous hydrogen systems. The regular purging of hydrogen lines ensures that the hydrogen is maintained to the specified high grade or purity that is required for fuel cell vehicle operation.

Purging is required upon start-up of the refuelling facility, before the plant is taken offline for maintenance and immediately after any extended period that the facility is not operated. The purging system includes a storage tank and compressor for the circulation of the purge gas.

2.5.4.6 Plant Item H6: GAS VENTING

Gas venting is a common industrial process safety measure to enable the controlled release of hydrogen overpressures and spent purge gas during normal operation, maintenance, purging and emergency stops. Vent systems include pressure relief valves, pressure relief lines and vent headers for the collection of hydrogen streams before they are discharged to the atmosphere. Any spent purge gas can be discharged in combination with the vented gases.

It is imperative to prevent the backflow or infiltration of excess air that may give rise to an ignitable, stoichiometric mixture of hydrogen and air. Check valves or molecular seals can also be used to restrict the backflow of air. The positioning of vent headers for the release of hydrogen and oxygen streams should be based on a calculated minimum separation distance. Vents are generally positioned above or adjacent to hydrogen storage vessels, compressor and dispenser.

Any form of blockage, restriction or obstruction to the venting process including ice formation must be avoided as this may lead to undesired levels of hydrogen within plant equipment items and process lines.

CGA G-5.5 is a standard from the Compressed Gas Association that provides detailed design guidelines for safe hydrogen venting systems, particularly at user sites. It focuses on the controlled and predictable discharge of hydrogen from safety devices and other components, ensuring concentrations remain below the lower flammable limit. While not mandated in Australia, adopting it aligns with international best practices for hydrogen safety.

2.5.4.7 Plant Item H7: PROCESS CONTROL AND AUTOMATION

The function of a process control and automation system is to ensure all plant equipment items are safely and reliably operated across all plant operating and ambient conditions in keeping with all technical specifications and functional descriptions of the plant and plant items. This includes the control, monitoring and recording of a broad range of process variables including: hydrogen operating pressure, temperature, humidity and flow rates, pH of fluids, the supply of electricity and circulation of chilled water and refrigerant.

The plant control and automation system controls and monitors the hydrogen refuelling plant and the vehicle filling process. The hydrogen refuelling process is powered, monitored and controlled via the electronic control panel that should be located in a non-hazardous zone. The vehicle and the hydrogen dispenser use a standard based protocol to communicate with one other and perform pre-fill safety checks, including a connection seal check. Only after all the checks are completed will the refueller commence the fuelling stage.

An important control for larger facilities is that the system is designed to shutdown and isolate as appropriate. System isolation breaks up the inventory into smaller segments which means less hydrogen is available to be released from a leak.

Various instruments including: hydrogen meters, sensors/detectors and analysers are used to provide accurate and reliable power, hydrogen and water measurement and detection capability across all plant items. A key feature of a hydrogen refuelling facility are the specially designed, hydrogen-compatible valves and fittings that control the flow of high pressure hydrogen.

2.5.4.8 Plant Item H8: FIRE PROTECTION AND FIRE-FIGHTING EQUIPMENT

Specific fire protection and fire-fighting equipment is required to protect the electrolyser plant operators, contractors and emergency responders, plant assets and the surrounding environment.

The design of a firefighting system for a hydrogen refuelling facility should address the specific fire hazards associated with the storage and handling, compression, dispensing and venting of gaseous hydrogen. Firefighting for any hydrogen facility presents specific challenges due to the unique physical properties and specific hazards of hydrogen that

require specialized firefighting techniques and equipment. Fire-fighting equipment should be strategically placed throughout the facility to ensure that all high-risk and hazardous areas are accessible in the event of a hydrogen fire.

Fire walls can be incorporated as passive safety measures to mitigate the risks associated with potential fire incidents at hydrogen refuelling facilities. These structures are strategically positioned to resist the spread of flames and radiant heat between hazard zones. Fire walls act as thermal shields, containing localized ignition and allowing additional response time during emergencies. To ensure both protection and operability, fire walls should be constructed from non-combustible, heat-resistant materials and designed with features that permit safe and efficient access to plant components when maintenance or removal is required.

Proponents should include passive fire protection including compartmentation and isolation, as well as fire and blast protection

Key firefighting equipment items include fire hydrants, hose reels, fire monitors and water pumps and storage vessels.

Facilities storing or producing H₂ may be required to seek written advice from the relevant fire authority relating to fire systems and emergency response plans (refer to chapter 3).

2.6 Hazards

This chapter outlines a range of potential hazards that can be present in hydrogen facilities. Hydrogen facilities involve a range of potential hazards, both at a facility level and in the operation of individual items of plant and equipment. This reflects both the physical properties of hydrogen, as outlined in chapter 2 but also the operating conditions of plant and equipment items used in a hydrogen refuelling facility, particularly those that are operated at higher pressures and temperatures. Not all hazards are of equal likelihood and some hazards described in this Guidebook are rare or may only occur in certain environmental conditions.

Importantly, the risks associated with hazards relating to hydrogen are entirely manageable through appropriate facility design and practices. For example, regardless of hydrogen quantity, hydrogen systems and operations can manage important hazards by providing adequate ventilation, designing and operating hydrogen plants to prevent hydrogen leakage and the uncontrolled mixing of hydrogen and oxidants, and eliminating potential ignition sources. Measures or actions that facility operators can take to manage risks are further discussed in chapter 2.

Australia already safely produces and uses hydrogen, ammonia and other hazardous materials. The capabilities, knowledge, experience and safety practices developed through operating and safely regulating existing industries will be a foundation for managing risks and hazards from the growing hydrogen industry (while recognising that regulatory frameworks and agency resources will need to be continuously reviewed and adapted as the industry scales up).

Further detail regarding operational hazards for different items of plant and equipment of hydrogen refuelling facilities are provided in Annexure 2.

Please note that while care has been taken to identify and describe all risks and mitigations, this has been provided for educational purposes and should not be relied upon as a replacement for advice from an appropriate expert.

2.6.1 Hydrogen-specific hazards

2.6.1.1 Material degradation

As hydrogen is the smallest and lightest of all elements it has a propensity to diffuse and permeate through the atomic matrix of solid materials that are used in hydrogen plants or equipment, including the metallic walls of containment vessels, pressurised piping, valves and other plant instruments in contact with hydrogen. Sustained exposure to even small amounts of hydrogen can have a detrimental impact on the physical and structural properties (e.g. strength, carbon content) of these materials. The degradation of hydrogen containment materials of hydrogen plant and equipment can lead to sudden and brittle fractures and cracks, the uncontrolled and potentially hazardous release of hydrogen and failure of pressurised components. The type, extent and speed of degradation (as expanded on below) depends on the material type, composition, physical properties, operating and environmental conditions (e.g. hydrogen pressure and temperature) and the mechanical loading on the material.

2.6.1.1.1 Hydrogen embrittlement of metals

The sustained exposure of a material to hydrogen, and specifically, the interaction of monatomic hydrogen within metallurgical features such as defects and grain boundaries, can lead to the embrittlement of the material. This can significantly reduce the tensile strength, ductility, fatigue (stress and strain) resistance and fracture resistance of the material. Embrittlement can result in both crack nucleation and propagation of a crack through the containment material. Given the extremely small size of a hydrogen atom, it can readily react with a metal or rapidly diffuse to the outside surface and cause a hydrogen leak. The extent of hydrogen embrittlement is dependent on material variables (e.g. nickel content in austenitic stainless steels, material strength and presence of welds) and primary mechanical variables (e.g. constant stress versus cyclic stress, the magnitude of constant stress or cyclic stress amplitude).

2.6.1.1.2 Hydrogen induced cracking

Hydrogen induced cracking (HIC) is a complex phenomenon involving several steps:

- 1) Hydrogen uptake: hydrogen from the environment enters the material
- 2) Hydrogen diffusion: hydrogen diffuses through the material, accumulating at microstructural inhomogeneities and defects (e.g. manufacturing flaws on component surfaces)
- 3) Hydrogen precipitation: at high hydrogen concentrations, absorbed hydrogen atoms recombine to form hydrogen molecules and increase the pressure within the material

- 4) Crack initiation and growth: pressure increases from hydrogen precipitation can lead to the formation of cracks within the structure of the material.

Stress-oriented HIC (SOHIC) is a special type of HIC that occurs in high residual or applied stress fields. It results in the formation of several HIC cracks in a material and therefore presents a more serious hazard than HIC.

2.6.1.1.3 High temperature hydrogen attack

High temperature hydrogen attack (HTHA) can occur in materials such as steels at elevated temperatures (>200°C) and pressures from the ingress of hydrogen reacting with dissolved carbon and metal carbides to form methane gas in the metal.

2.6.1.2 Hydrogen leakage

In order to operate hydrogen plant equipment within normal design limits, it is a standard industry practice for hydrogen to be released to the atmosphere from pressure relief valves and process vents. These are “primary grade” releases where the intentional and controlled release of hydrogen can be expected to occur periodically or occasionally during normal operation. The identification and mitigation of hydrogen hazards associated with the operation of all hydrogen plants focus on uncontrolled “secondary grade” releases of hydrogen that are not expected to occur in normal operation and, if they do occur, they are likely to do so infrequently and for short periods.

There are many potential sources of secondary grade releases including flange joints, valve stems, diaphragms, gaskets, seals, fittings, threaded joints and connections between instruments and piping. The majority of hydrogen leaks are caused by deformed seals or gaskets, valve misalignment or failures of flanges or equipment. Secondary grade releases also include hydrogen leaks that result from the material rupture of process equipment such as from a torn membrane of an electrolyser cell or the bursting of a containment vessel. Most of the leak sources for hydrogen facilities are the same as any other gaseous industry.

Hazards analyses for any hydrogen plant will assess the impacts of both primary and secondary releases of hydrogen that will have different physical characteristics such as temperature, velocity and release direction. Sophisticated and complex numerical modelling and analytical techniques such as Consequence Analysis, are used to characterise these hydrogen releases under a range of process and ambient conditions and develop mitigation measures to avoid these hazards from occurring.

Under specific pressure and flow conditions and the influence of initial momentum, a hydrogen leak may create a hydrogen jet stream that can transform into a hydrogen plume or cloud that will tend to float vertically due to its aerostatic buoyancy. The combined physical effects of wind, momentum and buoyancy-controlled flow will dictate the nature and characterisation of the jet flow and the rate of molecular diffusion of hydrogen in air and hence the probability of forming an ignitable hydrogen-air mixture and a flammable and potentially explosive atmosphere.

In a confined space or enclosure, a hydrogen-air mixture will converge at the top of the available volume and may increase in concentration of hydrogen allowed to accumulate in a restricted pocket of the confined space. This increases the probability of creating a potentially explosive mixture of hydrogen in air and presents an extreme hazard. Confined spaces in hydrogen facilities like enclosures and ducts present elevated explosion risks due to poor ventilation and hydrogen's tendency to rise and accumulate. AS/NZS 60079.10.1 provides the framework to classify these spaces as Zone 0, 1, or 2, based on:

- Source and grade of release (e.g., valves or flanges leaking gas)
- Ventilation effectiveness (low, medium, high dilution)

In confined spaces, dilution is often limited, increasing the likelihood of higher zone ratings. Proper classification is crucial for selecting equipment, designing ventilation or purge systems, and installing hydrogen gas detectors. This zoning process ensures ignition sources are properly managed making confined hydrogen installations safer.

Although hydrogen is a highly flammable substance, the probability of the hydrogen concentration of a hydrogen-air mixture reaching the LFL of hydrogen in an open space is low owing to the very high dispersion rate or diffusion of hydrogen in air. As a hydrogen leak disperses away from the release point, any initial momentum will eventually subside until the hydrogen leak moves passively with the prevailing flow of wind or mechanical ventilation. The rate of dispersion and dilution is dictated by the mass flow rate of the leak, the temperature and gravimetric density of the hydrogen cloud, obstructions, meteorological conditions and terrain. Both natural and mechanical forms of ventilation will accelerate the dilution of the hydrogen and in the majority of cases will keep the concentration of hydrogen below its LFL.

2.6.1.3 Hydrogen ignition

It is important to understand the difference between the ignition, combustion, deflagration and detonation of hydrogen to define the likelihood, magnitude and impact of hazards and the corresponding mitigation measures.

Ignition is the process of providing the necessary energy required to initiate the formation of a flame that occurs when a fuel reacts with an oxidant (e.g. oxygen that is present in a gaseous mixture such as air). This process requires a minimum amount of energy referred to as the ignition energy to initiate the formation of the flame.

A hydrogen plume will ignite when the burning condition is satisfied, that is the hydrogen concentration of a hydrogen-air mixture lies within the LFL and UFL of hydrogen in air being between 4 and 72.5% vol and encounters the smallest possible ignition energy (0.017 mJ).

It can be reasonably expected that the majority of hydrogen leaks that form a hydrogen cloud with a hydrogen concentration above the LFL of hydrogen will ignite, owing to hydrogen's extremely low ignition energy and the many potential sources of ignition energy. These sources can include flames, hot surfaces, incandescent material, electrical and

mechanical impact sparks, static electricity, shearing contact and friction from the gentle rubbing of surfaces or even a rapidly moving gas and a hard surface. It is therefore imperative to heavily focus on the prevention of hydrogen releases as a key mitigation measure for any hydrogen facility.

2.6.1.4 *Hydrogen combustion*

Combustion is a general term that encompasses all types of fuel burning in the presence of an oxidant such as oxygen and produces a flame that will release varying levels of thermal energy as heat or radiant energy. When ignited, a hydrogen-air mixture will undergo rapid combustion and proceed to burn in two different combustion (or reaction) modes: deflagrations that include flash fires and jet fires, and detonations. Both are types of explosions that produce shock waves based on the speed of the combustion. Burning modes present primary hazards for all hydrogen plants and differ in terms of their physical properties and characteristics, intensity and potential impact.

2.6.1.4.1 *Fire*

The speed of a hydrogen combustion zone or the propagating hydrogen flame of a hydrogen fire travelling through a space of air dictates the burning mode that will follow hydrogen ignition. Hydrogen fires range from microflames with a mass flow rate of 10^{-9} kg/s to high mass flow rate flames (hundreds of kg/s). Hydrogen releases may burn as laminar diffusion or turbulent non-premixed flames depending on the Reynolds number (Re) at the release point of a hydrogen leak.

The flame characteristics of a hydrogen fire (shape, length, height, radiative heat flux, radiant fraction and surface emissive power) will largely depend on the mass flowrate of the hydrogen and the composition and temperature of the product gas. The presence of obstacles, surfaces, enclosures and barriers in the path of the combustion zone will have a significant impact on the nature and direction of the jet flame and its potential impact. Energy in the form of heat is transferred into product gases and increases their temperature relative to the temperature of the reactant gases.

The flame temperature for hydrogen is relatively high at between 1,800°C and 2,200°C in air indicating that a hydrogen fire burns at a very high temperature. Hydrogen combustion can result in the local heating and damage of surfaces in the vicinity of a hydrogen fire. Exposure to hydrogen flames, hot air or radiant heat fluxes can result in first, second or third degree burns to operators and other plant personnel.

Compressed hydrogen under specific temperature and pressure conditions and when mixed with an oxidant can also undergo autoignition, a phenomenon where a gaseous fuel is spontaneously ignited in the absence of an ignition source. The autoignition of gaseous hydrogen can only occur when the hydrogen-air mixture exceeds the hydrogen autoignition temperature of 585°C in air.

A source of oxygen in the vicinity of the hydrogen plume will significantly increase the propensity for the combustion of a hydrogen-air gas mixture. No mixture of hydrogen, air

and nitrogen at NTP conditions will propagate flame if the mixture contains less than 5 % by volume oxygen.

2.6.1.4.2 Hydrogen deflagration

Deflagration is the phenomenon of a combustion zone and flame propagating at a velocity lower than the speed of sound (sub-sonic) typically below 100 m/s. The main mechanism of combustion is propagation of a flame front that moves forward through the gas mixture. The reaction zone (chemical combustion) progresses through the medium by processes of diffusion of heat and mass.

Deflagrations in the open air and in the absence of any obstacles (generally called flash fires), can generate overpressures (pressure above atmospheric pressure) of approximately 0.1 bar. Deflagrations in enclosures and/or confined or congested spaces can lead to more significant overpressures with uniform growth in pressure.

Under certain conditions, mainly in terms of geometrical conditions (such as partial confinement and many obstacles in the flame path that cause turbulent flame eddy currents), a subsonic flame front may continue to accelerate to supersonic speed, transitioning from deflagration to detonation. Deflagration-to-detonation transition (DDT) can be completed within a few seconds.

A deflagration will continue to build in strength as long as there is remaining fuel and congestion. Once the congestion is removed the deflagration will lose strength rapidly.

2.6.1.4.3 Hydrogen detonation

Detonation is the phenomenon of a reaction zone of chemical combustion, consisting of a co-incident flame front and self-driven shock or blast wave, propagating at a velocity higher than the speed of sound (supersonic), ranging from 1,600 to 2,000 m/s. The chemical reaction is initiated by compressive heating that is caused by the shock wave. The main mechanism of hydrogen detonation propagation is a powerful pressure wave that compresses the unburnt hydrogen-air mixture ahead of the wave to a temperature above the autoignition temperature of hydrogen (585 °C in air). The overpressure at the detonation front is typically higher than that of deflagration and can range from 10 to 20 bar.

The shock wave of a detonation travels at a constant speed and maintains its intensity as it moves through or around the impacted structures. This uniform propagation allows the detonation to maintain its destructive force over a significant distance. The rapid release of energy generated by both the flame front and the shock wave of a hydrogen detonation can result in significant damage and harm including the destruction of plant equipment and structures and severe personal injury and death of operators.

The differences between deflagration and detonation are summarised in table 2.3.

Table 2.3: Summary of the attributes of deflagration and detonation

Attribute	Deflagration	Detonation
Definition	Slow combustion with subsonic flame propagation	Rapid combustion with supersonic flame propagation
Speed of flame propagation	Subsonic, < 100 m/s	Supersonic, 1,600 to 2,000 m/s
Shockwave formation	No shockwave formation	Shockwave formation
Pressure rise	Lower but still potentially damaging.	High pressure rise, 10 to 20 bar
Temperature rise	Lower temperature rise	Higher temperature rise
Flame front	Smooth and gradual flame front	Sharp and abrupt flame front
Propagation mechanism	Heat conduction and convection	Shockwave compression and heat transfer

2.6.1.5 Convective and radiative thermal effects

A substantial release of thermal radiation from a hydrogen jet fire will present a serious hazard to operators and emergency first responders, particularly as a hydrogen fire is undetectable and non-visible by the human eye.

The radiative heat flux outside of a burning hydrogen flame has been reported as ranging between 10 and 40 W/m² and is dependent on the mass of hydrogen, the amount of water vapor in the atmosphere, view factors for surfaces and the distance from a shock wave. The convective thermal flux is similar in a hydrogen jet fire compared to that for other gases (e.g. methane / natural gas jet fires).

Although hydrogen jet fires do not have the presence of carbon to increase thermal radiation as for carbon based fuels, the fraction of heat radiated from hydrogen and natural gas jet fires with the same size, pressure and aperture size have been reported as comparable. Hydrogen jet fires with velocities of 1 kg/s and 7.5 kg/s (that are equivalent to natural gas jet fires of 3 kg/s and 22.5 kg/s) result in heat radiation fractions of 0.12 and 0.19.

2.6.1.6 Over-pressure

The hydrogen over-pressure hazard for the purposes of this Guidebook is defined by an uncontrolled exceedance of maximum allowable design pressure (MAWP) for a plant item but where hydrogen ignition does not occur.

The maximum operating pressure bullet tanks of a hydrogen refuelling facility can be up to 1,000 bar. This is much higher than the operating pressure of common industrial plants that either produce or consume hydrogen such as steam methane reformers (25-30 bar), Haber process for ammonia production (150-300 bar) and hydrocrackers for the catalytic cracking of heavy hydrocarbons (30-70 bar). In order to maintain a high level of safety and reliability,

it is essential that the operating pressure of hydrogen plants remains below the MAWP and within other specified operating conditions as stipulated by OEMs.

The over-pressure of hydrogen can cause a rapid increase of hydrogen pressure within a process stream (e.g. the outlet of a hydrogen compressor or a secondary grade release from a small aperture or hole in piping or the wall of a containment vessel). Over-pressure in a confined space, such as a storage vessel or a blocked vent, can also lead to ignition if the hydrogen is not released in a controlled and unrestricted manner. Over-pressure can also lead to leaks or ruptures in pipes and tanks and make routine maintenance and inspections more dangerous (e.g. filter changes).

An over-pressure condition for hydrogen or oxygen can also cause incidents such as projectiles and hose whipping that can be a significant hazard for operators and vehicle owners of a hydrogen refuelling facility.

2.6.1.7 Hydrogen reactivity

Although hydrogen in its purest form is not toxic nor a carcinogen, it is highly reactive with numerous compounds and most elements. At room temperature, the rate of reactivity is slow and negligible, however, at high temperatures, the rate of reaction is extremely elevated. Given its high reactivity, hydrogen has a high potential to react with a broad range of air-borne contaminants, organic substances and dust, and potentially produce a toxic gas. As a hydrogen fire will burn at a high burning temperature, the formation of a toxic gas is a potential hazard that should be considered in any HAZOP study.

As noted above, a hydrogen fire often burns invisibly particularly during daylight. This can be a hazard for people trying to evacuate and for first responders.

2.6.2 Additional hazards of a hydrogen refuelling facility

Hydrogen refuelling facilities involve a range of potential hazards, both at a facility level and in the operation of individual items of plant and equipment. This reflects both the physical properties of hydrogen, as outlined in chapter 2.2, but also the operational environment associated with electrical and gas equipment and pressure vessels.

2.6.2.1 High pressure operation and leakage

Higher pressure operation (of up to 1,000 bar) and the high frequency of hydrogen transfers across a hydrogen refuelling facility increase the probability of hydrogen leakage and ignition.

Transfers operations include from delivery tanker into storage tanks, from compressor to storage tanks, between low, medium and high pressure storage tanks, each time the hydrogen is dispensed into a vehicle tank and during repair or maintenance works. Hydrogen transfer operations are performed using both automated and manual actions and through the use of flexible/mobile components that must be compatible for high pressure hydrogen service.

2.6.2.2 *Nozzle-receptable connection freezing*

Water vapor in a high humidity atmosphere can freeze around the nozzle-receptacle connection at low pre-cooling temperatures for hydrogen transfer to the vehicle tank (-40°C). This will prolong the fuelling time and can prohibit the decoupling of the connection after a vehicle refuel. The probability of material degradation and hydrogen leakage from the dispensing apparatus subject to extended or repeated periods of freezing is low. However, any physical contact between the ice that is formed over the connection and a plant operator or vehicle owner could result in various degrees of cold burns. The process of ice removal from the connection presents a similar operational hazard.

