Hydrogen Electrolyser Plant – Minimum Information Required

To support efficient data transfer, reduce correspondence and enable an appropriate risk review to be completed, minimum information is required.

This document provides guidance on what information should be sent to Aviva to enable a prompt and thorough risk review.

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Introduction

To support Aviva's understanding of the hydrogen electrolyser project, the detailed information below is required.

We will review the documentation provided and, if necessary, may request further information to help us fully understand the risk.

Note: This document relates to Proton Exchange Membrane (PEM) hydrogen electrolyser plant and associated equipment only. It is focussed on property loss prevention and is not intended to address liability exposures. The presumption is that all regulatory requirements, such as fire, dangerous substances and explosion risk assessments, and compliance with local building regulations, codes, or standards, have or will be met.

Hydrogen Electrolysis

Hydrogen electrolysis is the process of using electricity to separate water (H_2O) into hydrogen (H_2) and oxygen (O_2), producing hydrogen which can be used immediately or stored for later use.

The use of containerised hydrogen electrolysis plants is becoming increasingly popular, as organisations seek to manage fuel costs and meet Environmental, Sustainability and Governance (ESG) objectives by using electricity generated from renewable energy sources—such as solar photovoltaic (solar PV) systems and wind turbines—to produce green hydrogen.

The hydrogen can be used for industrial processes, or more commonly to power vehicles such as lift trucks, delivery vehicles, etc. For larger applications, the hydrogen can be fed into fuel cells and used to provide electrical power.

There are two main types of electrolyser plant currently in use:

Alkaline Electrolysers (AEL). Traditional technology which uses a liquid alkaline electrolyte and porous diaphragm to separate hydrogen and oxygen from the water. These are used for large-scale hydrogen production and are outside of the scope of this document, and

Proton Exchange Membrane Electrolysers (PEM). These are compact systems for local generation and are the subject of this Loss Prevention Standard.

Proton Exchange Membrane Electrolysers (PEM) - Overview

PEM Electrolyser plant comprises a number of common components, including but not limited to:

Water Supply and Treatment. The water supply is critical to the process and will generally require significant purification prior to use in the electrolyser. Most systems will use a variety of filtration methods to remove particles, sediment, chlorine, dissolved salts and minerals, metals, etc. The water will also need to be de-ionised to produce the high grade of water suitable for processing.

The water purification plant in a PEM electrolyser produces ultra-pure water by removing minerals, salts and contaminants that would otherwise damage the membrane and catalysts. This is critical as trace impurities can rapidly degrade performance, reduce efficiency, and shorten stack lifetime, increasing the risk of failure and downtime.

Electrolyser Stack. This is the core item of plant that separates hydrogen and oxygen from the water supply. Electricity is applied across two electrodes submerged in water with an added electrolyte. This causes the water molecules to separate, via a membrane, into hydrogen at the cathode and oxygen at the anode.

The electrolyser is the core hydrogen-producing system, and its design, control, and protection directly impact efficiency, reliability, and the risks of fire or explosions.

Hydrogen Handling System. The hydrogen, upon leaving the stack, will need to be treated to remove any residual water, oxygen and heat. Associated equipment includes the hydrogen pipework, manifolds, pressure regulators and compressors required to efficiently/safely move and store the hydrogen.

Oxygen Handling and Venting System. Most of the oxygen produced in containerised systems will be vented directly to atmosphere. However, larger plants may incorporate oxygen capture for further use. Given the greatly increased hazards of mixing hydrogen and oxygen, strict segregation of the two systems is necessary with no cross over equipment utilised or oxygen venting near hydrogen systems.

Cooling and Ventilation. The electrolyser will require suitable powered cooling and ventilation systems to remove production heat. Most systems will incorporate a closed loop cooling system circulating through the stack and container with ancillary air coolers or heat exchangers to remove the collected heat. Efficient cooling is critical in prolonging system performance and component longevity.

Control, Monitoring, and Safety Systems. These systems operate the plant and help protect against breakdown, failure, leaks and fire/explosion events. Safety features include, but are not limited to:

- Process parameters such as pressure, temperature, and flow.
- Hydrogen and oxygen leak detection.
- Emergency automatic and manual shutdown systems.
- Interlocks and alarms.
- Forced emergency ventilation.
- Explosion and pressure relief systems.
- Gas and fire detection equipment.
- Earthing systems.