2.6.3 **General hazards**

2.6.3.1 *Equipment failure*

- power and electrical equipment failure
- mechanical equipment failure e.g. pumps and compressors
- instrument and device failure e.g. temperature probes, pressure gauges, pressure regulators, meters, analysers, detection devices.

2.6.3.2 *Other general hazards*

Other general hazards that can affect the safe and reliable operation of the facility but are not specific to the design and operation of a hydrogen plant include:

- interruptions to the purging systems (for example, due to interruptions to purge gas supply in the hydrogen lines)
- inadequate or poor facility design (for example, lack of consideration of safety hazards applicable to hydrogen, or inadequate safety measures across all process and ambient conditions)
- inadequate scope and response time of an automation and control system and instruments
- inadequate or lack of hydrogen or oxygen monitoring
- operator/human error: inadequate scope and frequency of maintenance and servicing e.g. lack of regular instrument calibration, incorrect equipment installation and operation

2.7 **Safety principles, governance and assessment**

2.7.1 **Accident prevention and preparedness - OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response - Third Edition**

As outlined in chapter 3, all hydrogen facilities are subject to regulatory obligations requiring the assessment and management of safety hazards and risks.

Where a facility meets the definition of a Major Hazard Facility (MHF), work health / operational and safety laws mandate specific requirements for addressing safety risks and MHF proponents or operators must comply with these requirements. These are detailed further at chapter 3 Safe Work Australia and state / territory safety regulators (refer

chapter 3) have published guidance that MHF proponents or operators can consider when developing their approaches for assessing and managing safety hazards and risks.

Hydrogen facilities that do not meet the MHF definition will also need to adopt appropriate strategies for assessing and managing safety hazards. For these facilities, the proponent's approach in developing its strategy, and the level of detail and depth of analysis and documentation required, will depend on the design and scale of the facility and should be proportionate to its potential risks and hazards.

The Third Edition of the Guiding Principles for Chemical Accident Prevention, Preparedness and Response⁶ ("Guiding Principles"), provide safety guidance for fixed installations where hazardous substances are produced, processed, handled, stored, used, or disposed of in quantities that pose a risk of chemical accidents. This makes this guidance applicable to hydrogen refuelling facilities of any size.

The Guiding Principles are published by the Organisation for Economic Co-operation and Development (OECD), which is an intergovernmental organisation in which Australia is one of 38 representative countries across North and South America, Europe and the Asia and Pacific region. While Australia has adopted the Decision-Recommendation concerning the Guiding Principles, compliance with these principles has not been mandated by domestic legislation in any Australian jurisdiction. Given this, the Guiding Principles are limited to providing guidance to support stakeholders to take appropriate actions to prevent, prepare and respond to chemical accidents.

The Guiding Principles outline key actions to be undertaken by proponents to minimise the risks and consequences of chemical accidents. This Guidebook notes that project proponents may seek to rely on the Guiding Principles to provide an underlying safety framework, where there is otherwise no legislated requirement for developing and documenting a safety framework for their facility and undertake safety assessments. Chapter 3.5 of this Guidebook identifies where a facility is, or is not required to have safety cases, safety management systems, and emergency plans under Australian law.

The essence of the Guiding Principles are the following:

- four general rules⁷, and
- nine principles for the role of industry.

The four general rules are:

1. Prioritise chemical accident risk prevention, preparedness and response.

⁶ OECD (2023), OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response - Third Edition, Series on Chemical Accidents, OECD Publishing, Paris, <https://doi.org/10.1787/162756bf-en>.

⁷ OECD (2023), OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response - Third Edition, Series on Chemical Accidents, OECD Publishing, Paris, <https://doi.org/10.1787/162756bf-en>, p14.

2. Identifying hazards and understanding risks of hydrogen accidents is critical for proponents to comply with safety laws (refer chapter 5).
3. Communicate widely on all aspects of chemical accident.
4. Co-operate amongst stakeholders to facilitate effective chemical accident prevention, preparedness and response.

The nine guiding principles for the role of industry in managing chemical safety, include:

1. Promoting a mature safety culture throughout the enterprise.
2. Establishing safety management systems and regularly review their implementation.
3. Utilising inherently safer technology principles in designing and operating hazardous installations.
4. Identifying and manage the risks arising from change.
5. Preparing and planning for any chemical accidents that may occur.
6. Educating and training for employees to work safely.
7. Tracking and learning from past accidents.
8. Seeking continuous improvement through applying good engineering and management practices.
9. Exercising corporate governance in all operations and all locations of an enterprise.

It should be recognised that these principles represent good practices and objectives to be achieved over time. As such they are not one-time actions and require ongoing vigilance.

Please note, while this Guidebook suggests the OECD approach as a suitable method, it is the responsibility of proponents to ensure the approach is utilised in a manner which satisfies their regulated safety obligations.

In considering an effective and proportionate strategy for managing hydrogen facility safety, proponents may need to seek the support of independent subject matter experts (SMEs) or consultants with relevant certifications, qualifications, competencies and experience. This reflects that expertise can support the various technical investigations, safety reviews and analyses, and process modelling that can be used to identify, verify and rank the relative importance or severity of specific risks and hazards.

A range of resources are publicly available that may support hydrogen facility proponents or operators in developing their approach and strategies for managing hydrogen safety. This may include resources published by Safe Work Australia for managing process safety in MHFs.⁸ While these resources are specific to MHFs, they may also provide useful guidance on approaches that may be employed by smaller facilities.

Other useful resources may be accessed from:

⁸ <https://www.safeworkaustralia.gov.au/safety-topic/industry-and-business/major-hazard-facilities/resources>

- The Australian Institute for Health and Safety (AIHS) - <https://aihs.org.au/> and its OHS Body of Knowledge (www.ohsbok.org.au/bok-chapters/)
- The US Center for Hydrogen Safety - www.aiche.org/chs
- The Institution of Chemical Engineers (IChemE) - www.icheme.org

2.7.2 Documenting safety compliance

Chapter 3.4.5 discusses the importance of both managing and evidencing compliance with regulatory obligations. To enable proponents to evidence compliance with safety obligations it is recommended that proponents undertake a formal safety assessment consisting of the systematic assessment of risk and a description of the technical and other measures needed to control the identified risks. Given the nature and severity of potential hazards for a hydrogen facility, regardless of the scale of plant or the amount of hydrogen that is produced, handled or stored, undertaking and documenting a formal safety assessment is recommended. However, there are different ways to approach a safety assessment, and proponents will need to form a considered judgement about the most appropriate approach given the nature and risk profile of their facilities. The level of detail required in safety assessments will depend on the size and complexity of the facility.

The purpose of the documented safety assessment is to attempt to validate and ‘prove the case’ that a hydrogen plant can be operated to a high level of safety with no or minimal risks so far as is reasonably practical (including demonstrating why the measures taken meet the legislative requirement of ‘so far as reasonably practical’—see chapter 3.4.4).

The safety assessment documentation should include:

- a review and assessment of plant operations to identify safety hazards and identify where accidents and unsafe situations are occurring or could occur
- a list of major identified hazards, risks and potential incidents and relative importance or ranking against the severity, impact or harm it may cause
- where appropriate a detailed assessment of specific hazards to understand the consequences associated with them
- an outline of the risk management methodologies that were applied to arrive at the outcomes of the risk assessment
- details of controls for the systematic and continuous identification of hazards, risks and incidents
- a list of how each prescribed compliance requirement is met with reference to where it is addressed in the Safety Case

Documentation of a proponent’s safety compliance should also contain a list of safety-related policies, systems and procedures at an organisational level. It also provides a brief description of the safety systems and procedures that have or will be implemented at a hydrogen facility. Hydrogen plant owners and operators in conjunction with site work health and safety officers should prepare, implement and strictly adhere to and regularly review the stipulated hydrogen safety documentation.

2.7.3 Hazard Identification study (HAZID) and Hazard and Operability (HAZOP) study

A Safety Assessment relies heavily on the completion of detailed, robust and defensible hazards and risk assessments. The potential hazards and risks at a facility are commonly identified in a Hazards Identification (HAZID) study and are further investigated in a Hazard and Operability (HAZOP) study although other techniques also exist.

The first step is to perform a HAZID analysis. HAZID analysis is a qualitative analytical technique used as a screening tool to identify scenarios that can potentially lead to hazardous conditions at the site under investigation. It results in the identification and characterisation of the key hazards at the facility (that is, “what can go wrong”). HAZID analysis is often the first study undertaken on a new design, as early as possible in the design process.

A HAZOP analysis may then be considered once the design is confirmed, and the way in which equipment is to be operated is understood. HAZOP analysis is a structured and systematic technique for system examination and risk management. In particular, HAZOP is often used as a technique for identifying potential hazards in complex systems and identifying operability problems. The HAZOP uses a brainstorming approach around a series of guide words and is designed to identify possible deviations from normal operation and their possible impacts. It is a more detailed and structured form of hazard assessment than a HAZID. A HAZOP will generally be undertaken once a detailed design is completed and the project team have a thorough understanding of the operation and associated risks and hazards.

Proponents should consider engaging an independent appropriately trained person to carry out the HAZOP and HAZID studies.

2.7.4 Hydrogen standards

Compliance with relevant Australian or international standards is essential to the safe and reliable design and operation of all hydrogen facilities. Operators should be familiar with local (and international) regulatory and safety standards that provide guidance on the proper handling and use of hydrogen. Although not within the scope of these codes, the proper handling and use of oxygen is also mandatory for all electrolyser plants.

In Australia, the development of hydrogen standards, technical specifications, technical reports and other guidance documentation is managed by the Standards Australia ME-93 Hydrogen Technologies committee that mirrors the ISO Technical Committee 197 Hydrogen Technologies. The IEC TC 105 committee provides global standards for the specific design and operation of electrical systems of hydrogen and fuel cell facilities.

Key Australian and international standards that are applicable to hydrogen refuelling facilities are in Annexure 2 at 2.3.1.

2.7.5 Hazardous Area Classification for hydrogen facilities

Hazardous Area Classification identifies areas in a facility where there are risks of flammable atmospheres forming. To address these risks, industry standards require the identification

and classification of hazardous areas where such atmospheres might exist. This process of hazardous area classification is governed internationally by the IEC 60079-10-1 standard and is adopted through ATEX⁹ in Europe and AS/NZS 60079.10.1¹⁰ in Australia and New Zealand. These standards provide a structured methodology for assessing the likelihood of explosive atmospheres and guide how zones are defined and protected.

According to these standards, a hazardous area is any part of a facility where an explosive atmosphere such as a hydrogen-air mixture might occur due to the properties of the gas and the facility's operating conditions. By classifying these areas, engineers and operators can determine which equipment is suitable, and what precautions are needed to minimise the risk of ignition.

Within this framework, areas are divided into zones, based on the frequency and duration of hydrogen presence:

- Zone 0 refers to areas where hydrogen is present continuously or for long periods under normal operations such as inside process vessels or gas lines
- Zone 1 refers to areas where hydrogen is likely to be present during normal operations such as around pressure relief valves, vent outlets, or filling systems
- Zone 2 covers locations where hydrogen is not expected under normal conditions but may appear briefly in the event of a leak these are usually areas surrounding well-maintained, sealed equipment.

Once zones are classified, the appropriate explosion-protected equipment is selected and installed. In these areas, work and maintenance activities are restricted or subject to special precautions (e.g. no naked flames, no smoking, no hot work without a work permit). Ventilation is employed strategically, and leak detection systems are deployed to provide early warning of gas release.

This systematic approach ensures that any work conducted near hydrogen is done with full awareness of the environment's risks. The classification of the area ensures that electrical equipment has the appropriate type of protection to keep risks and hazards to an acceptably low level. The probability of a flammable gas, such as hydrogen, being present within a specific area of plant is used as the basis for hazardous area classification.

2.7.6 Hydrogen training, certification and supervision

Although the majority of plant items of a hydrogen facility are controlled by automated systems, it remains important for operators to be well trained and experienced in both manual and automated plant operations. Theoretical and practical training and certification

⁹ ATEX (ATmosphères EXplosibles) is the name commonly given to the two European Directives for controlling explosive atmospheres.

¹⁰ Section 7.7 of AS/NZS 3000, requires that hazardous areas be classified in accordance with AS/NZS 60079.10.1 or AS/NZS 60079.10. This means that when dealing with electrical installations in hazardous areas, regard must be had to AS/NZS 60079.10.1 to determine the appropriate classification and subsequent requirements.

with safety equipment, standard protocols and emergency response procedures for the safe handling of both hydrogen and oxygen under different operating conditions is essential.

In terms of maintenance, training and education play a role in identifying potential issues and addressing them before they cause significant problems. Operators and maintainers must be familiar with the various maintenance schedules and procedures, including documentation, to ensure that equipment is properly maintained. To maintain electrical equipment it is likely that they will require electrical work licenses (the skills knowledge and training requirements are listed in the AS/NZS60079 series of documents).

The scope of operator training should include:

- properties and characteristics of hydrogen and oxygen gases
- safety and emergency procedures and protocols for the safe handling and use of hydrogen and oxygen
- operation, maintenance and trouble-shooting for all plant equipment, including compressors, hydrogen storage tanks, process lines, vents and instrumentation and controls
- documentation of operations to satisfy regulatory and other compliance requirements
- schemes for the identification of high pressure vessels and piping systems
- interpretation and implementation of data and procedures in safety data sheets
- troubleshooting and recognition of signs of pending equipment failure
- equipment calibration and testing procedures
- start up and shut down of equipment or plant
- area evacuation
- use of firefighting equipment in the presence of hydrogen, oxygen or a hydrogen fire.
- use of appropriate and hydrogen-specific personal protective equipment (PPE) in specific plant work areas.

2.7.7 Qualified personnel

It is important to ensure only experienced and appropriately licensed or registered professionals are appointed to carry out specific works (e.g. electricians that hold nationally recognised competencies for working with electrical equipment in hazardous areas). An appropriate IECEx certification body should perform initial and periodic audits and issue IECEx certificates to assure that hydrogen plant equipment that are operated in an explosive environment meet stringent safety requirements.

Experienced, competent personnel should participate in and/or supervise any work activity that carries more than minimal risk.

Qualified personnel conducting works should be trained in and familiar with the safety management system and follow the stipulated safety procedures of a hydrogen facility where they are conducting works.

Further information regarding safety measures for individual plant and equipment are outlined in chapter 2.7.

2.8 Hydrogen safety measures

Given hydrogen's unique properties and severity of associated hazards, all hydrogen plants will require the implementation of specific measures to ensure a high level of protection. This chapter outlines the applicable hydrogen standards and a non-exhaustive list of recommended measures that can support the safe and reliable design, installation and operation of a hydrogen facility.

Despite the inherent risks, hydrogen hazards are manageable through best practice facility design and the implementation of hydrogen-specific and general safety measures and safe operating practices over the entire life cycle of the facility. Best practice in hydrogen safety is grounded in five core requirements:

1. Identifying hazards (e.g. from a HAZID study) and definition of mitigation measures (e.g. from HAZOP and LOPA studies)
2. Ensuring system integrity (material selection for hydrogen service) and hydrogen containment
3. Providing proper ventilation to prevent or minimize the accumulation of hydrogen to unsafe levels (managing primary and secondary hydrogen releases and discharges)
4. Ensuring that all hydrogen leaks are readily detected, isolated and mitigated
5. Training plant operators and personnel to ensure that hazards and mitigations are understood and can be practically implemented and safety procedures and established work instructions are stringently followed.

2.8.1 Materials for hydrogen service

Appropriate material selection through the validation of material compatibility for hydrogen service and regular mechanical and material integrity testing and assessment of hydrogen plant equipment items will help to assure that plant equipment will perform as expected for planned and worst-case operating conditions without substantial material degradation, system failure or potential for uncontrolled hydrogen leakage.

The minimisation of sudden temperature drops in piping and vessel walls through regular monitoring and maintenance of material systems will also help to prevent such failures.

Metals that are less resistant to deterioration when exposed to hydrogen may still be used when analysis of pressure containing components shows that the mechanical loading is acceptable. The generally accepted demonstration method is fracture mechanics.

Several heat treatments of materials have been developed to optimise the performance of materials in hydrogen service. The two step retrogression-reaging treatment has proven effective to attain the necessary strength and other mechanical properties whilst maintaining a high level of resistance to corrosion and material degradation such as hydrogen embrittlement.

Materials commonly used in hydrogen service for specific ranges of material characteristics (e.g. chemical composition and strength), mechanical loading and environmental conditions are:

- Austenitic stainless steels
- Low-alloy and C-Mn ferritic steels
- Copper alloys
- Some aluminium alloys with specific modification (e.g. 7,000 series).

Materials commonly avoided in hydrogen service are:

- High strength ferritic and martensitic steels
- Gray, malleable, and ductile cast irons
- Alloys of nickel and titanium
- Alloys of aluminium with no modification.

Austenitic (300 series) stainless steels are recommended for gaseous hydrogen product piping, tubing, valves, and fittings. The most stable grade is Type 316/316L that is relatively immune to hydrogen embrittlement when exposed to high pressure hydrogen and is preferred over other grades of steel such as Type 304L and Type 321. Austenitic stainless steels should be used in the annealed condition.

Use of stainless steel, grade 304, 316 or 321 for construction materials is recommended for plant items in contact with hydrogen (e.g. electrolyser stacks and hydrogen storage vessels).

Vessels for oxygen service should be fabricated with simple mild steel and cleaned with degreaser and have any welding burrs removed before use.

2.8.2 Operation of plant equipment items

Hydrogen's wide flammability range, low ignition energy and combustion and hazard potential dictate hydrogen-specific plant design and operational requirements. All plant equipment items must be stringently operated to within specific equipment design and material limits. The specifications of OEMs and the recommended safe practices of safety data sheets (SDS) should be stringently adhered to.

In order to mitigate the risk of operating hydrogen plants at high pressure, industries employ a variety of safety measures. These include pressure relief valves, which are designed to release pressure in a controlled manner if it becomes too high, and regular inspections and maintenance to ensure that equipment is functioning properly. Training is also crucial, as workers need to understand the risks associated with high pressure and how to respond in case of an emergency.

2.8.3 Location of plant equipment and separation distances

A key design feature of any hydrogen plant is to minimize, if not prevent, any source of oxygen from mixing with a hydrogen stream. This can be achieved if the gas venting systems for these gases are positioned in the hydrogen plant with an appropriate separation distance.

Hydrogen separation distances are the minimum distances between a hazard source and an object (humans, equipment, structures and environment). This data assists in determining the location and relative position of key plant equipment items to maintain an optimum

level of process safety, mitigate likely foreseeable hydrogen incidents and prevent a minor incident escalating into a larger incident. Separation distances are also known as safety or set-back distances.

The following factors impact on the calculation and setting of separation distances:

- the nature of the hazard
- the operating conditions and the design of the analysed equipment/facility
- the type of target/object (people, structures, equipment)
- the environment between the latter and the source of hazard.

In this way, the harm potential for people or structures can be evaluated and compared with the harm criteria.

There are no fixed stipulations for fixed or variable set of safety distances currently prescribed by any regulation, code or standard for hydrogen plants that are operated in Australia. Proponents could have regard to NFPA 2, formerly known as the NFPA 2 Hydrogen Technologies Code. This is a comprehensive safety standard developed by the U.S. based National Fire Protection Association. It provides a unified framework for the safe generation, storage, transfer, and use of hydrogen.

One of the most critical aspects of a hydrogen system safety, as laid out in the NFPA 2 Hydrogen Technologies Code, is the concept of separation distances. These are the prescribed minimum distances that hydrogen equipment like storage tanks, pipes, and dispensers must be set apart from buildings, property lines, public spaces, and ignition sources. The rationale behind this is straightforward: hydrogen is highly flammable and disperses rapidly when leaked, creating an elevated risk for fire or explosion. NFPA 2 establishes these buffer zones based on sound engineering analysis, empirical data, and modelling of hydrogen's physical behaviour, with the goal of minimizing harm in the event of a release or accident.

The code tailors these distance requirements to the nature, quantity, and configuration of the hydrogen involved. For example, small-scale hydrogen storage may require only minimal separation, while large-volume compressed or cryogenic storage installations must be set considerably farther from structures or public areas. These requirements account for factors like gas dispersion patterns, thermal radiation from potential fires, and access for emergency response. These distances are based on risk assessments, hydrogen behaviour modelling, and empirical data.

This focus on separation distances makes NFPA 2 particularly valuable in the absence of mature local regulations.

A risk-based methodology such as consequence and risk analysis (CRA) modelling may also be considered to determine the minimum separation distances as part of the risk assessment process.

The main electrical system and control system processors, the feedwater system and any other equipment utilizing HV/LV motors would normally be located outside of a hazardous area as a fundamental safety principle. Compressors are located almost exclusively outdoors and not within any form of enclosure to avoid the over-pressure hazard.

If a hydrogen facility is supplied by trucked-in compressed hydrogen or liquid hydrogen, sufficient space will need to be provided for the ingress / egress and on-site parking of the trailers and tankers.

The hydrogen facility must also be arranged so that there is adequate access for maintenance.

2.8.4 Reduction of ignition sources

Ignition sources such as sparks from electrical equipment and sources of static electricity, open flames and hot objects in the vicinity of any hydrogen releases should be minimised to reduce the possibility of inadvertent hydrogen ignition. Sources of ignition at this extremely low energy level are numerous and include flames, hot surfaces, small sparks from electrical equipment and accumulations of static electricity. Friction between a rapidly moving gas and a surface can also generate enough static electricity for hydrogen ignition.

Given that hydrogen's minimum ignition energy is extremely small, it is practically impossible to eliminate all ignition sources but all attempts should be made to minimise these.

2.8.5 System purging

The regular purging or flushing of process lines is an essential safety measure for all hydrogen plants to ensure the content of oxygen and hydrogen are kept below ignition levels in piping systems.

Refer to chapter 2.5.4.5 Plant Item H5 SYSTEM PURGING for further detail.

2.8.6 Gas venting

Gas venting is a common industrial process safety measure to enable the safe and controlled release of gases to a safe location

Refer to chapter 2.5.4.6 Plant Item H6 GAS VENTING for further detail.

2.8.7 Process control and automation system

The continuous control and monitoring of both controlled and uncontrolled hydrogen releases from plant equipment is a primary mitigation measure and base requirement for the design and safe operation of any hydrogen plant.

Refer to chapter 2.5.4.7 Plant Item H7 PROCESS CONTROL AND AUTOMATION for further detail .

2.8.8 Hydrogen detection

Hydrogen detection is an important safety measure and key control for hydrogen refuelling facilities. Various types of hydrogen sensors and leak detector technologies exist, and while

none of them provide perfect detection, a combination of different technologies along with routine inspections is the best way to ensure safe operation. Hydrogen detectors or detection devices are used to identify and locate hydrogen leaks for both economic reasons (containment of hydrogen inventory) and safety reasons.

The placement of detectors should account for factors such as airflow, concentration levels and obstructions.

While gas detectors may not be suitable for outside applications and the use of ultrasonic detection can be challenging systems can be designed to detect hydrogen. Flame detectors are suitable for outside control. Several types of detection devices, both portable and fixed, are available on the market for the detection of hydrogen leaks and hydrogen flames as summarised in table 2.4.

Table 2.4: Summary of hydrogen gas and flame detection devices

	Portable	Fixed
Gas detection	Explosimeter	Explosimeter
	Combustible detectors	Acoustic detector
	Acoustic detectors	
	Chemochromic tapes / media	
	Soap	
Flame detection	Thermal imaging cameras	UV / IR
		Multi-IR

Where systems are contained such as electrolyzers proponents should consider point gas detectors which work well in enclosed spaces. Proponents should consider installing hydrogen gas and flame detectors in an enclosure.

2.8.9 Mechanical protection

Blast walls and barriers can be installed to provide additional mechanical protection in the operation of a hydrogen refuelling facility. These safeguards serve to restrict and impede the rapid dispersion of hydrogen and the explosion over-pressures and reduce the potential harm to operators, vehicle owners, vehicles, plant equipment and other assets in the vicinity of the facility. Blast walls and barriers can be both fire and blast barriers if they are designed to do so. Blast walls and barriers must be designed to incorporate access through the walls and barriers to allow access for the removal or servicing of plant components.

Proponents should include passive fire protection including compartmentation and isolation, as well as fire and blast protection.

Fire walls can be incorporated as passive safety measures to mitigate the risks associated with potential fire incidents at hydrogen refuelling facilities. These structures are strategically positioned to resist the spread of flames and radiant heat between hazard zones. Fire walls act as thermal shields, containing localized ignition and allowing additional response time during emergencies. To ensure both protection and operability, fire walls

should be constructed from non-combustible, heat-resistant materials and designed with features that permit safe and efficient access to plant components when maintenance or removal is required. Additional mechanical protection can be provided for hazardous areas of a hydrogen plant (such as hydrogen storage vessels) with a combination of fencing and locks. The very high or low operating temperatures of some hydrogen plant items can present thermal hazards to plant operators. Standard safety measures such as the installation of barriers and safeguards, equipment tagging and labelling and operator training are therefore required to avoid any human contact with either very hot or cold surfaces that could result in first, second and third degree burns. Plant integration

Ensuring adequate integration and operation of plant items and instruments that are often provided by several different vendors or OEMs is a base requirement for all hydrogen plants. Critical sub-systems for a hydrogen refuelling facility include:

- alarms, sensors, detectors, pressure relief devices and emergency stop and shut down systems
- specific hoses and fitting for the safe and reliable transfer of hydrogen from a supply trailer within the pressure range of 200 to 300 bar
- anti-tilt devices that are fitted to dispensers to enable the detection and shut down of the refuelling process in the event of a hydrogen incident or vehicle collision.

Proponents should do an overall system HAZOP looking at the integration of all sub-systems to ensure safe operation.

2.8.10 Access/egress

Plant design that provides ample access and egress to plant and equipment is a basic health and safety requirement that is often overlooked across process and other industries. Over 30% of workplace accidents are a result of slips, trips and falls that could have been avoided. Working on and maintaining serviceable hydrogen plant and equipment can be a hazardous task, so designing for adequate access and egress to these items in the layout of hydrogen facilities is a necessary prevention measure to reduce hydrogen accidents, incidents and near hits. Plant design should enable plant operators, contractors and emergency responders to readily control and suppress hydrogen fires.

2.8.11 Equipment replacement

It is important to replace plant equipment items as specified in order to maintain a high level of plant safety. For example, an electrolyser stack may need to be replaced at least once during its operational life due to degradation in stack performance. This is a more common requirement in the operation of PEM electrolyser stacks.

2.8.12 Noise

Noise levels from the hydrogen refuelling facility, principally from the operation of the chiller plant, must be less than 85dB depending on plant zoning.

Chapter 3 – Hydrogen Refuelling Facility Safety - Regulatory Obligations and Considerations

Australia's regulatory challenge for the transition to low emission fuels

Unlike other gaseous elements like natural gas, hydrogen safety is not regulated comprehensively under a single regulatory framework. For example, for natural gas supply chains, targeted legislation has been developed, tested and refined over many decades. The result is a comprehensive regulatory framework comprising gas safety, gas pipeline and end-use gas appliance legislation.

These frameworks may apply in whole or in part to facility safety for hydrogen supply chains (with variance between jurisdictions), however, in general there is not the same degree of comprehensive coverage in regulating hydrogen projects. Safety outcomes for hydrogen are achieved through compliance with a wide range of legislation.

The purpose of chapter 3 of this Guidebook is to provide transparency on the interaction of regulatory obligations to assist proponents to streamline their approach to compliance. Proponents should engage early with relevant regulators to discuss specific compliance expectations for their project.

3.1 Introduction

3.1.1 Chapter 3 glossary

In this chapter 3:

WHS means work health and safety

OHS means occupational health and safety

model Health & Safety Legislation means the model WHS Act, model WHS regulations and model codes of practice made under those laws

OHS laws (Vic) means the *Occupational Health and Safety Act 2004* (Vic), regulations and Compliance Codes

Health & Safety Legislation means collectively the model Health & Safety Legislation as enacted by most Australia jurisdictions and the OHS laws (Victoria)

MHF means major hazard facility

3.1.2 Structure of this chapter

This chapter 3 identifies the main legal requirements for facility safety that may need to be met by proponents when operating a hydrogen refuelling facility in Australia. This Guidebook provides transparency and regulatory guidance on Australia's national hydrogen regulatory framework. It does not provide detailed compliance notes on specific legislation.

This chapter 3 is supported by Annexure 3 (facility safety) and Annexure 5 (legislation summaries). Annexure 3 provides a more detailed comparison of specific legislation and obligations across all Australian jurisdictions. Annexure 5 provides greater context by providing a more wholistic summary of legislation referred to in this chapter 3.

The regulation of safety for hydrogen refuelling facilities is similar across all Australian jurisdictions, however, there are important differences. In Australia, safety requirements are structured through a combination of general and subject-matter specific legal obligations. Proponents should be aware of the following key elements:

- the overarching and generally similar safety requirements under the regulatory regimes for Work Health and Safety (WHS) laws (though with limited application in Victoria) and the Occupational Health and Safety (OHS) laws (specific to Victoria). These regimes impose primary duties of care that are applicable broadly across all workplaces, industries and activities, and are collectively referred to in this Guidebook as “Health & Safety Legislation” (see chapter 3.3.1)
- the subject matter specific requirements that apply to particular activities such as gas, electrical, plumbing, and handling hazardous chemicals and dangerous goods in Australia including general duties applicable in relation to those activities, worker competency and licensing requirements, and other requirements tailored to manage safety risks in relation to the relevant activity (together called “subject specific laws” – see chapter 3.4.3).

It is important to recognise that duties under Health & Safety Legislation and subject specific laws are complementary, overlapping and non-delegable. Together, they create a comprehensive framework for managing safety risks, with Health & Safety Legislation imposing overarching safety obligations, and subject-specific legislation addressing risks associated with particular hazards or activities.

For this chapter, facility safety regulation has been broken down as follows:

- work / occupational health and safety¹¹
- primary and general duties of care (addressing the core or foundational obligations under Health & Safety Legislation, as well as additional general duties tailored to specific risks or activities)
- whole of facility regulation
- hazardous chemicals / dangerous goods
- plant and equipment (including electrical appliances, gas appliances and pressure vessels)
- regulator engagement, notifications and consultation
- worker competency and licensing.

While there are many ways to group regulatory obligations, the categories above are a useful way to highlight the range of legal requirements that proponents must comply with

¹¹ Note that note that the themes referenced below are also subsets of general WHS/OHS requirements.

ensuring hydrogen refuelling facility safety, so far as is reasonably practicable. It also helps to show the extent of obligations which operate in parallel (and sometimes overlapping) where it may be possible to use a single compliance mechanism (e.g. one safety assessment) to demonstrate compliance with more than one obligation.

3.2 Compliance with safety obligations

Importance of understanding safety regulatory obligations

- Safety compliance is more than the absence of an incident or near miss
- Proponents need to demonstrate how they have proactively sought to manage safety and mitigate risks to comply with obligations
- Understanding the relevant safety regulations that apply to a facility is a critical first step to demonstrating obligations

While this Guidebook sets out the key regulatory obligations relating to hydrogen facility safety, it cannot detail the specific technical requirements for how to comply with these obligations.

Complying with safety obligations is important for a range of reasons including managing legal liability, corporate and industry reputation and most significantly, ensuring the safety of workers and the public. For the emerging hydrogen industry, it is also critical to building social licence and trust that a hydrogen industry can operate safely.

When considering these reasons, there are two parallel considerations:

- achieving safety in practice (i.e. having a workplace that is free from incident and injury) and
- demonstrating safety compliance (that is, understanding legal obligations and being able to provide evidence of compliance).

3.2.1 Demonstrating safety compliance

As discussed below in chapter 3.4.1, a facility can be in breach of its legal obligations even if an incident or injury has not occurred. Key aspects of demonstrating safety compliance include:

- understanding all regulatory obligations applicable to a facility. This Guidebook demonstrates that there may be multiple sources of obligations that operate in parallel. Before any other actions are taken, it is first important to understand regulatory obligations as these set the benchmark or target that all compliance actions need to achieve. It is impossible to demonstrate compliance without a clear and detailed understanding with what it is needed to comply.
- identifying hazards and risks
- determining and implementing controls, including assurance and auditing processes as appropriate, and
- preparing appropriate hydrogen facility safety assessment documentation.

As noted above, achieving safety (so far as is reasonably practicable) and effectively demonstrating regulatory compliance are overlapping concepts, but one does not necessarily guarantee the other.

While undertaking the steps above may assist to achieve safety in practice, it is critical that proponents also document all steps of their assessment, decision-making and supporting evidence so that in the event of an investigation (whether or not an incident has occurred) a proponent can demonstrate compliance with applicable obligations.

Chapter 3.5.3 discusses safety cases, safety management systems (SMS) and emergency plans¹² as mechanisms to document compliance with safety obligations. Safety cases are required for large major hazard facilities under Health & Safety Legislation and some other regulatory frameworks covering all parts of a facility or multiple co-located facilities. It is unlikely that hydrogen refuelling facilities will meet the relevant thresholds for a major hazard facility and so are not discussed further. Further information on major hazard facilities can be found in the National Hydrogen Regulatory Guidebook: Production Facilities.

However, where a safety case, or SMS is not mandated by legislation, it is ultimately up to a proponent to develop appropriate documentation to assist them to meet their obligations and be able to evidence compliance to regulators. In such cases, chapter 2.7 sets out key process steps that may assist a proponent to inform the development of an alternate form of documentation.

¹² See the duty to prepare, maintain and implement emergency plans required for all workplaces under section 43 of the model WHS Regulations.

3.3 Work (Occupational) health and safety

Key points:

Australia's Safety laws:

- include workplace health and safety regulatory obligations that apply to hydrogen refuelling
- are designed to promote safe practices and prevent incidents and injuries by requiring compliance with safety standards, protecting workers and the public
- require proponents to identify hazards, assess associated risks, and implement control measures to eliminate these risks so far as is reasonably practicable, and where they cannot be eliminated, to minimise them so far as is reasonably practicable
- Annexure 3, table 3.1 summarises the specific work health and safety / occupational health and safety legislation enacted in each Australian jurisdiction.

3.3.1 Application of Health & Safety Legislation across Australia

Health & Safety Legislation seek to ensure the safety of workers and other persons at or affected by activities carried out at a workplace. This is achieved by:

- protecting workers and other persons from harm by requiring duty holders to eliminate or minimise risks to health and safety so far as is reasonably practicable and where they cannot be eliminated, to minimise them so far as is reasonably practicable
- providing for consultation and representation on safety matters, and ensuring employees are actively involved in safety processes
- encouraging unions and employer organisations to take a constructive role in promoting improvements in safety practices
- requiring consultation, cooperation and coordination of activities between duty holders
- promoting the provision of advice, information, education and training for safety with employers obligated to provide training to ensure, among other things, that workers are aware of potential hazards and understand safe work practices
- securing compliance through compliance and enforcement measures
- ensuring appropriate scrutiny and review of actions taken by persons with powers or functions under the Health & Safety Legislation
- providing a framework for continued and continuous improvement in relation to safety matters, to encourage organisations to regularly review and update their safety practices and policies to adapt to new risks and enhance overall safety performance.

Health and Safety legislation is largely harmonised across all Australian jurisdictions through the enactment by each jurisdiction (other than Victoria) of laws mirroring the model WHS Act, model WHS Regulations and model Codes of Practice (with some variations in Northern Territory, South Australia, Queensland and Western Australia – refer to Annexure 3, table

3.1). The WHS Act in each harmonised jurisdiction is the foundational piece of safety legislation, outlining both general and specific responsibilities for persons conducting a business or undertaking (PCBUs) and other duty holders, such as workers and officers. The WHS Regulations in each harmonised jurisdiction provide further specific requirements for particular hazards and risks and prescribe further detail on how risks must be managed consistent with the general duties under the WHS Acts. The Codes of Practice in each harmonised jurisdiction provide practical guidance on how to meet the requirements outlined in the Act and Regulations.

Victoria has not adopted the model WHS regime but has similar duties and responsibilities under its *Occupational Health and Safety Act 2004* (Vic), *Occupational Health and Safety Regulations 2017* (Vic) and Compliance Codes (OHS Laws (Vic)).

Most hydrogen refuelling facility proponents must comply with the Health & Safety Legislation depending on the jurisdiction.

Annexure 3, table 3.1 provides a summary of each jurisdiction's application of WHS and OHS laws.

Safe Work Australia is responsible for maintaining the model WHS regime, but it does not regulate or enforce the legislation. Regulation and enforcement are undertaken by the relevant jurisdiction's separate regulatory authority and under that jurisdiction's enactment of the model Health & Safety Legislation or the OHS Laws (Vic) (refer to Annexure 3, table 3.1).

The interaction between Health & Safety Legislation and subject specific laws (e.g. electrical safety, gas safety or dangerous goods legislation) varies between jurisdictions. In some instances, Health & Safety Legislation may be expressly excluded from applying where there is this more subject-specific laws. In other instances, Health & Safety Legislation is given priority. However, in many cases the Health & Safety Legislation will operate concurrently with other subject-specific legislation and proponents will need to be aware that their hydrogen refuelling facility will incur obligations under both Health & Safety Legislation and other subject-specific safety regimes (see chapters 3.3 to 3.4).

Depending on the requirements of a particular jurisdiction, if proponents are aware of their concurrent obligations, they may be able to use the same compliance activities (e.g. completing and documenting a safety audit and hazard/risk assessment) to meet their obligations across both Health & Safety Legislation and other more subject-specific laws.

3.3.2 WHS Codes of Practice

The Health & Safety Legislation is supplemented by approved Codes of Practice and (in Victoria) Compliance Codes. Under the WHS Acts, Codes of Practice are approved for each State or Territory under section 274 of the applicable WHS Act. Under the OHS Act (Vic), Compliance Codes are approved under section 149. For the purpose of this Guideline, the term Code of Practice is intended to refer to both Codes of Practice and Compliance Code.

An approved Code of Practice provides practical guidance on how to achieve the safety standards required under the applicable Health and Safety Legislation and effective ways to identify and manage hazards and risks, and implement and maintain controls.

Each Code covers an issue, or situation or particular type of work (such as hazardous chemicals, working at heights, etc), and provides ways to identify and manage risks and sets out how to achieve the standards required under the Health & Safety Legislation. Although strict adherence to the Codes is not required under the Health & Safety Legislation, in Queensland only, duty holders must either comply with applicable Codes or manage hazards and risks arising from the work in a way that is different to the Codes, but provides an equivalent or higher standard of health and safety.

It is important to note that an approved Code of Practice is admissible in court proceedings. Courts must regard an approved Code as evidence of what is known about a hazard, a risk, a risk assessment or control and rely on a Code to determine what is reasonably practicable in the circumstances.

Codes of Practice provide practical guidance on achieving the standards set by Health & Safety Legislation, and while they are not legally binding (subject to the above caveat in Queensland), if approved they can be used as evidence by a duty holder in court to demonstrate compliance with statutory safety duties. Similarly, if not complied with, it may be difficult to evidence compliance without compelling evidence that the proponent adopted an alternative available means of managing the risk that ensured safety so far as is reasonably practicable.

Following an approved Code of Practice will assist the duty holder to achieve compliance with the health and safety duties in Health & Safety Legislation. Like regulations, Codes of Practice deal with issues and may not cover all relevant hazards or risks. The health and safety duties require duty holders to consider all risks associated with work, not only those for which regulations and Code of Practice exist.

3.3.3 Who is subject to Health & Safety Legislation?

The model WHS regime uses the term “persons conducting a business or undertaking” (PCBUs) and the OHS Act (Vic) uses “employers”. Both concepts (PCBU and employer) include a company, organisation or partnership, sole trader, unincorporated association or not-for-profit organisation.

The definition of a PCBU covers almost any organisation or person that does *anything*, unless they are excluded from that definition by particular legislative provisions (for example, persons who are engaged solely as workers or officers for a particular business or undertaking are not PCBUs for the purposes of that business or undertaking).

Under the OHS Act (Vic), the definition of "employer" includes any organisation or person who engages others to perform work. This includes employing persons under contracts of employment or training, but it also extends to other working arrangements captured by the OHS Act's extended definition of "employee." This extended definition includes not only

traditional employees but also certain contractors, subcontractors, and other persons who perform work under specific arrangements. This ensures that the obligations of employers under the OHS Act (Vic) apply to a wide range of working relationships.

In their respective legislative contexts, the terms PCBU and employer are used to capture most entities who are expected to comply with primary safety obligations under one unifying term.

It follows that that most, if not all entities involved in the design, construction, operation and decommissioning of a hydrogen project will be considered PCBUs (under the WHS Acts) or employers (under the OHS Laws (Vic)). This could include the head project company, design consultants, construction contractors, manufacturers and importers of equipment, entities installing or commissioning equipment, and persons operating or servicing plant and equipment. This Guidebook uses the term "proponent" as an umbrella term to refer to PCBUs and employers in the context of a hydrogen project.

Against this background, the Health & Safety Legislation provides a framework for safeguarding the health and safety of workers by outlining the duties of various duty holders. Under the WHS Acts, duty holders include PCBUs, officers, workers, and other persons at the workplace. Under the OHS Laws (Vic), duty holders include employers, self-employed persons, employees and officers, persons who manage or control workplaces, designers, manufacturers, suppliers, and persons installing, erecting or commissioning plant (all of whom will generally also be PCBUs under the WHS Acts). Each duty holder has specific responsibilities to ensure safety so far as is reasonably practicable, for example:

- Under the WHS Acts, officers of a PCBU have duties to exercise due diligence so far as is reasonably practicable to ensure the PCBU's compliance with WHS obligations¹³. Similarly, under the OHS Act (Vic), officers of an employer have a duty to take reasonable care to ensure the employer complies with its obligations under the OHS Act. This includes ensuring that the employer provides and maintains a safe working environment, so far as is reasonably practicable¹⁴, and
- workers and other persons at the workplace also have responsibilities to take reasonable care for their own health and safety and that of others¹⁵.

This Guidebook does not provide guidance on the apportionment of obligations or responsibilities between entities and or people involved on a project. Proponents should refer to existing WHS and OHS guidance on these matters.

¹³ See section 27 of the model WHS Act

¹⁴ See section 144 of the OHS Act (Vic)

¹⁵ See sections 28 and 29 of the model WHS Act and section 25 of the OHS Act (Vic)

3.3.4 Summary of Health & Safety Legislation

This section summarises some of the key elements of the Health & Safety Legislation relevant to hydrogen refuelling facilities. This Guidebook seeks to focus particularly on WHS obligations with specific relevance to hydrogen, proponents should note that there are other WHS obligations, not addressed here, that must be complied with. While there is important variation between jurisdictions, there are also similar obligations.