Hydrogen Storage. The hydrogen will typically need to be stored pending use. Storage methods include:

- Pressurised gas cylinders.
- Tube trailers.
- Fixed pressure vessels.
- On-site buffer storage.

Whichever storage method is used, the location should be suitable and at least 10 metres clear of buildings and valuable assets.

The safe storage and distribution of hydrogen within the installation is critical. Of importance are the containment, storage methods, system pressure, pipework integrity, isolation arrangements and safeguards.

PEM electrolysers are available in a number of sizes and outputs, but commonly range from 1MW to 10MW, with larger equipment also available and expected to become popular as the sector expands.

Minimum Information Required

To enable Aviva to complete a full and thorough review of the electrolyser installation and hydrogen production, please try to provide as much of the following information as possible.

Background Information

An overview and background of the project is required to establish the basis for the proposal. Please provide details of the following:

Ownership and Control

1. Project ownership and management.
2. Operational site ownership and management.
3. PEM contractor details.
    - Provide details of their experience, previous projects, etc.

    Note: PEM projects should follow an Engineering, Procurement and Construction (EPC model) where one organisation has overall responsibility for the lifecycle of a project which includes design, planning, sourcing materials, managing suppliers, construction, commissioning and handover.
4. Companies involved in the Operation and Maintenance (O&M)
    - Provide details of their experience, previous projects, etc.
5. Vendor and equipment supplier details, etc.

Regulatory Status

1. These include:
    - European Directive 2012/18/EU, also known as the Seveso III Directive (EU) / COMAH (UK) / or other country relevant directive.
    - Control of Major Accident Hazards Involving Dangerous Substances in the United Kingdom.
    - Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations in Ireland.
    - Environmental Emergency Regulations, CSA Z767 PSM Standard, federal and provincial guidance, etc., in Canada.
2. Permits or licences to operate.
3. Required consents to operate.

General Plant Operations

1. Purpose of hydrogen generation, e.g., vehicle fuel, trade processes, etc.
2. Basis of revenue generation for the proposal , e.g., direct sales, grid balancing, etc.
3. Quantities of gas generated (hydrogen and oxygen).
4. Volumes of gas to be stored (hydrogen and oxygen) within individual storage units and storage pressure.
5. Gas storage method, e.g., liquid or gaseous?
6. Gas storage type, e.g., tank, manifolded-cylinder pallet (MCP), tube trailer, etc.
7. Power supply required; its stability; maximum output required; resilience and redundancy arrangements.
8. Water flow rates required; resilience and redundancy arrangements.
9. Critical or key equipment identified with any resilience or redundancy provided and their location. E.g. N+1, N+2, 2N, etc.
10. Anticipated equipment and spares lead times.
    - Spares holdings and spares strategy.
11. Hours of occupancy? Continuous 24 hrs/day? Shift based? Days/per week?
    - Number of personnel on site per shift, and in total.
12. Geographical location including any natural catastrophe exposures and/or associated assessments of the entire site, any external processes and associated buildings or equipment containers e.g. lightning, flood, earthquake, etc.
    - Flood resilience or mitigation design where appropriate.
    - Lightning exposure and surge protection design where appropriate.
    - Seismic exposure bracing and shut-off valves design where appropriate.
13. Third party exposures to and from the location.

Process Control and Oversight

1. Process control and alarm strategy with associated response to any alerts, alarms, etc., raised. Does this include, but is not limited to, the following parameters:
    - Temperature
    - Pressure
    - Flow
    - Level
    - Water purity/contaminants including salts
    - Oxygen concentration in the hydrogen stream.
    - Hydrogen concentration in the oxygen stream.
    - Electrolyser voltage and current
2. The associated cause and effects, including interlock rationale, for the above process control strategy. This is to include:
    - Automatic and manual initiators.
    - Safe isolation and shut down events.
3. Engineering Action Requests – how they are managed and implemented.
4. Commissioning/validation procedures.