Summary of some key Health & Safety Legislation obligations

WHS regulatory element	Application to hydrogen refuelling
Primary and general duties	<p>The obligations established through the Health & Safety Legislation include the application of primary and general duties and impose obligations regarding a range of specific matters, such as duties to manage risks associated with access/egress from the workplace, fixtures, fittings, plant and equipment and to consult, cooperate and coordinate activities with other duty holders.</p> <p>Chapter 3.4 of this Guidebook discusses primary and general duties in further detail.</p>
<p>Managing risks to health and safety and general workplace management</p> <p><i>Chapter 3, applicable WHS Regulations</i></p> <p><i>OHS Regulations (Vic) (various)</i></p>	<p>The Health & Safety Legislation also prescribe the ways in which proponents must comply with their safety duties. Risk management requires employers to identify hazards, assess associated risks, and implement control measures to mitigate or eliminate these risks. This proactive strategy is essential for preventing workplace injuries and illnesses.</p> <p>Proponents should be aware of the aspects of hydrogen properties, characteristics and supply chains that differ from other fuels such as natural gas and how these affect hazard and risk assessment.</p> <p>Chapter 2.7 of this Guidebook discusses hazards and risks and chapter 2.8 discusses controls for hydrogen refuelling facilities.</p> <p>Chapter 3.5.3 of this Guidebook discusses safety cases (required for major hazard facilities), SMS and emergency plan requirements under existing Health & Safety Legislation.</p>

<p>Specific duties for hazardous work including work involving noise, hazardous manual tasks, confined spaces, falls, demolition work, diving work, licensing of high risk work and accreditation of assessors of competency</p> <p><i>Chapter 4, applicable WHS Regulations</i> <i>Chapter 3, OHS Regulations (Vic)</i></p>	<p>Hydrogen refuelling facilities will likely involve a range of activities that will trigger the hazardous work obligations.</p> <p>Current practices for the construction and operation of hydrogen refuelling facilities will likely have similar hazards and risks to other industries.</p> <p>Accordingly, this Guidebook does not discuss these hazardous work obligations in detail.</p>
<p>Electrical safety and energised electrical work</p> <p><i>Chapter Part 4.7, applicable WHS Regulations</i> <i>Section 114, OHS Regulations (Vic)</i></p>	<p>Current practices for the electrical safety for construction and operation of hydrogen refuelling facilities will likely have similar electrical hazards and risks to other industries.</p> <p>Chapter 3.7.5 of this Guidebook discusses electrical safety in further detail.</p>
<p>Plant and structures</p> <p><i>Chapter 5, applicable WHS Regulations</i> <i>Part 3.5, OHS Regulations (Vic)</i></p>	<p>Chapter 5 of the applicable WHS Regulations focuses on ‘Plant and Structures’ and outlines duties related to managing risks associated plant and structures. Chapter 5 applies to hydrogen facilities in a similar way to other industrial projects.</p> <p>If work involves plant, proponents must always try to eliminate risks so far as is reasonably practicable, or where the risk cannot be eliminated, minimise them, so far as is reasonably practicable. Duties as a proponent with management or control of plant in the workplace include:</p> <ul style="list-style-type: none"> • managing risks to health and safety • providing and maintaining safe plant so far as is reasonably practicable • taking all reasonable steps to ensure that plant is used only for the purpose for which it was designed, unless the proposed use does not increase the risk to health or safety

	<ul style="list-style-type: none"> ensuring that the maintenance, inspection and, if necessary, testing of the plant is carried out by a competent person managing particular risks associated with powered mobile plant using specific control measures safely using, handling, storing and transporting plant so far as is reasonably practicable. <p>Chapter 3.7 of this Guidebook discusses plant and equipment regulation in further detail.</p>
<p>Construction work</p> <p><i>Chapter 6, applicable WHS Regulations</i></p> <p><i>Part 1 of chapter 5, OHS Regulations (Vic)</i></p>	<p>The hazards and risks associated with the construction of hydrogen refuelling facilities will likely be similar to other established industries.</p> <p>Accordingly, this Guidebook does not discuss these hazardous work obligations in detail.</p>
<p>Hazardous chemicals</p> <p><i>Chapter 7, applicable WHS Regulations</i></p> <p><i>Chapter 4, OHS Regulations (Vic)</i></p>	<p>Hydrogen is a hazardous chemical because at 20°C hydrogen has a flammability range with air at standard pressure of 4-75% and is accordingly a Category 1A flammable gas in accordance with Globally Harmonised System (GHS) of Classification and Labelling of Chemicals</p> <p>Hazardous chemicals are defined in the applicable WHS Act as a substance, mixture or article that satisfies the criteria for any one or more hazards classes in the GHS. Hydrogen is a category 1A flammable gas under the GHS and as such chapter 7 of the applicable WHS regulations applies to hydrogen.</p> <p>Chapter 3.6 of this Guidebook discusses hazardous chemicals in further detail.</p>
Major Hazard Facilities (MHFs)	<p>For hydrogen, if a facility stores, handles, or processes 50 tonnes or more of hydrogen, it is considered an MHF¹⁶.</p>

¹⁶ The hazardous chemicals at MHF threshold quantities and calculations are described in sections 3 and 4 of Schedule 15 of the model WHS Regulations. Section 3 addresses the threshold quantity if there is a single hazardous chemical. Section 4 sets out the approach

<p><i>Chapter 9, applicable WHS Regulations</i> <i>Part 5.2, OHS Regulations (Vic)</i></p>	<p>Refer to chapter 3.5.1 of the National Hydrogen Regulatory Guidebook: Production Facilities for further detail on MHFs.</p>
<p>Incidents and notifications</p> <p><i>Part 3, applicable WHS Act</i> <i>Part 5, OHS Act (Vic)</i></p>	<p>The Health & Safety Legislation also emphasise incident reporting and investigation. Duty holders must report workplace incidents involving death or serious injury/illness, or dangerous incidents (including near misses and incidents where no injury occurs) to be reported and investigated to prevent future occurrences. In Victoria, this also includes most incidents requiring medical treatment.</p> <p>Chapter 3.9 of this Guidebook discusses worker reporting and notifications in further detail.</p>
<p>Worker competencies and licensing</p> <p><i>Part 1.1, applicable WHS Regulations</i> <i>Part 6, OHS Act (Vic)</i></p>	<p>Proponents and workers must ensure competency through training and experience. Licensing ensures regulatory standards and legal requirements are met.</p> <p>Section 5 of the applicable WHS Regulations defines ‘competent person’ to include amongst other specific requirements a person who has acquired through training, qualification or experience the knowledge and skills to carry out the task.</p> <p>Chapter 3.10 of this Guidebook provides general guidance on regulatory requirements for worker competencies and licensing in the hydrogen context. However, this Guidebook does not identify specific training courses or qualifications required to demonstrate such competency.</p>

for determining the threshold quantity if there is more than one hazardous chemical present or likely to be present at the facility: the aggregation formula. If the result of the aggregate formula is >0.1 the proponent must notify the relevant regulator. If the result is >1.0 , the facility will automatically be an MHF.

3.4 Primary and General Duties of Care for hydrogen Refuelling facilities

3.4.1 Primary and General duties of care

Key points:

- There are a range of broad duties across all jurisdictions designed to ensure safety and minimise risk in all Australian jurisdictions.
- These broad duties (variously called primary or general duties) exist alongside more prescriptive obligations in a range of subject-specific provisions.
- By understanding their primary and general duties and how they interact with other more specific obligations, a proponent may be able to streamline compliance activities by using the same or similar documentation and technical advisories to demonstrate regulatory compliance.
- Chapter 3.4.4 discusses the standard of care required to meet these broad duties. Annexure 3, table 3.2 and 3.3 summarises relevant primary and general duties applying in each jurisdiction.

This is particularly important to hydrogen, because there is less consistency in how subject-specific laws apply. Whereas general duties in gas safety laws cover most aspects of natural gas activities, they do not comprehensively cover hydrogen. Accordingly, general duties under Health & Safety Legislation and subject-specific laws for dangerous goods, gas safety and electrical safety combine to capture the totality of hydrogen refuelling supply chains.

In every Australian jurisdiction, broad duties of care establish overarching regulatory obligations for ensuring safety, so far as is reasonably practicable, at hydrogen refuelling facilities. These duties, called primary or general duties depending on the specific legislation, are found in both Health & Safety Legislation and subject-specific laws.

The primary and general duties provide a broad framework for managing safety in all workplaces. Under both Health & Safety Legislation and subject-specific laws, these duties are supported by more detailed and targeted obligations that address specific risks or activities requiring additional regulatory focus. Together, these obligations create a complementary and overlapping regime of regulatory requirements. Proponents must ensure compliance with all applicable obligations relevant to the work conducted as part of their business or undertaking, unless legislation expressly provides otherwise.

General duties relevant to subject-specific laws for gas, electricity, dangerous goods and plumbing provide overarching safety measures tailored to a specific activity, industry or trade and apply to proponents under subject-specific Health & Safety Legislation.

The primary and general duties in different laws operate in parallel and proponents must comply with all such duties that apply. In practice, compliance activities for a more specific duty may also demonstrate compliance for the broader obligation. As such there are opportunities for proponents to streamline compliance activities.

Proponents should engage early with all relevant regulators to identify how they may meet their overlapping primary and general and other duties. At a basic level meeting duties requires a process of hazard identification, risk assessment, and implementation and maintenance/review of controls. Proponents should capture their risk assessments in written documents, so that these documents can assist proponents in ensuring that they comply with their obligations and can evidence compliance to regulators.

If a proponent fails to meet the primary or general duties, then they may have committed an offence, and may be subject to prosecution. Penalties for contravening safety requirements may carry significant financial penalties for both organisations and individuals, and if a fatality occurs, it is possible for individuals to be sentenced to imprisonment if they are convicted of industrial manslaughter or a category 1 breach of the primary duty. It is important for proponents to be aware that they may be prosecuted for non-compliance with safety duties even without a safety incident occurring. Prosecutions can be initiated for breaches of primary or general duties even if no actual harm has resulted as the duties are designed to prevent incidents by ensuring compliance with safety standards and practices.

Prosecutions are generally undertaken by the relevant regulatory authorities, whether the WHS regulators, WorkSafe Victoria, Comcare, or regulators responsible for subject-specific laws. Every Australian jurisdiction has a WHS or OHS regulator to administer Health & Safety Legislation in their State or Territory. Regulators may provide advice or guidance on Health & Safety Legislation rights, duties and responsibilities, and how to comply with the Health & Safety Legislation in a jurisdiction. This advice can be written or verbal. However, advice from a regulator does not replace or minimise the duties under the Health & Safety Legislation, and proponents must always ensure that they satisfy themselves of their own compliance with their obligations, without relying solely on regulator guidance.

The National Compliance and Enforcement Policy¹⁷ promotes a nationally consistent approach to compliance and enforcement of the WHS Acts, Regulations and Codes of Practice. It does this by setting out the principles which underpin how regulators approach monitoring and enforcing compliance. While WHS regulators have their own policies and procedures, WHS regulators recognise the need for a nationally consistent approach to compliance and enforcement of the Health & Safety Legislation.

If there is evidence of an alleged breach, regulators consider what enforcement action, if any, should be taken. The most appropriate enforcement tool will depend on all the circumstances. The National Compliance and Enforcement Policy provides guidance in relation to matters for regulators to consider including in relation to the breach (i.e. the seriousness of the breach), the duty holder (i.e. compliance history), and the public interest (i.e. deterrence impact).

¹⁷ Available on the Safe Work Australia website, <https://www.safeworkaustralia.gov.au/>

This approach is generally consistent across various safety duties, including those in subject-specific laws for gas, electrical, dangerous goods and plumbing. The goal is to maintain high safety standards and manage risks before they result in incidents.

3.4.2 Primary and General duties in Health & Safety Legislation

The Health & Safety Legislation establish a range of primary and general duties including an overarching primary duty requiring that proponents ensure the health and safety of workers and others affected by their work activities. These duties apply under both the WHS Acts and the OHS Act (Vic), with some differences in terminology and scope.

Primary and general duties provide a principles-based approach to regulatory duties or obligations. The primary duty in the Health & Safety Legislation establishes an overarching and generally consistent approach to facility safety across all jurisdictions. There are no substantial variations between the primary duty provisions in the applicable WHS Act, and the general duties set out in the OHS Act (Vic) for the purposes of hydrogen refuelling facilities.

Primary and general duties in Health & Safety Legislation include:

- WHS Act: primary duty of care placed on PCBU to reduce risks to health and safety of workers and other persons.¹⁸ This duty involves eliminating risks to health and safety as far as reasonably practicable, and if not possible, minimising those risks as far as reasonably practicable. The duty includes providing safe work environments, safe systems of work, proper training, and maintaining equipment and facilities to ensure safety.
- OHS Act (VIC): general duties are placed on employers, the self-employed, employees, designers, manufacturers, suppliers and other duty holders (most of whom will also be PCBUs under the WHS Acts). These general duties require a duty holder to protect health and safety, so far as is reasonably practicable. The duty holder must eliminate risks to health and safety, so far as is reasonably practicable and reduce risks to health and safety, so far as is reasonably practicable, if it is not reasonably practicable to eliminate the risks.

Annexure 3, table 3.2 provides examples of WHS primary duties and OHS general duties.

Proponents should note that primary duties under the Health & Safety Legislation are not transferable¹⁹. As such, while particular tasks and safety procedures may be undertaken by an agent or third party (such as a contractor) an obligation to ensure safety will always sit with the proponent and more than one person can have the same primary duty²⁰. Where

¹⁸ Section 19, model WHS Act

¹⁹ See section 14, model WHS Act. Whilst the OHS Act (Vic) does not expressly state that safety duties are non-delegable, it is generally understood that duties cannot be transferred to another party.

²⁰ Sections 15 and 16, model WHS Act

different persons hold mutual obligations, each must discharge their duty to extent of their influence and control over the risk.

3.4.3 General duties in subject-specific laws

Each Australian jurisdiction also has specific legislation that outlines the general duties for facility safety (separate to those addressed in the Health & Safety Legislation above) across various industries and competencies. These general duties in subject-specific laws include dangerous goods, electrical work, plumbing work, gasfitting, and construction. These may operate with respect to Health & Safety Legislation, or in concert and in parallel with the Health & Safety Legislation. In some instances, the Health & Safety Legislation are expressly excluded from applying where Queensland's subject-specific laws, such as the *Petroleum and Gas (Production and Safety) Act 2004* (Qld), apply.

Electrical and gas legislation focus on safe installations and maintenance, while plumbing legislation ensures public safety and system integrity to prevent hazards. For dangerous goods, including hydrogen, the duty of care emphasises safe handling, storage, and transportation to prevent accidents, adhering to the Australian Dangerous Good Code (ADG Code) and specific safety measures for hydrogen's flammability.

Annexure 3, table 3.3 provides examples of subject-specific general duties.

3.4.4 Standard of care: what is reasonably practicable?

Key points:

- The general standard of care for eliminating or reducing risk for both primary and general duties is 'so far as reasonably practicable'
- Proponents in meeting this standard should eliminate risk where possible or where elimination is not possible reduce the risk as much as reasonably practicable
- The likelihood of a hazard or risk occurring, the potential degree of harm are key factors in determining what is reasonably practicable. Cost cannot generally be relied upon as a basis for choosing not to implement a reasonably available safety control. Proponents should engage with regulators early to ensure a common understanding of current practices and minimise risk
- Chapter 2.8 discusses key hydrogen facility hazards and safety measures.

For most obligations under the Health & Safety Legislation (including the primary and general duties) the standard of care for determining the measures that must be taken is to eliminate risk where it is reasonably practicable to do so, or if it is not reasonably practicable to eliminate risks, minimise those risks 'so far as reasonably practicable'.

The Health & Safety Legislation²¹ clarifies that the standard of ‘so far as is reasonably practicable’ requires duty-holders to take all reasonable steps to ensure health and safety by taking into account and weighing up all relevant matters, including:

- the likelihood of the hazard or the risk concerned occurring
- the degree of harm that might result from the hazard or the risk
- what the person concerned knows, or ought reasonably to know, about:
 - the hazard or the risk
 - ways of eliminating or minimising the risk
- the availability and suitability of ways to eliminate or minimise the risk, and
- the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

What is ‘reasonably practicable’ is a standard which serves to limit or qualify the scope of what would otherwise be an absolute obligation or duty to ensure safety.

The concept of what is reasonably practicable is objective, meaning it is judged by the standard of behaviour expected of a reasonable person in the duty holder's position. This involves a balance between what can be done and what is reasonable to do in the circumstances. The High Court judgment in *Baiada Poultry Pty Ltd v The Queen* (2012) 246 CLR 92 clarifies that:

"The words "reasonably practicable" indicate that the duty does not require an employer to take every possible step that could be taken. The steps that are to be taken in performance of the duty are those that are reasonably practicable for the employer to take to achieve the identified end of providing and maintaining a safe working environment. Bare demonstration that a step could have been taken and that, if taken, it might have had some effect on the safety of a working environment does not, without more, demonstrate that an employer has broken the duty..."

Considering what is ‘reasonably practicable’ requires a weighing and balancing of the likelihood of the hazard or risk occurring and the degree of harm which might result. The greater the likelihood of a risk eventuating, the greater the significance this will play when weighing up all matters and determining what is reasonably practicable. If harm is more likely to occur, then it may be reasonable to expect more to be done to eliminate or minimise the risk.

Importantly, "cost" is not a justification for doing nothing, or for choosing not to implement a reasonably practicable safety control. In order for cost to be relevant, it must be grossly disproportionate to the risk to outweigh the implementation of a safety measure. Furthermore, cost can only be considered by the proponent after the proponent has taken account of the other factors prescribed in section 18 of the WHS Acts.

²¹ Section 18 model WHS Act, subsection 20(2) OHS Act (Vic)

Chapter 2 demonstrates that hydrogen can be highly hazardous at any quantity, including below MHF thresholds. Chapter 2.6 sets out some of the key hazards and risks for hydrogen refuelling facilities. However, with rigorous assessment of hazards and risks for each facility and implementing and assuring appropriate mitigations, facilities can achieve acceptable safety levels to facilitate large-scale roll-out and support development of an Australian hydrogen industry.

There is a range of information publicly available on processes to assist proponents in evidencing compliance. Regulatory obligations relating to undertaking a safety assessment and developing a safety case, SMS and / or emergency plan are discussed further in chapter 3.5.3 and broader technical considerations relating to accident prevention and preparedness are discussed in chapter 2.

3.4.4.1 Definitions of 'reasonably practicable'

Courts have determined that, the phrase 'reasonably practicable' can be taken to mean something that:

- is narrower than 'physically possible' or 'feasible', and does not require a PCBU / employer to take every possible step that could be taken
- is to be judged on the basis of what was known at the relevant time, and
- involves balancing the likelihood of the risk occurring against the cost, time and trouble necessary to avert that risk.

An important element the Health & Safety Legislation definitions of reasonably practicable is 'what the person concerned knows, or ought reasonably to know'. It is known as the 'state of knowledge' element and must be balanced with the other elements.

3.4.4.2 State of Knowledge

The state of knowledge is concerned with what a given duty holder knows of the identified matters and what the duty holder 'ought reasonably to know'. This is an objective standard that emphasises the positive nature of the duty. It requires a duty holder to keep abreast of industry knowledge including in legislation, cases decided by courts, regulations, Codes of Practice / Compliance Codes, standards and articles in trade journals.

The state of knowledge for the Australian renewable hydrogen industry is still developing. As an emerging industry there is also no agreed practice or precedent. Accordingly, proponents may need to place greater emphasis on monitoring the developing state of knowledge and demonstrating why a particular approach was taken.

The Courts have accepted that:

- the fact that a person who is in control of a particular 'matter' affecting safety does not know something that should have been known by a person in that position cannot answer the question whether it was reasonably practicable for that person to have done

something about the matter, the crucial issue is rather, ‘who might ordinarily be expected to have that knowledge’

- the objective ‘state of knowledge’ of the risk and gravity of injury and the means of mitigating the risk is that possessed by persons generally who are engaged in the relevant field of activity and not merely the actual knowledge in fact possessed by a specific entity, and
- whether a measure could, or should, have been taken in a particular case is an objective assessment that has to be tested against the general state of knowledge about that risk, as well as any specific knowledge that was available in that industry.

Chapters 2.7 and 2.8 sets out some of the matters that should be considered in relation to hydrogen refuelling facility safety. Proponents will also need to obtain advice specific to their own project.

3.4.5 Managing and evidencing compliance with primary and general duties

Given the broad nature of primary and general duties, how proponents satisfy these obligations and evidence such compliance, will be determined on a case-by-case basis.

Chapter 2.6 sets out some of the key hazards and risks that should be considered as part of demonstrating compliance with primary and general duties of care. Ultimately, proponents need to demonstrate that their safety management approach is proportionate to the risk and meets the legislated standard of care. This requires proponents to have a thorough understanding of the hazards and risks for their specific project. Chapters 2.7 and 2.8 identifies safety processes that can assist proponents to build this understanding.

Except for the obligations to develop safety framework documentation for certain whole of facility regulations (refer chapter 3.5), there is no legislated requirement to develop a safety case for projects below the MHF threshold.

Even for those jurisdictions where there is no legal obligation to complete a safety framework, it is recommended as a matter of good safety practice that all hydrogen facilities undertake and document their accident prevention and preparedness showing how key risks and hazards have been reduced to as low as reasonably practicable (refer to chapter 2.7).

The level of detail contained in this documentation should be proportionate to the risks and hazards of the hydrogen facility. This can either be achieved by:

- utilising a safety framework comprising a safety case, SMS and emergency plan similar to that required for a major hazard facility (see chapter 3.5 of the National Hydrogen Regulatory Guidebook: Production Facilities) or
- other documentation capturing the safety assessment, outcomes and supporting evidence (see chapter 2.7).

Proponents should engage early with the relevant safety regulators to discuss whether their proposed safety approaches are sufficient to comply with relevant safety regulations.

3.4.6 Primary and General Duties - Enforcement

Key points:

- Safety regulators have extensive enforcement powers under WHS and other laws
- Early engagement with regulators can be useful in assisting proponents' and regulators' understanding of safety compliance requirements
- Undertaking project research and design activities consistent with compliance expectations can streamline any applicable approval processes and avoid delays or additional costs if further actions are required to demonstrate regulatory compliance.

A range of regulatory authorities in Australia play a role in ensuring compliance with the Health & Safety Legislation and across the legislation covering specific industries and trades. Regulatory authorities possess a range of powers to enforce compliance with WHS obligations (e.g. primary and general duties), including prior to an incident occurring.

Enforcement powers include:

- **Inspection and Investigation:** Regulators can conduct inspections and investigations to ensure compliance with safety standards and identify potential hazards
- **Issuing Notices and Orders:** Regulators have the authority to issue improvement notices, prohibition notices, and other orders to rectify non-compliance or halt unsafe practices
- **Dispute Resolution:** Where an issue arises in relation to WHS matters onsite, and a party to the issue requests it, the Regulator can appoint an investigator to attend the workplace to assist in resolving the issue.
- **Penalties and Prosecutions:** Regulators can impose fines and initiate legal proceedings against individuals or organizations fail to meet safety obligations
- **Licensing and Permits:** Regulators manage the issuance, renewal, and revocation of licenses and permits required for certain high-risk activities
- **Guidance and Education:** as an alternative to stronger enforcement action, Regulators may provide guidance, training, and educational resources to help organizations understand and comply with safety regulations
- **Monitoring and Reporting:** Regulators monitor compliance through regular reporting requirements and maintain records of incidents and enforcement actions.

These powers enable regulators to maintain high safety standards and protect workers and the public from potential hazards in various industries. Where injury or death occurs or where there has been a failure to comply with the range of obligations, including primary or general duties of care to ensure the safety so far as is reasonably practicable, non-compliance can be prosecuted in all Australian jurisdictions.

Annexure 3, table 3.4 provides specific examples of powers of WHS inspectors under the applicable Health & Safety Legislation.

3.5 Whole of facility regulation

Key points:

- There are a range of laws that apply to a hydrogen refuelling facility as a whole. The laws that apply vary based on facility size and jurisdiction
- Whole of facility regulation operates in parallel and can overlap with primary and general duties, subject-specific laws and laws regulating plant and equipment
- Whole of facility regulation promotes early engagement with regulators through either upfront approval or notification processes
- Proponents are often required to demonstrate the safe operation of facilities before or shortly after commencing operation. Chapter 3.5.2 and Annexure 3, table 3.5 discusses safety cases in detail.
- For projects that are not subject to whole of facility regulation, this Guidebook recommends that proponents still engage early with regulators
- Undertaking project research and design activities consistent with compliance expectations can streamline any applicable approval processes and avoid delays or additional costs if further actions are required to demonstrate regulatory compliance.

After the primary and general duties, the next broadest category of regulation is those laws that apply to a whole of a hydrogen refuelling facility.

In some jurisdictions there are laws that specifically regulate facilities that operate for refuelling gas. There is limited national consistency for regulation in this context.

Where jurisdictions do have specific gas facility regulation these laws provide an additional layer of safety regulation for facilities that fall within their scope. Examples include *Petroleum and Gas (Production and Safety) Act 2004* (QLD) (P&G Act) and the *Dangerous Goods Safety Act 2004* (WA).

In jurisdictions that do not have specific whole of facility regulation for facilities other than major hazard facilities, proponents are encouraged to engage with regulators in a similar way to ensure that whole of facility safety is managed even if specific regulatory requirements are covered by a range of different legislation.

Proponents should note that even though the regulatory frameworks addressed below seek to comprehensively regulate safety, it does not exclude the operation of any of the other regulatory requirements identified in this Guidebook. Proponents should ensure that they are aware of all their obligations.

Due to the emerging nature of the hydrogen industry proponents should:

- be aware there is not the same level of practice and precedent that supports the whole of gas facility regulation, and should ensure that the steps taken to comply with gas facility regulation also meets their primary duties of care
- note specific obligations relating to plant and equipment that are still relevant
- ensure they are familiar with all safety obligations referred to in this Guidebook to assess opportunities to streamline any compliance activities undertaken. This can be assisted by early engagement with the relevant jurisdiction's safety regulator.

3.5.1 Queensland and Western Australia

3.5.1.1. *Queensland: Petroleum and Gas (Production and Safety) Act*

The *Petroleum and Gas (Production and Safety) Act* (P&G Act) regulates the technical and safety aspects of gas production, transmission, distribution and use and deals with licensing of gas transmission pipelines. The P&G Act specifically regulates refuelling facilities through the definitions of operating plant, fuel gas and fuel gas delivery network.

Section 674 of the P&G Act requires the operator of an operating plant to make or adopt a compliant safety management system. Section 675 provides the content requirements for safety management systems.

Resources Safety and Health Queensland has published a Hydrogen Safety Code of Practice to inform industry specific stakeholders about safety requirements and approvals. The code has been published for the purposes of providing a consolidated and accessible reference point for fuel gas requirements that apply to hydrogen applications. The Code provides certainty about legislative requirements for hydrogen as a fuel gas and guidance for compliance under the P&G Act and regulations. The Code includes guidance as to when the P&G Act and regulations do not apply including when the storage of hydrogen at a facility is determined to be an MHF.

Refer to Annexure 3, table 3.5 for further detail.

3.5.1.2. *Western Australia: Dangerous Goods Safety Act*

The *Dangerous Goods Safety Act 2004* (WA) covers all aspects of dangerous goods production, storage, handling, piping and transport. It is independent of but operates in parallel with the WA WHS Act and Regulations. The safe storage, transport and handling of gaseous and liquefied hydrogen is controlled by the *Dangerous Goods Safety Act 2004* and associated regulations. In many respects this regime is broader than the WA WHS Act and Regulations as it regulates risks to people, property and the environment. It has different language but similar outcomes in relation to the duty of care in relation to assessment and mitigation of risk to the lowest reasonable level.

Under section 8 of the *Dangerous Goods Safety Act 2004*, 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.

The Dangerous Goods Safety (Major Hazard Facilities) Regulations 2007 (WA) provides for licensing of storage and handling facilities exceeding 5,000L of hydrogen²², which are otherwise consistent with chapter 9 of the model WHS Regulations. This is the only dangerous goods legislation, or WHS legislation that invokes a licensing threshold below the MHF scheduled amount of 50 tonnes of hydrogen or 10% notification threshold.

Proponents should be aware that in June 2024 the WA Government published a Dangerous Goods Safety Guide for the storage, handling and production of hydrogen. The guide is designed to assist all persons who store, handle or produce hydrogen gas and liquid in WA to understand what is required from a dangerous goods safety perspective.

3.5.2 Emergency Plans

Section 43 of the model WHS Regulations establishes a duty for every workplace to have an emergency plan. Proponents should note that it is your duty to:

- make an emergency plan, including an effective response to emergencies
- test the plan
- maintain the plan so that it's always effective
- arrange training for workers on the emergency plan and the procedures in it
- implement the plan in an emergency and follow emergency services' instructions.

You must consult with your workers and their health and safety representatives, if they are in place, when you are making and reviewing emergency plans. If you share WHS duties with others in the workplace, you must coordinate with them for a master emergency plan.

²² Note that this is the total volume (in liters) of all storage and pipework containing hydrogen (i.e. the water capacity).

3.6 Hazardous chemicals and dangerous goods

Key points:

- There are overlapping regulatory regimes for hazardous chemicals and dangerous goods in Australia. Key interactions include with the WHS and OHS Laws, transport of dangerous goods laws including the the Australian Dangerous Goods Code (ADG Code) and State and Territory legislation implementing the ADG Code and pipelines legislation.
- Only the Northern Territory, South Australia, Victoria and Western Australia have standalone dangerous goods laws.
- In jurisdictions that do not have specific dangerous goods laws hydrogen is regulated through a combination of safety regimes (i.e. Safety Laws, primary and general duties of care, whole of facility regulation, and plant and equipment regulation).

Hazardous chemicals and dangerous goods laws focus on managing risks associated with substances that have the potential to cause harm to people, property and the environment due to their explosive, corrosive, toxic or flammable nature.

3.6.1 Classification of hazardous chemicals and dangerous goods

A number of chemical classification frameworks are relevant to the definition of hydrogen in Australian regulations as a hazardous chemical or dangerous good. Among these, two classification frameworks are particularly relevant: the Globally Harmonised System (GHS) and the ADG Code.

3.6.1.1 The GHS

The GHS of Classification and Labelling of Chemicals (published by the United Nations) is a system for harmonizing hazard classification criteria and chemical hazard communication elements worldwide. The GHS classification framework is referred to in Australia's WHS Regulations and OHS Regulations (Vic).

Under the GHS, a chemical's classification is determined by assessing the chemical's properties against classification criteria. Under the GHS, flammable gases are gases having a flammable range when mixed with air at 20°C and a standard pressure of 101.3 kPa. The GHS outlines three categories of flammable gases – Category 1A, 1B and 2 – that differ based on properties such as pyrophoricity (that is, whether the gas is liable to ignite spontaneously in air at a temperature of 54°C or below) or chemical stability.

At 20°C hydrogen has a flammability range with air at standard pressure of 4-75% and is accordingly a Category 1A flammable gas. Hydrogen can also be captured by other GHS classification criteria (for example, 'gases under pressure').

3.6.1.2 The ADG Code

The ADG Code applies to road and rail transport of dangerous goods and is given its authority by its incorporation into State and Territory transport legislation. However, the ADG Code is also used by non-transport regulations for the purpose of defining dangerous goods.

The ADG Code allocates UN numbers to chemicals classified. Hydrogen can be identified in the ADG Code under different UN numbers including UN1049 HYDROGEN COMPRESSED and UN1966 HYDROGEN, REFRIGERATED LIQUID. This Guidebook considers only compressed and not liquefied hydrogen.

The ADG Code also identifies chemicals that meet specific types of hazards. Under the ADG Code, Division 2.1 flammable gases are gases which at 20°C and a standard pressure of 101.3 kPa:

- (i) are ignitable when in a mixture of 13% or less by volume with air; or
- (ii) have a flammable range with air of at least 12 percentage points regardless of the lower flammability limit. Flammability should be determined by tests or by calculation in accordance with the Australian Dangerous Goods Code, 2024, Edition 7.9 Page 101 with methods adopted by ISO (see ISO 10156:2017 *Gas cylinders — Gases and gas mixtures — Determination of fire potential and oxidizing ability for the selection of cylinder valve outlets*). Where insufficient data are available to use these methods, tests by a comparable method recognised by the competent authority may be used.

Hydrogen gas is ignitable when a hydrogen-air mixture exceeds a hydrogen concentration of 4% vol. in air and as such it meets the categorisation elements in a Division 2.1 Flammable Gas.

Some legislation also expressly prescribes or defines hydrogen, rather than drawing on classification frameworks like the GHS or ADG Code.

3.6.2 Hazardous Chemicals under Health & Safety Legislation

Chapter 7 of the model WHS Regulations focuses on the management of hazardous chemicals, including their classification, labelling, and safe handling. It outlines the duties of proponents and workers related to the use, storage, and disposal of hazardous chemicals.

Hazardous chemicals are defined in the model WHS Act as a substance, mixture or article that satisfies the criteria for any one or more hazards classes in the GHS. Hydrogen is a category 1A flammable gas under the GHS and so chapter 7 of the model WHS regulations applies to hydrogen.

Chapter 7 of the model WHS Regulations specifically includes requirements for providing Safety Data Sheets (SDS), health monitoring for workers, and managing risks related to hazardous atmospheres and storage and handling of hazardous chemicals, including the

need for risk assessments and the implementation of control measures to minimise risks to health and safety.

Under chapter 7 of the model WHS Regulations:

- proponents have a duty to manage risks associated with hazardous chemicals, including:
 - Providing and maintaining a work environment free from risks to health and safety
 - Ensuring workers are properly trained and supervised in the safe use of hazardous chemicals
 - Providing necessary personal protective equipment (PPE)
 - Implementing health monitoring programs for workers exposed to specific hazardous chemicals.
- workers must take reasonable care of their own health and safety and the health and safety of others at the workplace. This includes following procedures, using provided PPE, and reporting any hazards or unsafe situations.

Chapter 4 of the OHS Regulations (Vic) applies to the supply and use of hazardous substances in Victorian workplaces in order to control injuries, health effects and death resulting from exposure to hazardous substances and carcinogens. The Regulations impose specific legal responsibilities on employers, as well as self-employed persons, employees, manufacturers, importing suppliers and suppliers. WorkSafe Victoria provides a guide for hazardous substances health and safety which provides guidance for employers on how to protect employees from the workplace health and safety risks of hazardous substances.

WorkSafe Victoria has published a Hazardous substances health and safety guide for employers on how to protect employees from the workplace health and safety risks of hazardous substances. The guide notes that employer must so far as is reasonably practicable, eliminate any risks associated with hazardous substances in the workplace. If it's not reasonably practicable to eliminate the risk, an employer must reduce the risk, as far as reasonably practicable, by:

- using a less hazardous substance or a safer form of the substance
- isolating employees from exposure, or
- using engineering controls.

The guide also notes that an employer must review and, if necessary, revise any measures implemented to control risks associated with hazardous substances at the workplace, if the employer receives advice from a registered medical practitioner, or at the request of a health and safety representative.

The guide recognises that under the OHS Act (Vic) an employer has a duty to consult employees and health and safety representatives when identifying hazards and deciding on control measures²³. The guide provides that employers are required to²⁴:

- obtain a current Safety Data Sheet (SDS) for each hazardous substance
- make the SDS accessible to employees
- keep a list of product names and SDSs for all hazardous substances used at the workplace
- keep a list of who uses the substances or may be exposed to them
- not alter the information on an SDS.

3.6.3 Dangerous Goods and Substances

Dangerous goods (or dangerous substances) legislation aims to keep people and property safe from dangerous goods and explosives.

There are overlapping regulatory regimes for dangerous goods and hazardous chemicals in Australia. Key interactions include with the WHS Acts and OHS Laws (Vic), transport of dangerous goods laws including the ADG Code and State and Territory legislation implementing the ADG Code and pipelines legislation.

These laws will often expressly identify under which law a dangerous good will be regulated. As a nascent industry, hydrogen is often not expressly listed in definitions in this legislation in the same way as natural gas.

Depending on the legislation, whether hydrogen falls within a specific definition may depend on the proposed use of the hydrogen (e.g. whether it is intended to be used as a fuel and therefore be a ‘fuel gas’) or whether hydrogen is combusted or used in a fuel cell (e.g. some definitions only refer to combustion or burning of fuels), or whether the hydrogen is blended with another substance (some definitions refer to hydrocarbons and would capture blended hydrogen).

This means that the interaction of these regimes is not as clear for hydrogen as it is for other gases. Proponents should be aware of how hydrogen may be regulated under each of these regimes. As all are designed to ensure safety, and as such in practice there is opportunity to find commonality in compliance activities.

Not all jurisdictions have specific dangerous goods or dangerous substances legislation. Only the Northern Territory, South Australia, Victoria and Western Australia have standalone dangerous goods laws (refer to Annexure 3, table 3.6). In jurisdictions that do not have specific dangerous goods laws hydrogen is regulated through a combination of the other

²³ Section 35 of the OHS Act (Vic)

²⁴ Sub-division 2, Division 2, Chapter 4 OHS Regulations (Vic)

safety regimes identified in this chapter (i.e., Health & Safety Legislation, primary and general duties of care, whole of facility regulation, and plant and equipment regulation).

In South Australia, Victoria and Western Australia, dangerous goods legislation defines dangerous goods by reference to the ADG Code. As noted in chapter 3.6.1, hydrogen is classified as a division 2.1 flammable gas under the ADG Code and so will meet these definitions of dangerous goods. In the NT, the *Dangerous Goods Act 1998* (NT) applies to hydrogen where it is a 'fuel gas' (see Annexure 3, table 3.7).

Dangerous goods and substances legislation regulates the safe storage, handling and transport of dangerous goods. Common obligations include:

- general duties to ensure safety (see further chapter 3.4.3)
- proper classification with dangerous goods being correctly classified to their hazard class
- packaging and labelling where goods must be packaged appropriately and labelled with hazard symbols
- placarding where vehicles transporting dangerous goods must display placards indicating the type of goods being carried
- documentation which requires that proper transport documentation must accompany dangerous goods
- safety equipment requirements where vehicles must carry safety equipment for handling emergencies
- emergency procedures which operators must follow in case of spills or accidents, and
- segregation and stowage whereby dangerous goods must be stored and transported in a way that prevents reactions between incompatible substances.

This Guidebook does not address the transportation of hydrogen. However, when hydrogen transport containers are located at a hydrogen refuelling facility, depending on the specific laws, they may be treated as storage for that facility.

3.7 Plant and Equipment

3.7.1 Plant and Equipment regulatory framework

Key points:

- In addition to laws that apply to all workplaces, or whole hydrogen refuelling facilities, there are obligations that relate to individual plant and equipment or groupings of plant and equipment. These obligations may operate in parallel and/or in addition to other obligations.
- Proponent's will need to consider the specific nature of plant and equipment at their facility as there may be individual pieces of plant and equipment that are regulated separately.
- As an emerging industry, there is very limited practice and precedent establishing how hydrogen plant and equipment meet Australian laws.
- Overseas manufacturers may not understand the broader context of the laws with which their products need to apply.
- Accordingly, proponents will need to be particularly aware of how obligations attach to individual plant and equipment.
- Annexure 3, table 3.8 (electrical safety plant and equipment) and table 3.10 (gas appliances) identify jurisdiction specific plant and equipment legislation and obligations.

In managing workplace safety, it is important for proponents to understand the interrelationship between primary or general duties, whole of facility regulation, hazards chemicals and dangerous goods, and specific plant and equipment obligations. The plant and equipment regulations most relevant to hydrogen refuelling include:

- Duties relating to plant and equipment under Health & Safety Legislation, including duties regarding:
 - management or control of fixtures, fittings or plant at workplaces; and
 - design, manufacture, importing, supply, installing, constructing or commissioning of plant
- Pressure vessels: registration of pressure vessels is mandated under Schedule 5 of the model WHS Regulations (refer to chapter 3.7.3) Electrical equipment / installations: this is typically contained in electrical safety acts (refer to chapter 3.7.5 and Annexure 3, table 3.9)
- Dangerous goods: regulation of certain gas containers is regulated under dangerous goods laws (refer to chapter 3.6.3).

The existing approvals for all these types of plant and equipment include the following types:

- registration and approval of design of plant and equipment, including certification by a competent person (competent person also includes prescribed licensed trades as relevant) as to the safe operating capability of the design

- registration and approval of plant and equipment prior to supply to the market of that plant and equipment, including certification by a competent person as to the safe operating capability, and ability to meet standards, of that equipment
- certification by a competent person of the installation, operation and maintenance of plant and equipment, including where that plant and equipment are an ‘installation’ made up of operating systems of component plant and equipment
- the production and approval by a regulator of safe operation specifications, training, and integration into safety management plans.

Obligations applying to specific plant and equipment will operate in parallel (i.e. in addition to) primary and general duties and whole of facility regulation. In practice this means that:

- Proponents must ensure they are aware of and comply with specific plant and equipment obligations in addition to other laws
- Specific safety requirements relating to plant and equipment are relevant to compliance expectations for broader obligations such as primary and general duties and whole of facility obligations.

3.7.2 Control of risks associated with plant and equipment

Plant and equipment obligations focus on the safe operation, maintenance, and management of individual pieces of equipment or machinery / plant within the facility. These obligations ensure that each piece of equipment or plant meets specific safety standards.

Obligations can include:

- requiring duty holders to take all reasonably practicable steps to manage risks, conduct regular inspections, and comply with safety standards, protecting workers and the public from potential hazards
- maintaining detailed records of inspections, maintenance activities, and any incidents involving the equipment are also maintained to ensure accountability and continuous improvement.

Plant and equipment obligations establish safety standards that should be integrated into a proponent’s assessment of compliance with broader safety compliance. For instance, the safety standards for specific equipment set a baseline that should be incorporated into the overall safety considerations for the facility, ensuring a consistent safety approach.

Risks identified at the equipment level should feed into the facility-wide risk management plan, helping to create a comprehensive safety strategy. Training programs for specific equipment should be aligned with broader safety training to ensure consistency and a comprehensive understanding among employees. Additionally, records from equipment maintenance and incidents should be integrated into the facility’s overall safety documentation and reporting systems.

The chapters below provide specific information about the obligations that apply to plant and equipment.

3.7.3 WHS regulation of plant and equipment generally

The interaction between plant and equipment obligations and whole of facility WHS obligations is about creating a cohesive and comprehensive safety strategy. By integrating the specific safety standards and practices of individual equipment into the broader safety framework, facilities can ensure a consistent and thorough approach to workplace safety, ultimately protecting the health and well-being of all workers and the public, so far as is reasonably practicable.

Regulatory obligations relating to plant and equipment operate in addition to the Health & Safety Legislation and whole of facility obligations. While they are discrete obligations, to the extent that plant and equipment obligations demonstrate a standard or expectation of safety for plant and equipment, this standard is relevant when assessing the requirements for demonstrating whole-of-facility safety or the safety standard for primary and general duties.

The obligations apply to designers of plant, importers of plant, suppliers of plant, PCBU's installing, constructing or commissioning plant, persons with management or control of plant, and persons operating plant. Key obligations include:

- Provision of information relating to plant
- Emergency stop controls
- Control of risk through inspection
- Installing or commissioning plant with regard to information provided by a designer, manufacturer, importer or supplier
- Plant must not be commissioned unless the person installing or commissioning the plant has established so far as is reasonably practicable that the plant is without risk to the health and safety of any person
- Warning devices
- Maintenance, inspection and testing.

Chapter 5 of the model WHS Regulations addresses the control of risks associated with plant and structures, including maintenance and inspection, pressure equipment, and the registration of plant design and items of plant.²⁵

There is a model WHS Code of Practice: *'Managing risks of plant in the workplace'* and a similar Compliance Code under the OHS Laws (Vic). These Codes offer practical guidance on managing risks associated with plant in the workplace including guidance on what is plant, who has duties and identifying and controlling risk. The Code is an approved under the

²⁵ See Part 3.5 of the OHS (Vic) Regulations

Health and Safety Legislation. (See chapter 3.3.2 for more guidance around Codes of Practice under the Health & Safety Legislation).

The Australian Business Licence and Information Service (ABLIS) is also a useful resource for businesses seeking information on licenses and registrations. ABLIS primarily provides information on licenses required for various business activities, including those related to WHS.

Registration requirements aim to ensure that high-risk plant is designed safely and operates according to relevant technical standards. Examples of Registrable Plant include pressure vessels (refer to chapter 3.6.4 of this document), tower cranes, lifts and escalators, concrete placing booms, and mobile cranes.

Fines and penalties can be imposed for non-compliance with registration and inspection requirements. Regular maintenance and inspection are required to ensure the safety and functionality of plant and structures. This includes hydrogen storage tanks and compressors.

The model WHS Regulations mandate that duty holders must ensure that plant is maintained in a safe condition and inspected regularly to prevent risks to health and safety. Plant must be inspected by a competent person to ensure safe operation, which is part of the registration process.

Persons with management or control of plant, including owners, operators, and those responsible for installation, maintenance, or repair, have duties to ensure plant is safe, so far as is reasonably practicable.

3.7.4 Pressure vessels

Pressure equipment must comply with specific safety standards to prevent accidents due to pressure failures. For a hydrogen refuelling facility, the main class of plant and equipment that could require registration are pressure vessels including hydrogen storage tanks and compressors.

The model WHS Regulations require that pressure equipment be designed, manufactured, and maintained according to recognized standards, such as the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code to prevent risks associated with high-pressure hydrogen systems.

Refer to the Production Guidebook for detailed discussion on the application of pressure vessel definitions to electrolyser stacks.

The regulation of pressure vessels has two key aspects for hydrogen refuelling facilities:

- general safety compliance, including potentially relevant standards, and
- whether an item of plant is specified in Part 1 of Schedule 5 of the model WHS Regulations and the design is required to be registered under WHS and OHS laws and is

specified in Part 2 of Schedule 5 of the model WHS Regulations and the item of plant must be registered under WHS and OHS laws.

For the purposes of hydrogen facilities, the most relevant items of plant in Schedule 5 are the:

- registration of the design under Part 1 of Schedule 5: Item 1.1 Pressure equipment, other than pressure piping, and categorised as a hazard level A, B, C or D according to the criteria in section 2.1 of AS 4343:2014 (Pressure equipment—Hazard levels).
- registration of the item of plant under Part 2 of Schedule 5: Item 3.2 Pressure vessels categorised as hazard level A, B or C according to the criteria in Section 2.1 of AS 4343:2014 (Pressure equipment—Hazard levels), except gas cylinders, LP Gas fuel vessels for automotive use and serially produced vessels.

It is important to note that the determination of whether a design or item of plant is based on the specific criteria in Section 2.1 of AS 4343:2014 . It is not based on whether the design or item of plant would more broadly be captured by AS 4343:2014 if the Standard was to be read as a whole.

In addition, the Australian Standards such as AS 4343:2014 (Pressure Equipment — Hazard Levels) and AS 3788 (Pressure Equipment — In-Service Inspection) provide detailed guidelines on the classification, design, and inspection of high-risk equipment like pressure vessels.

Pressure vessels are classified according to their hazard level (A, B, or C) based on AS 4343:2014. Those with a Hazard Level of A, B, or C require registration.

A pressure vessel is a vessel subject to internal or external pressure which includes any interconnected parts and components, valves, gauges and other fittings up to the first point of connection to connecting piping. These vessels can be fired heaters and gas cylinders. Pressure vessel designs must be registered to ensure they meet safety standards. Pressure vessels must undergo regular in-service inspections to ensure they remain safe throughout their operational life.

Pressure vessel owners have a specific responsibility to ensure their vessels are safe to operate and meet all applicable regulations.

Individuals involved in plant registration and inspections must meet specific competency standards.

3.7.5 Electrical equipment and installations

Within Australia, electrical equipment safety is the responsibility of State and Territory governments administered through local legislation, regulatory requirements and compliance activities. Although minor inter-jurisdictional differences exist, the broad objectives are consistent. The obligations are mandatory in every State and Territory. Primary duties of care require a person conducting a business or undertaking to ensure the

business is conducted in a way that is ‘electrically safe.’ This includes making sure the electrical equipment used, designed, manufactured, imported and supplied is also ‘electrically safe’.

An example is section 10 of the *Electrical Safety Act 2002* (Qld) which defines electrical risk, electrically safe and electrical safety. The regulation of electrical components includes the following definitions:

- Electrical installation²⁶
- Electrical equipment²⁷
- Electrical appliance.

Because hydrogen facilities use electrical equipment such as electrolyzers, compressors, and dispensers, understanding the definitions of electrical equipment, installations, and appliances is important for compliance and safety.

Electrical installations are the broadest classification and encompass the complete system of wiring components and equipment used to deliver and utilise electricity. Electrical installations can include one or more pieces of electrical equipment. Examples include:

- Power Distribution Systems: Infrastructure that delivers electricity to various components like electrolyzers and compressors.
- Control Systems: Automated systems that manage the operation of hydrogen refuelling processes.

Electrical equipment includes any apparatus, appliance, or device used for generating, transmitting, converting, or utilizing electrical energy. Examples include:

- Compressors: Used to compress hydrogen gas for storage and refuelling.
- Dispensers: Equipment that transfers hydrogen from storage tanks to vehicles.

Electrical appliances include devices that consume electrical energy to perform a specific function. Examples include:

- Hydrogen Fuel Cells: Used in vehicles and stationary applications to convert hydrogen into electricity.
- Cooling Systems: Employed to maintain optimal temperatures for hydrogen storage and compression.

Annexure 3, tables 3.8 and 3.9 identify relevant laws and provides detail on specific definitions across jurisdictions.

²⁶ See for example section 15 of the *Electrical Safety Act 2002* (Qld)

²⁷ See for example section 14A of the *Electrical Safety Act 2002* (Qld)

3.7.6 Gas plant and equipment

Hydrogen facilities may include various gas components and systems including hydrogen storage and hydrogen compressors that must adhere to specific safety legislation and standards. The regulation of gas plant and equipment can include gas distribution systems and gas infrastructure, gas appliances and gas installations. While there are a range of definitions, and other than gas installations (which are dealt with under the chapter 3.5 above regarding whole of facility regulation) most gas definitions are not relevant to hydrogen refuelling.

Gas distribution systems and gas infrastructure: This broadly includes the pipelines used to supply gas to customers. These matters are out of scope for this Guidebook but will be addressed in the National Regulatory Guidebook: Hydrogen Pipelines. Examples include:

- Gas Distribution Systems: Infrastructure that delivers gas to various components like reformers and compressors.
- Control Systems: Automated systems that manage the operation of hydrogen production and refuelling processes.

Gas appliances: Gas appliances are devices that consume gas energy to perform a specific function. Definitions of gas appliance predominantly capture end-use appliances and are generally not applicable to plant and equipment at a hydrogen refuelling facility. End-use gas appliances are out of scope for this Guidebook. Gas Appliances can be:

- Type A Appliances: Typically, domestic or light commercial appliances (e.g., small-scale hydrogen generators).
- Type B Appliances: Industrial or heavy commercial appliances (e.g., large-scale industrial reformers and compressors).

Gas installations: the system of pipes, fittings and equipment used to convey, use or control gas and generally used to capture all or part of a facility (refer to chapter 3.5 whole of facility).

Gas Infrastructure: Refers to the larger network of pipelines, storage facilities, and distribution

Refer to Annexure 3, table 3.10 for examples of relevant State legislation regulating the safety of gas installations and equipment.

3.8 Regulator engagement and statutory notifications.

Key points:

- To achieve safety and environmental outcomes and ensure community support for hydrogen projects, proponents have a range of engagement requirements with the public, regulators and other key stakeholders.
- Legislated requirement to engage early and submit information for consideration by regulators varies significantly between jurisdictions.
- Irrespective of legal requirements, early and ongoing engagement with regulators and stakeholders is important for proponents to operate safe and compliant hydrogen operations in Australia.
- Statutory notifications to regulators can be proactive (applying prior to project commissioning), during operation, or reactive (requiring notification of an incident).

Early and ongoing engagement with regulators is important for proponents to operate safe and compliant hydrogen operations in Australia. This includes pre-project consultation, ongoing notification of activities and incidents, and worker engagement. Key legislation like the Health & Safety Legislation and State subject-specific laws emphasise these principles.

By involving regulators early in the planning and development stages, proponents can align their processes with legal requirements, thereby avoiding potential compliance issues and enhancing safety outcomes. For example, early consultation with SafeWork regulators can help identify and mitigate risks associated with hydrogen refuelling facilities.

Some regulations mandate regulator engagement through approvals or notification requirements prior to or shortly after commissioning (refer to chapter 3.5 whole of facility regulation). Even where not mandated by legislation, it is strongly recommended that proponents engage early with regulators including discussing regulatory requirements and activities required to demonstrate compliance.

This chapter also discusses notifications. In the context of regulatory compliance and safety management, notification refers to the formal process of informing regulatory authorities about incidents, such as a hydrogen leak or explosion, or incidents involving injuries or danger to persons, to ensure prompt action and risk mitigation. Notifications allow regulators to investigate, enforce corrective measures, and improve overall safety standards. A notification is a process by which the proponent informs the regulator in a formal manner.

For example, under the model WHS Act and Regulations the relevant regulator must be notified in several specific circumstances related to workplace safety and health including:

- **Notifiable Incidents:** These include the death of a person, serious injury or illness of a person, or a dangerous incident arising from the conduct of a business or undertaking (some types of work-related dangerous incidents must be notified even if no-one is

injured). The WHS Acts also impose a duty to ensure so far as is reasonably practicable, that the site where the incident occurred is not disturbed until an inspector arrives at the site or any earlier time that an inspector directs, except as required to do things such as assisting injured persons, making the site safe, and complying with regulators or law enforcement.

- **Hazardous Chemicals:** Notification is required when hazardous chemicals listed in Schedule 11 of the model WHS Regulations exceeds (or is likely to exceed) the manifest quantity prescribed in Schedule 11 of the model WHS regulations

3.8.1 Notifications relating to commencement, completion or other specific activities

Notifications to regulatory bodies about the commencement, completion, or specific activities of a hydrogen project maintain transparency and ensures regulatory oversight. These notifications help regulators monitor compliance and address any emerging risks promptly. For example, notifying SafeWork SA about the start of a hydrogen project allows for timely inspections and guidance.

Proponents engaged in high-risk construction work must adhere to section 299 of the model WHS Regulations and / or section 324 of the OHS Regulations (Vic) (as applicable) by preparing and submitting a Safe Work Method Statement (SWMS). This document outlines specific high-risk activities, identifying associated hazards, and detailing measures to control these risks. Creating a SWMS involves consulting with the workers who will be performing the tasks, ensuring that the document is accessible to them. Regular reviews and updates are necessary to maintain its effectiveness.

Upon completing a construction project, businesses may need to notify the relevant WHS regulator to confirm adherence to safety protocols. This process might include a final inspection and certification to ensure compliance with safety standards, along with a completion report that details the management of safety measures. Any incidents that occurred during the project must also be reported.

Maintaining a hazardous chemicals manifest, which includes a site plan and emergency contact details, is mandatory, and this manifest must be regularly updated.

Although construction work is excluded from the scope of this Guidebook, proponents involved in commissioning or undertaking construction work (including through contractors) should be aware that significant and complex safety obligations will apply.

Another example in subject-specific laws is in the *Gas and Electricity (Consumer Safety) Act 2017* (NSW) which requires that operators notify the regulator of serious incidents and certain activities involving hydrogen.

3.8.2 Incident Notifications

Incident notification is an important central aspect of maintaining a safe and compliant work environment. When a workplace incident occurs, swift and accurate reporting is not just a

best practice it's a legal requirement under the Health & Safety Legislation and State and Territory subject-specific laws. Proponents need to notify the relevant regulator which may include the relevant WorkSafe authority (for Health & Safety Legislation) or industry specific regulator. It is important to note that one incident may be captured under multiple regulatory schemes and so one incident may create multiple notification requirements. The form and timing of notifications under statutory requirements are specified by the legislation and the regulator(s) - i.e. legislation may specify the wording or form of a notification.

These laws are designed to ensure that hazards are identified, risks are mitigated, and workplaces are held accountable for maintaining safe conditions.

Incident notification helps prevent future accidents by enabling thorough investigations and the implementation of effective safety measures. It also supports injured workers by ensuring they receive necessary medical attention and workplace support. Compliance with these legal obligations protects employees, employers, and the broader community, reinforcing a culture of responsibility and continuous improvement in workplace safety.

For example, sections 38 and 39 of the model WHS Act focus on the duty to notify the regulator of notifiable incidents and preserve incident sites. From an overarching perspective proponents should be aware that section 38 of the model WHS Act requires a proponent to notify the WHS regulator immediately after becoming aware of a notifiable incident. Section 35 of the model WHS Act defines a 'notifiable incident' as:

- (a) the death of a person or
- (b) a serious injury or illness of a person or
- (c) a dangerous incident.

There are similar requirements in State and Territory subject-specific laws.

Prompt notification of incidents to regulatory authorities ensures swift action to mitigate risks and prevent recurrence. Incident notifications allow regulators to investigate the causes, enforce corrective measures, and improve overall safety standards. For example, reporting a hydrogen leak or explosion to the relevant authority ensures that appropriate steps are taken to address the hazard.

Notification allows regulators to:

- investigate the causes of the incident
- enforce corrective measures to address the issues
- improve overall safety standards by learning from incidents and making necessary changes.

There are a range of legislative obligations in each jurisdiction which mandate that a hydrogen project proponent must notify a regulator or other entity of incidents impacting

facility safety. Examples of the legislation, the requirements and who are required to be notified are outlined in Annexure 3, table 3.11.

3.9 Stakeholder Engagement and Consultation including workers and duty holders

Key points:

- Under the Safety Laws, persons conducting a business or undertaking must consult with workers and other duty holders on health and safety matters. Consultation helps identify hazards, assess risks, and implement effective control measures, ensuring a safer working environment.
- Section 46 of the model WHS Act requires duty holders to consult, cooperate, and coordinate activities with others who have a duty in relation to the same matter.
- Section 47 of the model WHS Act requires proponents to consult with workers who are, or are likely to be, directly affected by a matter relating to work health or safety.
- The model WHS Code of Practice: *Work health and safety consultation, cooperation and coordination* provides practical guidance on how to effectively consult with workers about work health and safety and meet your duties under the model WHS Act.
- Open communication fosters a positive safety culture, encouraging proactive hazard reporting and continuous improvement.
- Regular consultation ensures that all stakeholders understand their roles and responsibilities in maintaining safety standards.
- Annexure 3, tables 3.12 and 3.13 provide examples of obligations relating to consultation.

Ensuring the safety of a facility is not a solitary effort it requires meaningful engagement and consultation with a diverse range of stakeholders, including workers, duty holders, the broader community, and other key participants. Effective consultation fosters a culture of safety, where risks are proactively identified, solutions are collaboratively developed, and compliance with regulatory requirements is strengthened.

Workers and duty holders play a crucial role in facility safety, as they possess firsthand knowledge of workplace risks and practical insights into operational challenges. Their involvement not only enhances hazard identification but also ensures that safety measures are realistic, effective, and consistently applied.

Beyond the workplace, engaging with the community and other stakeholders such as local authorities and industry experts helps build trust, transparency, and accountability. Public consultation ensures that concerns are addressed, environmental and social impacts are considered, and the facility operates in alignment with broader societal expectations. Involving non-regulatory stakeholders, such as community groups, industry partners, and

educational institutions, helps ensure that safety measures are comprehensive, practical, and widely supported.

By fostering open communication and collaboration, organizations can create safer environments, improve compliance, and ultimately protect the well-being of both individuals and the surrounding community. Consultation is not merely a regulatory requirement it is a fundamental principle of responsible facility management.

Engagement by proponents with various stakeholders, including workers, duty holders, contractors, and the community, is important for developing effective safety strategies in the hydrogen industry. Stakeholder engagement fosters a culture of safety, encourages the sharing of diverse perspectives, and enhances the identification of potential hazards. Examples of duties to consult with duty holder are set out at Annexure 3, tables 3.12 and 3.13.

3.9.1 Duties to consult

All jurisdictions include a duty to consult within the operation of the Health & Safety Legislation.

For example, proponents should be aware of overarching requirements in section 46 of the model WHS which requires proponents, so far as is reasonably practicable, to consult, co-operate and co-ordinate activities with all other persons who have a duty in relation to the same matter.

Section 47 of the model WHS Act requires proponents to consult, so far as is reasonably practicable, with workers who carry out work for the business or undertaking and who are (or are likely to be) directly affected by a health and safety matter.

Proponents must consult with workers in accordance with section 49 of the model WHS Act including when:

- identifying hazards and assessing risks
- making decisions about ways to eliminate or minimise those risks
- making decisions about the adequacy of facilities for the welfare of workers, and
- proposing changes that may affect the health or safety of workers.

Workers must also be consulted when developing procedures for:

- consulting with workers on work health and safety
- resolving work health and safety issues
- monitoring workers' health and workplace conditions, and
- providing information and training for workers.

This duty to consult recognises that input from participating workers improves decision-making about health and safety matters and assists in reducing work-related injuries. Details of these requirements for each jurisdiction are set out in the Annexure 3, table 3.12.

Some duty holders have additional consultation requirements, such as designers, importers and manufacturers of plant, persons authorising work on electrical equipment, and principal contractors for construction work. The model WHS Code of Practice: *Work health and safety consultation, cooperation and coordination* includes a list of these requirements.

Outside of the Health & Safety Legislation, an example of consultation includes the *Hydrogen and Renewable Energy Act 2023* (SA) which includes in its objectives at subsection 3(a) to enable appropriate consultation before authorised operations are undertaken. The Act also requires consultation, including by the Minister, in relation to a number of actions including declaring a release area, granting a renewable energy feasibility licence, an agreement for a special enterprise, and identifying environmental impacts.

3.9.2 Consultation and engagement

Facility safety protects workers and others from hazards, and consultation and engagement with workers and duty holders is essential for achieving this goal. Under the WHS Acts, consultation cooperation and coordination of activities with other concurrent duty holders is a legal requirement and helps ensure that safety measures are effective, while engagement fosters a culture of safety and encourages proactive participation from all stakeholders.

When workers and concurrent duty holders are actively involved in safety discussions, it leads to the identification of potential hazards and the implementation of effective control measures. This collaborative approach not only enhances safety but also ensures compliance with legal requirements, such as the WHS Laws, which mandates consultation on health and safety matters.

Regular consultation fosters open communication, building trust and improving relationships between workers and management. When workers feel valued and involved in safety decisions, their commitment to maintaining a safe workplace increases, leading to higher job satisfaction. Additionally, effective safety measures can significantly reduce the costs associated with workplace accidents and injuries.

Providing ongoing training and education ensures that all workers are aware of safety practices and their roles in maintaining a safe workplace. Implementing feedback mechanisms, such as suggestion boxes, digital platforms, or direct communication with safety officers, allows workers to report hazards and provide feedback on safety measures.

Engagement can be further enhanced by encouraging workers to lead safety discussions and incorporating their feedback into safety policies can also foster a sense of ownership and responsibility. Using real-life scenarios and interactive training tools can make safety training more engaging and relevant to workers' daily experiences.

By prioritising facility safety and actively involving workers and duty holders in safety discussions, organizations can create a safer, more compliant, and more productive work environment.

3.10 Worker competency and licensing

Key points:

- Licensing confirms that a worker has met the minimum legal requirements to perform electrical work. It does not guarantee that the worker is competent in all areas of the scope of the licence such as specialised areas as hazardous locations. Workers must hold appropriate licenses or certifications to carry out regulated tasks.
 - Licensing requirements vary by State and Territory.
- Competent workers are less likely to make errors that could lead to injuries or damage to facilities. Workers must have the necessary skills, experience, and qualifications to perform specific tasks safely.
 - Required for roles involving hazardous materials, risk assessments, and technical operations.
- Employers must ensure workers meet licensing requirements and competency standards to comply with Australian workplace safety laws.
- ‘Competent person’ is defined at subsection 5(1) of the model WHS, and includes a person who has acquired through training, qualification or experience the knowledge and skills to carry out the task.
- Employers must ensure workers receive adequate training including induction programs, ongoing competency assessments, and emergency response training.

The regulatory frameworks for facility safety in each jurisdiction place obligations on proponents to employ particular types of workers to do particular types of jobs. In employing workers, the general categories of these regulatory obligations relevant to the activities of hydrogen proponents include:

- competent person
- licensed worker
- training obligations.

The following provides examples explaining the nature of regulatory obligations that relate to work skills and training.

Annexure 3, table 3.14 provides examples of competent persons, licensed workers and training obligations.

3.10.1 Worker competency under Safety Laws: the *competent person*

Many provisions in both WHS, dangerous goods, and electrical or gas safety legislation place the legal obligation on the operator of the facility to employ a ‘competent’ person to undertake tasks. There is, however, some variation as to what the phrase means, and what legal obligations it presents. Some examples include:

- the WHS Laws define a competent person at subregulation 5(1) of the model WHS regulations to include both specific requirements for specific circumstances as well as a general position where competency includes a person who has acquired through training, qualification or experience the knowledge and skills to carry out the task
- similarly, the OHS Regulations (Vic) provide at regulation 122, that certain tasks involving plant (e.g., maintenance, inspection, or operation) must be carried out by a person with the necessary training, qualifications, or experience to perform the task safely
- the Electrical Safety Regulation 2013 (Qld) at subregulation 7(2)(c) defines a qualified technical person to include an individual who is competent to perform electrical work as, or for, a licensed electrical contractor²⁸
- gasfitting works and workers subject to the *Gas Standards Act 1972* (WA) at section 13A centres around the holding of a certificate of competency, permit or authorisation granted under the Act authorising the relevant operation, work or process.

The tasks can be specific or general in nature, and often those tasks have a regulatory obligation. Examples include providing certification as to the safe design, installation or inspection of certain types of plant and equipment (such as electrical or gas installations or pressure vessels), the assessment and analysis of risk, or the design and delivery of training.

It is a legal obligation of facility safety for workers to be designated as being competent at the tasks they perform, and there are standards that must be met. These standards can vary by industry, nevertheless, the general scope is that the person must have the skills, experience and knowledge to conduct the task, be able to recognise risks to health and safety, and have the knowledge and authority to correct those risks. Workers who operate plant should also be competent or suitably supervised during training, so they do not put themselves or others at risk.

It is important that proponents understand the extent of the obligation of the ‘competent person’ within the Health & Safety Legislation and other laws impacting on facility safety. The model WHS Code of Practice for *Managing the risks of plant in the workplace* provides a description of a ‘competent person’ which includes:

- a person who has acquired through training, qualification or experience the knowledge and skills to carry out the task
- a competent person has a more specific meaning in the following circumstances:
 - For design verification, the person must have the skills, qualifications, competence and experience to design the plant or verify the design.
 - For inspecting plant for registration purposes the person must have:
 - educational or vocational qualifications in an engineering discipline relevant to the plant being inspected, or

²⁸ The AS/NZS60079 series details the competencies required to perform electrical work on electrical equipment in hazardous areas.

- knowledge of the technical standards relevant to the plant being inspected.

The model WHS Regulations establish a number of obligations that relate to worker competencies and the management of risks of plant in the workplace. Examples include:

- Subregulation 246(2) provides the purpose of registering an item of plant is to ensure that it is inspected by a competent person and is safe to operate. To have an item of plant registered, the item must be inspected and a statement provided by a competent person stating the plant is safe to operate.
- Regulation 267 provides that a person is competent to inspect an item of plant if the person has educational or vocational qualifications in an engineering discipline relevant to the plant, or knowledge of the technical standards relevant to the plant to be inspected.
- Subregulation 204(3) establishes a requirement that a proponent with management or control of plant at a workplace must ensure that a person who installs, assembles, constructs, commissions or decommissions or dismantles the plant is a competent person.
- Subregulation 206(1) establishes an offence where the person with management or control of plant at a workplace must take all reasonable steps to ensure that plant is used only for the purpose for which it was designed, unless the person has determined that the proposed use does not increase the risk to health or safety. Subsection 206(2) provides that in determining whether or not a proposed use of plant increases the risk to health or safety, the person with management or control of the plant must ensure that the risk associated with the proposed use is assessed by a competent person.
- Regulation 213 provides that a proponent with management or control of plant at a workplace must ensure that maintenance, inspection and, if necessary, testing of plant is carried out by a competent person.
- Subregulation 252(1) provides that a person is eligible to be a design verifier for the design of an item of plant if the person is a competent person.

To summarise, each proponent must turn their mind to the exact nature of the plant and equipment present, the competencies required to design, register, install, operate and remove plant, noting the nature of the hazards present. Where there is an existing legal obligation that provides for a particular licensed trade to undertake particular plant or equipment installation or commissioning work, a person who commissions that plant must turn their mind to the broader competent person duty.

3.10.2 Licensed Trades and accreditations

There are a range of provisions in legislative instruments across all Australian jurisdictions that place the legal obligations on proponents and/or the operator of a facility to employ a 'licensed' person to undertake specific work tasks or roles.

Under the Health & Safety Legislation licences are required for high risk work, asbestos removal work and for the operation of an MHF. Regulation 5 of the model WHS Regulations provides definition of licence holder including:

- (a) in the case of a high risk work licence—the person who is licensed to carry out the work or
- (b) in the case of an asbestos assessor licence—the person who is licensed:
 - (a) to carry out air monitoring during Class A asbestos removal work and
 - (b) to carry out clearance inspections of Class A asbestos removal work and
 - (c) to issue clearance certificates in relation to Class A asbestos removal work or
- (c) in the case of an asbestos removal licence—the person conducting the business or undertaking to whom the licence is granted or
- (d) in the case of a major hazard facility licence—the operator of the MHF to whom the licence is granted or transferred.

The model WHS Code of Practice: *Managing the risks of plant in the workplace* provides guidance in relation to licensing. This includes regulation 85 of the model WHS Regulations provides that a proponent conducting a business or undertaking at a workplace must not direct or allow a worker to carry out high risk work for which a high risk work licence is required unless the person sees written evidence provided by the worker that the worker has the relevant high risk work licence for that work.

Certain types of work require the worker to have a high risk work licence before they can operate the plant or undertake the work. Schedule 3 of the model WHS Regulations sets out the classes of high risk work licences and the types of plant involved, and Schedule 4 of the model WHS Regulations sets out the competency requirements for a high risk work licence.

Various State and Territory jurisdictions also require licensed professionals for specific tasks, particularly in electrical, plumbing, and gas work. These licensing regimes are contained in subject-specific laws which define the scope of permissible work and specify the required qualifications for different tasks. Many of these legislative instruments relate to electrical, plumbing and gas safety legislation.

For example, the *Home Building Act 1989* (NSW) imposes various licensing requirements in relation to specialist work. Specialist work includes electrical wiring work, gasfitting work, plumbing and drainage work, air conditioning work and refrigeration work. This work is required to be performed or supervised by a person with a contractor licence or supervisor or tradesperson certificate.

In this context ‘Electrical wiring work’ has the same meaning as it has in the *Gas and Electricity (Consumer Safety) Act 2017* (NSW). This includes work on an electrical installation (specifically, installation, repair, altering, removing or adding to the electrical installation), or the supervising of that work. An electrical installation means fixed appliances, wires, fittings and equipment used for conveying, controlling and using electricity. This will apply to hydrogen refuelling facilities to the extent that they include plant that conveys, controls or

uses electricity. Applicable pieces of equipment will require licensed contractors, supervisors or tradespersons to undertake their installation (and any repair or maintenance following installation).

Electrical Licensing in NSW is currently a role of NSW Fair Trading. All electricians working in NSW must hold a valid electrical licence regardless of the value of the job or whether the work is residential, commercial or industrial. Failure to hold a valid electrical license carries severe penalties.

As another example, in the ACT the *Construction Occupations (Licensing) Act 2004* (ACT) imposes licensing requirements on electrical wiring work and gas fitting work. The installation, maintenance and repair of plant and equipment in hydrogen refuelling facilities will need to be undertaken by a licensed electrician and/or licensed gasfitter. For electrical work a licensed electrician is required for 'electrical wiring work' to be undertaken on an 'electrical installation' as defined in the *Electrical Safety Act 1971* (ACT).

One of the many requirements in the gas and electrical safety laws is that a licensed worker with the requisite qualifications must perform work on any piece of plant or equipment that meets the definition of an electrical installation. This ensures that only qualified individuals handle such tasks, maintaining safety and compliance with relevant regulations. This is just one example of the many requirements in gas and electrical safety laws which require a licensed worker with the requisite qualifications to 'work' on a piece of plant or equipment that meets the definition of an electrical installation.

In general, the legislative frameworks define the type of work and then provide a licensing regime to determine what license is required to do what type of work. The types of work that are regulated can include the provision of certificates of compliance with relevant safety regulations or standards, the provision of certification of inspection and maintenance, and the installation and operation of certain types of plant and equipment.

This section of this Guidebook is important in the context of the outcomes of the matrix of definitions which disclose that there are significant items of plant which meet the definition of 'electrical equipment and installation', but there are limited provisions which meet the definition of gas equipment or installation'.

The *Gas Standards Act 1972* (WA) prohibits a person from performing gasfitting work (as defined in the regulations) unless authorised by a gasfitting permit, certificate of competency or authorisation. The Gas Standards (Gasfitting and Consumer Gas Installations) Regulations 1999 defines 'gasfitting work' as 'an operation, work or process in connection with the installation, removal, demolition, replacement, alteration, maintenance, or repair of a gas installation'.

The *Gas Standards Act 1972* (WA) defines 'gas installation' as 'any appliance, pipes, fittings or other apparatus installed or to be installed for or for purposes incidental to the conveyance, control, supply or use of gas'. The equipment in a refuelling facility, which does

not include production equipment (i.e. one supplied via a distribution system or a periodically refilled bulk tank), is a gas installation in so far as the equipment is associated with the conveyance, control, supply or use of gas. This will likely include most equipment.

The equipment in a refuelling facility, which includes production equipment (i.e. one supplied via an electrolyser and related process equipment), is equally a gas installation in so far as the equipment is associated with the conveyance, control, supply or use of gas. What items of equipment forms part of a given gas installation will vary depending on the configuration of equipment of the refuelling facility but will generally start downstream of the production or refining equipment.

Clearly, gas is present within a hydrogen refuelling facility and the skills and training of, for example, an expert high pressure gas fitter with additional hydrogen specific training or knowledge may be appropriate. Currently, because the existing gas regulatory frameworks are generally based on natural gas distribution and supply networks reliance on the prescriptive licensed trades provisions are not necessarily sufficient to meet broader legal obligations in relation to ‘competent’ persons, appropriate training and the general duty to ensure safety. Therefore, the proponent is obliged to nominate a competent person to obtain the ‘gas authorisation permit’ in the state, until a nationally consistent unit of competency has been established for practitioners working on hydrogen refuelling facilities.

3.10.3 Training

The focus on training obligations sits as a key element underpinning the primary and general duties of care for worker safety. Providing training that meets the relevant regulatory obligation also supports and relies upon the concept of the competent person in ensuring that the training is appropriate and adapted to its purpose and will comply in practice with the legal obligation which is to eliminate or reduce the risk to the lowest practical level.

Section 19 of the model WHS Act establishes the primary duty under the WHS Laws (see more detail regarding the primary duty at chapter 3.4 above). Paragraph 19(3)(f) provides that, without limiting the primary duty, a proponent must ensure, so far as is reasonably practicable, the provision of any information, training, instruction or supervision that is necessary to protect all persons from risks to their health and safety arising from work carried out as part of the conduct of the business or undertaking.

This training should include information, instruction, and supervision tailored to specific tasks and worker needs, as required by Health & Safety Legislation.

Safe Work Australia provides guidance regarding training and supporting your workers to stay safe at work. Under the model WHS Acts, proponents must ensure workers are provided with the information, training, instruction and supervision required to help them remain healthy and safe in the workplace. The information that is provided must be easy to understand and should include:

- potential risks associated with their work

- how to work safely
- the safety policies and procedures in place
- how to raise a WHS issue, and
- how to deal with emergencies.

The following three steps will help proponents to ensure workers are appropriately trained and supported:

1. provide induction and workplace health and safety training for new workers
2. train workers for their specific tasks, and
3. provide ongoing training and supervision.

Training requirements may be implicit and/or explicit through legislative instruments in each jurisdiction. For example, the Dangerous Goods Safety (Major Hazard Facilities) Regulations 2007 (WA) expresses the duty in relation to dangerous goods whereby an operator of a dangerous goods site must ensure that a person involved with the storage and handling of dangerous goods at the site is provided with induction, information, training and supervision and keep records of induction and training activities for at least 5 years.

As another example, Part 2 of the *Electrical Safety Act 2022* (NT) establishes a range of general duties which are not transferable, and proponents may be subject to multiple duties. The *Electrical Safety Act 2022* include references to the *Training and Skills Development Act 2016* (NT) which regulates the training and skills development system, focusing on apprenticeships, traineeships, and vocational education and training. It aims to ensure quality training, promote equitable access, and support partnerships between industry, education, and training providers.

Training is one of the many requirements which may be implicit and / or explicit through legislative instruments in each jurisdiction. This is a complex issue in the context of the existing regulatory framework and their specific application to hydrogen refuelling facilities because, hydrogen training in contrast with both competencies and licensed trades, in gas, electrical and plumbing trades does not have the many years of practice or precedent that exist in traditional industry. Given this, proponents should consider carefully the skills and knowledge that will be needed for employees to undertake different roles in their facilities, and to ensure they can, at a minimum have an informed view about the nature of training needs. In doing so, they should ensure that there is some level of expert or competent person involvement in considering these needs, including consideration of:

- agreed / benchmarked competencies for each job role within hazardous industries, and
- established, accredited (peer reviewed / oversighted) training courses, delivered by identified and agreed 'competent' persons that ensure the training for employees is appropriate and adapted for the nature of the work.

Chapter 4 – Regulatory obligations: Planning and Environment

Planning – development approval requirements

Key points:

- Each State and Territory has its own planning framework and planning scheme
- Depending on the location of a project, planning processes may require engagement with local councils or State/Territory governments
- Planning schemes require proponents to develop a community engagement strategy, identify hazards, assess associated risks, and implement control measures to mitigate or eliminate these risks
- In general, hydrogen refuelling facilities are captured under existing definitions of service station or equivalent
- Each Australian jurisdiction has general guidance on their respective planning frameworks. This Guidebook does not replicate this information, but Annexure 4, table 4.1 provides a high level summary and contacts.
- Hydrogen refuelling facilities will be a development for the purpose of planning legislation and projects will, in general, require development approval with limited exemptions.

4.1.1 Australian planning frameworks in context

Planning regulation in each Australian State and Territory apply controls on land use and development of projects. State and Territory planning regulation broadly includes:

- strategic land use planning which prescribes high-level planning objectives and requirements
- site specific development controls where development of individual projects are assessed against applicable planning frameworks, usually through the submission and assessment of a development application.

In all States and Territories there is overarching planning legislation, supported by strategic environmental or planning instruments, which detail the criteria for assessing individual development applications. Strategic planning instruments may be developed at the State and Territory level, local council area, or at a targeted area of significance.

Local councils in Australian States play a crucial role in administering these laws, particularly in planning and development approvals. In the Australian Capital Territory and the Northern Territory, all planning and development approvals are managed at the Territory Government level.

In general, hydrogen projects in the planning context will fall within definitions of service station or equivalent but may also trigger requirements of hazardous chemicals projects.

However, the application and operation of planning instruments varies significantly between jurisdictions (including the allocation of responsibility between States and Territories and local councils). Proponents should ensure they comply with the relevant planning instruments for the area in which they are operating (see Annexure 4, table 4.1).

Each Australian jurisdiction has general guidance on their respective planning frameworks and this Guidebook does not replicate that information (see Annexure 4, table 4.1). Rather, this chapter 4 of This Guidebook will focus on the practical application of development controls to hydrogen projects by considering the following issues:

- Will hydrogen refuelling projects require development approval?
- What development application pathways are relevant to hydrogen refuelling projects?
- How are hydrogen refuelling facilities treated when there is combined land use (e.g. where facilities are co-located with another activity)?
- How are refuelling facilities classified under planning laws (e.g. service station)?
- What are the hydrogen refuelling specific requirements for development approvals?

4.1.2 Is a hydrogen refuelling facility a development?

The threshold for determining if a development approval may be required is whether a proposed activity is considered ‘development’ under the law of the relevant jurisdiction.

While the definition of ‘development’ varies across planning legislation, it commonly includes:

- building, demolition/removal/alteration and other construction works on land
- the start of a new land use or change to (or rezoning of) an existing land use
- earthworks (excavation or fill)
- subdivision or consolidation of land (not all jurisdictions).

This Guidebook is targeted at the development of hydrogen refuelling facilities whether on a brown- or greenfield site or through augmentation/retrofitting of an existing service station. In each case, a hydrogen refuelling facility **will be** development for the purpose of planning legislation.

4.1.3 Relevant development approval pathways

Planning legislation generally makes it an offence to carry out development without a development approval (unless it is an exempt activity such as minor works or otherwise authorised).

It is anticipated that in all State and Territories hydrogen projects will, in general, require development approval with limited exemptions.

The core steps in the development approval process are generally consistent across all States and Territories. However, the specific process and approval authority vary significantly (in this Guidebook collectively called the ‘development approval pathway’).

The development approval pathway available for a hydrogen project will depend on a range of factors, including location (whether it is in a particular local government municipality, a port, city or designated development area), requirements of the relevant planning instruments, potential environmental impacts, scale, and economic or employment impacts for the State or Territory.

Table 4.2 at Annexure 4 summarises the most likely development approval pathways relevant to hydrogen refuelling developments in each State and Territory.

The requirements for evaluating a development application for a hydrogen refuelling project are discussed in chapter 4.2.4 (below).

4.1.4 Requirements for development approvals.

Irrespective of which development approval pathway a proposal follows, there is broad consistency in the hydrogen specific matters that need to be considered when evaluating a development application for a hydrogen refuelling facility.

Relevant matters for consideration when evaluating development applications include: the requirements of applicable planning instruments and site-specific development controls, the likely impacts of the development (including environmental impacts on the natural and built environments, social and environmental impacts), the suitability of a site for development, submissions received, and the public interest.

For the purpose of this Guidebook, the most significant specific considerations for a hydrogen refuelling facility are:

- safety of the facility and potential impacts on surrounding areas (refer chapter 4.2.5 below)
- assessment of environmental impacts (refer chapter 4.2.6 below).

Examples of other matters that proponents might need to address in a hydrogen development application include:

- Utilities – what arrangements have been put in place for the supply of utilities?
- Noise – indications are that noise levels associated with hydrogen refuelling facilities in both construction and operation are within common parameters for industry. Is construction or operation intended to occur outside of regulated hours?

- Traffic, transport and parking – will hydrogen be produced on-site or received from another location? How will the facility impact upon road networks and parking?
- Air quality – will construction or operation of the facility impact air quality in the vicinity and, if so, how will those impacts be minimised or managed?
- Waste management – what are the classification of waste streams for construction and operation and how will on-site waste be minimised or managed?
- Community and stakeholder engagement – what is the strategy for community and stakeholder engagement and management of complaints?
- Spoil management – construction of facilities requires excavation of large quantities of soil. The proponent needs to develop measures for safe handling, transporting, reusing and/or disposing of surplus soil.
- Stormwater management – The proponent needs to manage stormwater to ensure that runoff is directed away from operational areas. Generally, development applications require the submission of blueprint which contains the design of drainage systems (pipes, channels, conveyances, sediment trap, etc.) for safe management and control of runoff.
- Amenities – how does the development impact the local amenity? Does the emergence of industrial buildings diminish the quality of life that the neighbouring communities previously enjoy?

These matters are not necessarily specific to hydrogen projects and are not discussed further in this Guidebook.

4.1.5 Planning laws and facility safety: hazard assessment and mitigation

Due to the presence of hydrogen (a hazardous chemical), all hydrogen refuelling facilities are inherently hazardous and require a thorough and robust assessment of risk and the ongoing management of safety. Facility safety is addressed in detail in chapter 3 and this chapter 4.2.5 considers only the interaction between planning laws and safety.

The regulatory requirements to evaluate hydrogen facility safety as part of a development approval process varies significantly between jurisdictions. In different jurisdictions, depending on the type of application made, a decision-maker / regulator may have the discretion to consider additional matters such as safety as part of its planning assessment, or this may be outside of its jurisdiction or statutory considerations.

As a matter of best practice and to ensure safety is appropriately evaluated, proponents should:

- engage early with the relevant safety authorities, including at the same time or earlier than engaging with planning authorities

- incorporate assessment and compliance with best practice facility safety into planning applications (refer to chapter 2 and chapter 3 of this Guidebook in relation to facility safety best practice).

Annexure 4, table 4.3 provides further detail on the facility safety requirements in the evaluation of development applications.

4.1.6 Assessment of environmental impacts

Planning frameworks require that the likely impacts of a development on the natural and built environments, and social and economic impacts in a locality are considered in the evaluation of development applications.

As such, proponents are required to undertake an environmental impact assessment (EIA) and report to government on the potential environmental impacts of their project.

Planning and environment protection legislation in all jurisdictions mandate a formal EIA process following prescribed steps in specified circumstances.

Depending on the jurisdiction, the requirement for and level of EIA required is determined by the potential for a project to cause environmental harm and/or whether the proposed project meets prescribed thresholds for certain activities, such as the manufacture or storage of hazardous chemicals. An EIA may need to be supported by detailed environmental monitoring of native flora and fauna for up to 2 years to account for seasonal variations. Monitoring may be overseen or guided by a state or commonwealth agency to meet environmental assessment needs.

There is variation across jurisdictions as to whether the EIA process is undertaken by an environmental protection agency or planning authority, and how the outcomes of the EIA process is incorporated into the development application evaluation.

For example, depending on the jurisdiction, the EIA:

- may result in a stand-alone environmental approval that is a prerequisite to, or separate from, obtaining a development approval
- may need to be considered in the evaluation of a development application or other assessment pathway
- may give rise to veto rights over a development application.

Even where a legislated EIA process is not required, development approval authorities will consider sustainable development principles. The environmental considerations that must be considered for a particular application needs to be determined on a case-by-case basis. It will depend on the applicable law, planning instruments, location, nature and scale of proposed development, the site constraints and development controls.

For hydrogen refuelling, key matters that should be detailed in any development application include:

- the potential discharges and fugitive hydrogen emissions from a facility
- identification, management and mitigation of impacts to environmental values in and surrounding the proposed project's boundaries.

Chapter 4.3 provides details on specific environmental assessment triggers and requirements.

4.1.7 Determining the dominant purpose

Hydrogen refuelling facilities may be co-located with a range of other existing or potential land uses. For example, hydrogen refuelling could involve:

- refuelling facility co-located with a hydrogen production facility of varying scale
- refuelling facility combined with facilities for converting and distributing hydrogen derivatives, such as liquid hydrogen, methanol, ammonia or other hydrogen carrier (each carrier may trigger different land use classifications)
- refuelling facility co-located within an existing transport hub, interchange or intermodal terminal.

Like other developments, hydrogen refuelling developments will often be carried out for more than one purpose.

As such, the first step in characterising a development is determining a development's dominant or principal purpose.

Annexure 4, table 4.4 provides some general examples of how land uses for a range of potential hydrogen refuelling scenarios may be considered under planning legislation. Each scenario will depend upon the specific details of the project, its location, governing legislation and site-specific development controls.

4.1.8 Land use classification

In most jurisdictions, hydrogen refuelling facilities are not expressly identified in a standalone land use classification. Existing land use classifications relating to the retail sale of fuel are generally broad enough to capture the dispensing of hydrogen.

Annexure 4, table 4.5 sets out some of the possible land use classifications for each jurisdiction. This table is indicative only as land use classification is highly location specific and subject to the relevant planning requirements applicable to the project.

Proponents will need to obtain their own independent advice to determine which land use classification(s) applies to their project.

4.1.9 Nature of development application (Land use permissibility)

Zoning is used in planning instruments to control the sort of uses that will be permitted, restricted or prohibited within a specified area. Each zone allocates different uses.

There is significant variation between jurisdictions in whether and to what extent developments are permitted to occur in a specified zone.

Proponents should refer to each jurisdiction's zoning tables to determine permissibility for their project in a particular location. However, broadly developments are classified in zones as:

- **Exempt use:** certain uses are exempt from obtaining approval
- **Permitted or accepted without consent:** In general, permitted or accepted land uses means that the use is permitted or accepted provided it complies with any relevant development standards or requirements specified in that jurisdiction's planning framework
- **Discretionary:** consent is required with a more comprehensive assessment of whether the proposal is appropriate in its context. Discretionary uses may not be allowed in all instances in all locations. Discretionary uses allow an application to be made which is then assessed as to whether the proposed use is suitable on the proposed site having regard to the applicable planning framework
- **Prohibited:** a use is prohibited and cannot proceed. In some jurisdictions, this may require an application to change the zoning of the land before a development application can be submitted. Note: there are nuances across jurisdictions on prohibited land uses and specific advice should be obtained.

Due to the highly variable nature of permissibility, this Guidebook does not provide a summary of potential permissibility for hydrogen refuelling projects. Proponents should refer to each jurisdiction's zoning tables to determine permissibility for their project in a particular location.

4.1.10 Planning considerations for hydrogen a refuelling facility at a port

Some jurisdictions have specific planning frameworks that apply to developments on land in a port or within specific ports that may be separate or complementary to the standard development pathway.

The safety and environmental considerations identified in this Guidebook remain relevant to hydrogen developments in all locations. However, for hydrogen refuelling facilities, proponents should seek advice on specific or additional requirements if that location is a port.

Annexure 4, table 4.6 provides a high-level summary of some of the specific legislative instruments applying to undertaking projects in a port area.

4.1.11 Application of Airports and Airspace regulations

In Australia, major airports in each State and Territory are on Commonwealth land and the responsibility of the Commonwealth Government. These airports are regulated under the *Airports Act 1996* (Cth).

Airspace in Australia is regulated by the Civil Aviation Safety Authority (CASA). CASA is the safety regulator in respect of civil air operations in Australia in accordance with the *Airports Act 1996* and the Civil Aviation Safety Regulations 1998 (Cth) (CASR).

The *Airports Act 1996* establishes a system for regulating leased federal airports, including:

- major development plans will be required for significant developments at airports (developments over \$25 million)
- most building activities on airport sites require approval (maintenance type activities may be exempt)
- buildings and structures on airport sites must be certified as complying with the relevant regulations and in some cases the jurisdictional codes and/or Australian Standards
- each airport must have an environmental strategy, and the regulations may deal with environmental standards at airport sites
- regulations may control intrusions into prescribed airspace around airports.

Hydrogen facilities near airports may require approvals if it causes emissions or turbulence above levels prescribed by the CASR. The *Airports Act 1996* also provides for activities to be 'controlled activities' where the activity exceeds certain emissions of steam or gas, but no levels have been prescribed at this time.

The CASR also contains provisions that regulate activities that may impact on aircraft operations. Regulation 139.165 and Regulation 139.170 of the CASR respectively require a person to notify the CASA if:

- a person proposes to construct or erect an object or structure that will:
 - have a height of 100 metres or more above ground level or
 - include an emissions source that generates a gaseous efflux with a velocity exceeding 4.3 metres per second at the point of emission.
- a person proposes to undertake an activity that will create an emissions source that generates a gaseous efflux with a velocity exceeding 4.3 metres per second at the point of emission.

Regulation 139.180 of the CASR provides that CASA may determine that a structure or emissions that triggers the above matters, are a hazard to aircraft operations. CASA may

consider the kinds of objects or structures or emissions that may constitute a hazard to aircraft operations by reference to the Part 139 Manual of major made under the CASR.

4.2 Environmental Impact Assessments (EIA)

Key points:

- Environmental impact assessments (EIA) are a tool used to identify the environmental, social and economic impacts of a project prior to decision-making
- An EIA is typically associated with a development approval process; however, it is also a tool more broadly applicable as part of a range of environmental obligations
- Hydrogen facilities will likely be required to undertake some form of EIA.
- Most jurisdictions can require either a streamlined or more comprehensive EIA depending on the potential environmental, social or economic impact of a hydrogen facility.
- Annexure 4, table 4.7 provides a summary of the legislated EIA processes for each jurisdiction.

4.2.1 Overview of EIAs

Environmental laws in Australia are governed at multiple levels.

At the Commonwealth level, the primary legislation is the EPBC Act. The EPBC Act focuses on protecting matters of national environmental significance, such as world heritage sites, wetlands, and threatened species. The Commonwealth Government is responsible for assessing and approving actions that may have a significant impact on these matters.

Each State and Territory has its own environmental laws that regulate land use, development, pollution control, and biodiversity protection. For example, States have their own environmental protection agencies that manage pollution control and waste disposal. Local councils, created under State and Territory laws, play a crucial role in administering these laws, particularly in planning and development approvals.

EIA is a tool used to identify the environmental, social and economic impacts of a project prior to decision-making. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce or avoid adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers.

An EIA is typically associated with an approval process (refer chapter 4.2) including development approvals. However, it is a tool that is also more broadly applicable as part of a range of environmental obligations (refer chapter 4.4).

In general, EIA regulations and process will apply to refuelling facilities in a similar way to other projects. This chapter 4.2 of focuses on providing guidance on how the broader EIA principles-based framework may apply in the hydrogen context.

There are broadly three levels of environmental assessment:

1. proponent self-assessment (refer chapter 4.3.2)
2. streamlined EIA – proposals with lower potential environmental impact (refer chapter 4.3.3)
3. comprehensive EIA – proposals with more significant potential environmental impact (refer chapter 4.3.4).

Depending on the jurisdiction, legislation mandates that an EIA process be undertaken either by reference to a list of prescribed activities or to the extent of the environmental impacts the activity may have.

Annexure 4, table 4.7 provides a summary of the legislated EIA processes for each jurisdiction.

4.2.2 Proponent self-assessment

Proponents will need to first undertake a self-assessment of the potential environmental impacts of the project. This self-assessment is necessary to determine which legislated EIA, if any, will be relevant to their project.

Even if a project is not required by legislation to undertake an EIA, it is still necessary for the project to understand its potential environmental impacts. In particular, where the project goes through a development application process, a development authority may still assess the potential environmental impacts of the project as part of its decision-making criteria.

All State and Territory jurisdictions incorporate environmental objectives into planning legislation in one way or another. Legislation across different jurisdictions can include:

- promoting sustainable development
- facilitating ecological sustainability
- protecting ecological processes and natural systems
- protecting biological diversity
- responsible use of land and water resources
- providing for the sustainable use and development of air, land and water
- ensure that effects of developments on the environment are considered
- proper environmental management of chemicals.

It is likely that hydrogen projects will be required to go through some form of EIA and so self-assessment is not discussed further. If such a situation should arise, proponents should have regard to the specific requirements of individual development authorities. At a minimum, the following information should be included:

- identification of environmental values and assessment of anticipated impacts of the proposal on those environmental values
- details of the avoidance, mitigation and offset measures to be implemented by the proposal
- location details and site characteristics and development controls
- community and stakeholder engagement
- expected environmental, social and economic effects of the development
- proposed safeguards and management plans.

4.2.3 Streamlined EIAs

Where projects are likely to have a lower level of environmental impact, regulatory frameworks commonly provide for a streamlined EIA process.

Annexure 4, table 4.8 summarises the streamlined EIA processes across Australia (as noted above).

4.2.4 Comprehensive environmental impact assessments

Projects that are likely to have a more significant environmental impact are required to undergo a comprehensive EIA. As noted above at chapter 4.2.6 an EIA may include the need for environmental monitoring of native fauna and flora.

Annexure 4, table 4.9 summarises the comprehensive environmental assessment processes across Australia.

4.2.5 Requirements of an environmental impact assessment

Each jurisdiction has its own specific requirements and generally have comprehensive guidance on navigating the EIA process.

Common requirements of an EIA include:

- background of the project and project rationale
- location details and site characteristics
- description of the project's components/infrastructure
- description of project phases and scheduling (e.g. construction, commissioning, operation and decommissioning)

- details of the activities and processes taking place within the facility during the operational phase
- community and stakeholder engagement
- statement of expected environmental, social and economic effects of the development
- information on potential emissions to land, water and air resulting from the activities and processes conducted within the facility
- proposed safeguards, mitigation measures and management plan
- consequences of not proceeding with the project / alternatives to the project
- procedures to implement for ongoing and continuous improvement.

4.3 Environmental approvals, offences and obligations

Key points:

- This Guidebook focuses on those environmental obligations more significantly impacted by the nature of hydrogen facilities.
- This Guidebook does not discuss those environmental obligations more significantly impacted by the location or footprint of activities (such as restrictions on areas of high conservation value or impacts on threatened/protected species).

4.3.1 Australian environmental regulation in the hydrogen context

Environmental matters are regulated across the Commonwealth, States, and Territories to protect the environment as well as to prevent and manage activities that have or may have an adverse impact on the environment.

For this Guidebook, environmental considerations have been categorised into obligations significantly impacted by the nature of project activities and obligations that are more significantly impacted by location and footprint of operations.

Environmental obligations more significantly impacted by nature of project activities	Environmental obligations more significantly impacted by location and footprint
General environmental approvals and licences.	Restrictions on activities in areas of high conservation value.
General environmental duty to prevent or minimise environmental harm or environmental nuisance.	Impacts on threatened / protected species.
Pollution offences.	Use and over-abstraction of water resources.
Environmental harm offences.	
Contamination offences.	
Transport and disposal of controlled wastes.	

This Guidebook is focused on environmental matters that are most directly affected by the design and operation of a hydrogen facility. In contrast, environmental matters that would be relevant to any project in a particular area irrespective of whether that project was a hydrogen project such as restrictions on activities in areas of high conservation value, impacts on threatened or protected species, land clearing or the use or over-abstraction of water are not considered in detail in this Guidebook.

4.3.2 The Environment Protection and Biodiversity Conservation Act

4.3.2.1. Overview

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Environment Protection and Biodiversity Conservation Regulations 2000* (EPBC Regulations) are Australia's main national environmental legislation applying to all Australian jurisdictions and External Territories. The EPBC Act will apply to a hydrogen project where it has, will have or is likely to have a significant impact upon a matter of national environmental significance (MNES) or is carried out on or impacts Commonwealth land, Commonwealth marine areas, or is undertaken by a Commonwealth agency.

The need for an EPBC Act approval requires an assessment as to whether a project has, will have or is likely to have a significant impact on a matter of national environmental significance protected under the Act, or is undertaken by a Commonwealth agency or involves Commonwealth land and will have a significant impact on the environment. It is an offence to carry out an action (which includes a hydrogen project) that has, will have or is likely have a significant impact on a matter protected under the EPBC Act without assessment and approval. Unlike State and Territory regulations under the EPBC Act there is no specific focus on pollution, waste, contaminants or other specific environmental impacts. Accordingly, whether a hydrogen refuelling facility requires approval under the EPBC Act will be influenced most significantly by the location of the project and whether the project will or has potential to significantly impact upon the matters protected by the Act.

The EPBC Act operates concurrently with environmental protection legislation in the States and Territories. A proponent may need to obtain approval under both the EPBC Act as well as the applicable State or Territory legislation for a hydrogen project. The EPBC Act is not intended to exclude or limit the concurrent operation of any law of a State or Territory.

4.3.2.2. Scope of the EPBC Act

The EPBC Act protects MNES, which are:

- world heritage properties
- national heritage places
- wetlands of international importance (listed under the Ramsar Convention)
- listed threatened species and ecological communities

- listed migratory species (protected under international agreements)
- Commonwealth marine areas
- the Great Barrier Reef Marine Park
- nuclear actions (including uranium mining)
- water resources (that relate to coal seam gas development and large coal mining development).

The EPBC Act also applies when actions are taken:

- on Commonwealth land or that impact upon Commonwealth land
- by an Australian Government agency anywhere in the world
- that impact Commonwealth heritage places overseas.

Any action that may have a significant impact on any of the areas listed above must be referred to the Commonwealth Minister for the Environment. The Minister will determine whether the referred action requires assessment and approval under the EPBC Act. If an approval is required, the action will be assessed by that department (with the exception of project assessed under a bilateral agreement see chapter 4.4.2.3). The Minister will decide whether to approve or refuse the action, and if approved, what conditions of approval may apply. It is an offence to carry out any action that has, will have or is likely to have a significant impact on a matter protected under the EPBC Act without assessment and approval.

‘Significant impact’ is described in the *Significant impact guidelines*²⁹ as an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted and upon the intensity, duration, magnitude and geographic extent of the impacts. Proponents should consider all these factors when determining whether an action is likely to have a significant impact on matters of national environmental significance.

Chapter 4.2 (above) discusses environmental impact assessments and is relevant to the EPBC Act. Specific information on assessments under the EPBC Act can also be found on the Commonwealth government website.

4.3.2.3. *Bilateral Agreements*

All States and Territories currently have bilateral agreements with the Commonwealth regarding the concurrent operation of the EPBC Act.

²⁹ [Significant Impact Guidelines 1.1 - Matters of National Environmental Significance - DCCEEW](#)

If a proposal requires assessment under both the EPBC Act and State or Territory legislation, a Bilateral Agreement may apply. In such cases, the Commonwealth Minister for the Environment uses the State or Territory's environmental assessment as the basis for their decision as to whether a proposal should be approved under the EPBC Act.

The Commonwealth Minister for the Environment remains responsible for decisions under the EPBC Act, including whether an approval should be granted, but bilateral agreement assessments can prevent duplication in the environmental assessment process.

If a proponent believes their project will trigger the requirement for assessment under both the EPBC Act and State or Territory environmental assessment legislation, the proponent should communicate with the Commonwealth and relevant jurisdiction to determine whether a bilateral assessment process can apply.

4.3.3 General environmental protection and pollution

All Australian jurisdictions have a framework for broad environmental protection. Environmental protection seeks to prevent or diminish environmental harm or manage activities that could impact the environment. The most common way that regulations provide broad environmental protection is through the control of pollution. Pollution is defined in varying ways across each jurisdiction, but in general the aim is to assess and regulate anything that could have an adverse impact on the quality of the surrounding environment, affect the safety or health of human beings, or otherwise affect environmental values.

A *pollutant* is generally defined very broadly, for example it will often include:

- a gas, liquid or solid
- dust, fumes, odour or smoke
- an organism (whether alive or dead), including a virus or a prion
- energy, including heat, noise or radioactivity, or light or other electromagnetic radiation.

The act of *polluting* can include to cause or fail to prevent the discharge, emission, depositing, disturbance or escape of a pollutant.

Pollution can include water pollution, air pollution, noise pollution and land pollution.

The way that legislation establishes specific offences or approval requirements using the concepts of pollution (whether or not the specific term is used) varies across jurisdictions. However, there are some common concepts:

- an approval or authorisation from the relevant environmental protection authority or environmental regulator is required where the environmental impacts of a facility will cause or have the potential to cause environmental harm (refer chapter 4.4.4).

State and territory environmental protection authorities regulate the prescribed actions and as such approvals or authorisations are issued for the lawful conduct of such action

- many jurisdictions have specific general environmental duties that require a person to take all reasonably practicable measures to minimise pollution or prevent environmental harm (refer chapter 4.4.5)
- it is generally an offence to pollute the environment with potential to cause environmental harm (refer chapter 4.4.6).

In some jurisdictions in addition to environmental harm related offences, there are specific pollution obligations. Pollution related regulations include:

- Obligations to assess, prevent, minimise, control and mitigate pollution
- Obligation relating to pollution events including notification, clean up and remediation
- Offences relating to pollution.

Annexure 4, table 4.10 summarises specific pollution obligations.

All jurisdictions generally require some form of permit, licence or approval for activities that will or may pollute. For hydrogen refuelling facilities, key areas for potential pollution include the management of wastewater, emissions or unauthorised discharges of hydrogen gas or other hazardous material.

The concept of pollution is generally distinguished from contamination (refer chapter 4.4.7). Contamination is commonly described as the presence of a substance at or above the concentration at which the substance is normally present. While there is variation between jurisdictions, this Guidebook utilises this distinction between pollution and contaminants for the purpose of highlighting key obligations for hydrogen refuelling facilities.

4.3.4 Environmental approvals, authorisations and licences

In all jurisdictions there is a requirement for the upfront assessment of potential environmental impacts (including pollution and risk of environmental harm). This is most commonly a combination of environmental impact reporting under planning frameworks (refer chapter 4.2.6) and environmental approvals under environmental protection legislation (this chapter 4.4.4). Different jurisdictions also use different terms such as environmental licences, permits, consents or authorisations. This Guidebook uses the broad term *approvals* to cover all such requirements.

In many instances, the assessment of environmental approvals and the consideration of environmental impacts under planning frameworks utilise an EIA process prescribed by regulation. Specific requirements for EIAs are discussed in detail in chapter 4.3.

This chapter 4.4.4 focuses on specific environmental approvals, which in some instances may require an EIA (such as discussed in chapter 4.3) as part of assessment but will result in a stand-alone environmental approval. This chapter will also identify where an environmental approval is relevant to the evaluation of a development application.

Annexure 4, table 4.11 summarises the nature of environmental approvals and licences in Australia.

4.3.5 General environmental duty

Most jurisdictions' environmental protection frameworks include a general environmental duty to manage activities to reduce risk of environmental harm. In Queensland and Victoria, failure to comply with the general environmental duty is an offence (in Queensland only where the failure causes, or is likely to cause, serious or material environmental harm). In other jurisdictions, failure to comply with the duty does not of itself constitute an offence but compliance with the duty may be enforced by issuing an environment protection order, clean-up order or court order.

The general duty broadly requires a person to take all reasonably practicable measures to prevent or minimise environmental harm. This duty applies in addition to other regulatory environmental obligations and duties including any requirement to obtain an authorisation under an environmental approval or licence (see chapter 4.4.4) for the activity. What is reasonably practicable is determined on a case-by-case basis and involves consideration of a range of matters including the:

- nature of the harm or potential harm
- sensitivity of the receiving environment
- current state of technical knowledge for the activity
- likelihood of successful application of the different measures that might be taken
- financial implications of the different measures as they would relate to the type of activity.

In some jurisdictions, compliance with the general environmental duty may provide a defence to certain offences or can be a consideration when determining penalties if an activity causes an environmental nuisance or causes material or serious environmental harm.

Annexure 4, table 4.12 provides a summary of the general environmental duties across all jurisdictions.

4.3.6 Environmental harm

4.3.6.1. Overview of environmental harm

Australian environmental protection legislation establishes a system of offences relating to actions that cause unlawful, serious or material environmental harm or an environmental nuisance.

Depending on the jurisdiction, definitions of environmental harm may reference pollution or waste or refer to specific activities. In general, whether defined through reference to pollution or waste, the concept is similar—environmental harm is any adverse effect on an environmental value. An environmental value is a quality or physical characteristic of the environment that is conducive to ecological health, or public amenity or safety.

Environmental harm is a very broad concept. It can be caused by things such as tree clearing, fishing, pollution, mining, damming rivers, killing native animals, soil erosion and aircraft noise and may be temporary or permanent. As noted above this Guidebook focuses on discussing environmental harm in the context of pollution, contaminants and waste rather than broader environmental harm issues (e.g. land clearing), which are less related to hydrogen refuelling facilities.

4.3.6.2. Types of environmental harm

The precise terminology and definitions of environmental nuisance, harm, material harm and serious harm varies between jurisdictions. In general, jurisdictions adopt the following statutory concepts:

Environmental nuisance	<p>Environmental nuisance is generally an unreasonable interference or likely interference with an environmental value caused by:</p> <ul style="list-style-type: none"> • emissions, fumes, noise, dust, odour or light • an unhealthy, offensive or unsightly condition because of a pollutant or contaminant. <p>Nuisance claims may also be brought under common law.</p>
Environmental harm	<p>Environmental harm generally means any actual or potential adverse effect on the environment as a result of human activity that has the effect of degrading the environment (whether temporarily or permanently and of whatever magnitude, frequency or duration). It can also include environmental nuisance.</p>
Material environmental harm	<p>Material environmental harm generally means environmental harm that is significant, not trivial or negligible and which results in:</p>

	<p>(a) actual or potential loss or property damage, or necessitates remedial action or</p> <p>(b) actual environmental harm to an area of high conservation value or of special significance</p> <p>of more than a prescribed threshold amount for the subject jurisdiction.</p> <p>It may also include environmental nuisance of a high impact or on a wide scale.</p>
Serious or significant environmental harm	<p>Serious environmental harm means environmental harm that is greater than material environmental harm. Serious environmental harm is very significant, irreversible, of a high impact or widespread harm that results in</p> <p>(a) actual or potential loss or property damage or</p> <p>(b) actual harm or damage to an area of high conservation value or an area of special significance</p> <p>that exceeds the prescribed thresholds of the subject jurisdiction.</p>

The penalty for causing environmental nuisance or harm is also often determined by the nature of a proponent's conduct. The penalties will vary depending on the severity and circumstances of the offence, whether the activities were carried out wilfully, intentionally, negligently or with or without knowledge and may include potential fines and / or imprisonment. For corporations, there are generally executive officer duties and liabilities in addition to those of the corporation.

Not all breaches of environmental obligations are of equal significance and there are different types of enforcement actions available in each jurisdiction depending on the offence.

Cause environmental harm	The lowest level of penalty where a facility causes environmental harm.
Negligently	Where a person was negligent in their actions that could have prevented the environmental harm.

Knowingly or recklessly	Where a person knew that environmental harm could occur or was reckless.
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Annexure 4, table 4.13 provides a summary of environmental harm related offences

4.3.7 Contamination

4.3.7.1. *Overview of contamination obligations*

Waste and chemicals can cause land, air and groundwater contamination. Changes in land, air or groundwater quality can pose a risk of harm to human health and the environment and cause environmental harm.

Contaminated land environmental obligations address these risks and work alongside general environmental duties and obligations.

Obligations relating to contamination arise in several ways:

- obligations not to cause contamination
- obligations to manage contamination or contaminated land regardless of who caused the contamination
- notification of contamination events relating to a current or in some cases historical activity.

4.3.7.2. *Managing contaminated land*

Obligations to manage contaminated land generally arise where a person has the management or control of land. These obligations will apply to land on which the construction or operation of hydrogen refuelling facilities is being carried out. The responsibility for the management or control of land should be considered broadly and can include:

- holding a legal interest in the land, such as owner, leaseholder or committee of management
- having access to the land or use of the land.

Managing contaminated land can involve:

- identifying, investigating and assessing contamination suspected to be present
- implementing interim controls to manage risks while assessment is undertaken
- clean up or remediation to make the site suitable for its current and future use
- ongoing monitoring to prevent further spread of contamination.

Annexure 4, table 4.14 summarises contaminated land related obligations for each jurisdiction.

4.3.7.3. Notification of contamination events

The duty to notify of contamination events may also overlap with other notification or reporting obligations relating to pollution (refer to chapter 4.4.3).

The duty to notify is not limited to owners of land on which contamination occurs or is discovered and will vary in each jurisdiction.

Annexure 4, table 4.14 summarises the obligations in each jurisdiction to notify contamination events.

4.3.8 Waste

4.3.8.1. Overview of waste obligations

There are three common themes to regulation of waste in Australian environmental laws:

- licensing of waste management facilities
- movement of controlled waste between jurisdictions
- obligations for the handling, collection, transport, disposal and storage of waste including use of licensed contractors.

4.3.8.2. Licensing of waste management facilities

The licensing requirements for waste management facilities varies between jurisdictions. In general, waste is any substance (whether solid, liquid or gaseous) that is unwanted, abandoned, discharged, emitted, deposited or thrown away.

Waste management facilities are commonly defined to be a facility used for the storage, sorting, treatment, processing or disposal of waste and can include recycling. They can include landfills, recycling facilities, alternative waste treatment facilities and specialised facilities for hazardous and medical waste.

It is noted that a hydrogen facility may generate prescribed or listed wastes (as defined in relevant state or territory legislation) during the course of its operations. As such, the facility may be considered to be undertaking an activity producing prescribed/listed waste which triggers a requirement for a waste licence.

4.3.8.3. Movement of controlled wastes between jurisdictions

The National Environment Protection Council (NEPC) made a National Environment Protection (Movement of Controlled Waste between States and Territories) Measure (NEPM) covering the transport of controlled waste between Australian States and Territories.

The NEPM introduced a system to track the movement of controlled waste around Australia. The NEPM is relevant to waste producers, waste transporters and the operators of waste receiving facilities.

A 'controlled waste' is one that can harm human health and the environment unless it is managed properly. The NEPM requires the transport around Australia of these potentially dangerous wastes to be thoroughly documented.

Controlled wastes appear as List 1 of Schedule A to the NEPM (see note below), together with the relevant waste codes. The codes are a shorthand way of identifying controlled wastes and are used in applications and authorisations for the national tracking system under the NEPM.

Hydrogen refuelling facilities operating in a manner similar to that described in chapter 1 and 2 are unlikely to use a substance in List 1 of Schedule A to the NEPM. However, if a hydrogen facility produces / generates any of the substances in List 1 (controlled waste) and transport the substances to other jurisdictions for treatment, disposal or for other purposes, the producer (i.e. hydrogen facility) is bound and mandated to comply with NEPM's requirements including (but not limited to) tracking and consignment authorisation. As such, proponents should assess the application of the NEPM to their project on a case-by-case basis.

Proponents should ensure that they:

- comply with applicable guidelines relating to the transport and tracking of waste
- use only entities appropriately licensed to transport waste.

4.3.8.4. Obligations for the handling, collection, transport and storage of waste including use of licensed contractors

Obligations for handling, collection and transport of waste varies between jurisdictions.

Proponents that create, manage or control industrial waste should classify it. Classification of waste is the process of identifying and describing industrial waste. Classifying waste helps manage risks of harm to human health and the environment, comply with the general environmental duty, determine which waste duties apply, and determine a lawful place to take waste for resource recovery, reuse or disposal. Different categories of waste will trigger different obligations.

Substances likely to be present at a hydrogen refuelling facility that are likely to trigger waste obligations include:

- electrolyte solution (e.g. waste potassium hydroxide is a controlled waste under the NEPM. The interstate transport of this material will require the hydrogen facility to comply with the requirements under NEPM.)

- general industrial waste

Depending on the classification of waste, obligations relating to waste include:

- take reasonable steps to contain waste, prevent escape or contamination
- provide information regarding the waste to the next person in the supply chain so that they can meet their duties
- take reasonable steps to identify and assess alternatives to waste disposal
- report to the relevant jurisdictional EPA each time the waste is exchanged (waste tracking)
- transport only in a permitted vehicle
- ensuring that waste handlers, collectors, transporters and treaters are duly authorised.

4.3.9 Notification of environmental matters / incidents

Proponents are required to notify where any serious environmental harm is caused or threatened as soon as practicable after becoming aware. There is a requirement to notify even if environmental harm does not ultimately occur.

Penalties apply for failure to notify regulators of environmental matters / incidents within the required timeframes. These penalties operate in conjunction with offences relating to any environmental harm caused and obligations to remedy any damage or harm.

Annexure 4, table 4.15 summarises the obligations to notify of environmental matters/incidents.

4.3.10 Requirements for persons to hold an environmental approval

Some jurisdictions require that only a fit and proper person may hold an environmental approval. This may include considerations that the person has:

- contravened a law relating to the physical or biological environment
- contravened a law that relates to heritage, health or cultural matters, including matters relating to sacred sites
- contravened a law under which a tax or royalty is payable
- had an environmental approval cancelled or suspended
- committed an offence that involves an element of fraud or dishonesty
- behaved or is likely to behave in a way that is inconsistent with the person's duties as an approval holder.