Documentation

1. Site Plans, showing full layout, vent and/or flare locations, pressure relief valve (PRV) exhaust locations, water and gas storage, loading/unloading, etc.
2. Plant schematic drawings and/or Piping and Instrumentation Diagram (P&ID).
3. Project GANNT chart with key timeframes and deliverables (construction works only)
4. Basis of Safety Document explaining how safety will be engineered, demonstrated, and maintained during the lifetime of the electrolyser.
5. Hazard and risk assessment studies including hazard and/or operability assessments or analyses such as HAZOP, etc.
    - Status of recommended actions.
    - Details of any outstanding actions and their anticipated completion dates.
6. Explosion and jet fire modelling - confirming the explosion overpressures in mbar and the radii to defined damage thresholds, e.g., 20-30mbar glazing damage, etc.
7. Design standards the process has been designed to.

Management Systems and Procedures

Effective management programmes help ensure that hazards are controlled and monitored throughout the life of the operation. Please provide details of the following:

Management Programmes

1. Standard operating procedures.
2. Emergency operating procedures.
3. Management of change procedures.
4. Process deviation reporting and investigation procedures.
5. Management of hot works.
   Note: Hot works should be prohibited on installations producing or storing hydrogen.
6. Management of smoking and vaping arrangements.
7. Employee training and including role and hazard competency assessments. E.g. electrical, hydrogen and oxygen hazards, fire and explosion, etc.
8. Contractor control procedures and arrangements
9. Site security arrangements including access control, detection systems, monitoring and response procedures.
10. Emergency response procedures for anticipated events such as gas leak or release, fire, explosion, security, etc., including Fire and Rescue Service (FRS) and police engagement.

System Safety

1. Electrostatic risk protections and controls.
    - Clothing and footwear
    - Non sparking tools for maintenance tasks.
    - Earth bonding and grounding continuity checks and maintenance.
    - Safety in maintenance against electrical discharge.
2. Electrical maintenance arrangements, e.g., testing frequency, competence of maintenance company, outstanding actions, portable devices, fixed wiring, etc.
    - Availability and use of thermographic imaging cameras.
3. Compliance with Pressure Systems Safety Regulations, e.g., written scheme of examination and periodic inspections.
4. Programme of non-destructive testing on pipework and welds, etc.
5. Positive material identification for replacement components.
6. Remote shutdown arrangements.

7. Site start-up, shutdown, maintenance, and operating procedures.
   - Have all OEM requirements been identified and incorporated?
   - Has leak testing been completed prior to start-up?
8. Is safe, compliant degassing of waste electrolyte carried out before any intrusive work or startup?

Detection, Monitoring, Interlock and Cause and Effect Strategy

1. Specification of all gas (oxygen and hydrogen leak), fire (smoke, flame, etc.) and explosion related detection and protection systems.
2. Location of all detection and protection systems within appropriate drawings.
3. Local and remote monitoring of the process including all safety critical parameters.
4. Cause and effect strategy, interlocks and associated shutdowns.
   - Confirmation of automatic isolations upon gas leak, fire, etc.
     - Safe shutdown of the process?
     - Power supplies?
     - Gas-storage shutoff, etc?
   - Testing and confirmation of this strategy with prescribed intervals.
5. Voltage and current monitoring parameters.
   - Are the voltage and current continuously monitored?
   - Is the process interlocked to isolate and shut down safely should levels deviate outside of pre-determined safety thresholds?
6. Temperature monitoring parameters.
   - Is the temperature continuously monitored?
   - Is the process interlocked to isolate and shut down safely should levels deviate outside of pre-determined safety thresholds?
7. Pressure monitoring parameters.
   - Is the pressure continuously monitored?
   - Is the process interlocked to isolate and shut down safely should levels deviate outside of pre-determined safety thresholds?
8. Local and remote monitoring of any gas detection systems.
9. Local and remote monitoring of any fire detection systems.
10. Local and remote monitoring of any fire protection systems.
11. Local and remote monitoring of any explosion detection or relief systems.
12. Inspection, testing, maintenance and calibration of sensors and detection devices
    - Are gas detection devices subject to scheduled sensor calibration?

Containers and Buildings

This section focuses on the buildings or equipment containers on site. Please provide details of the following:

1. Construction of the building and equipment containers. This includes any insulation materials.
   - This is recommended to be non-combustible.
2. Explosion relief design, including design standard; basis of design; size; location; confirmed lack of obstructions, and confirmation that it is directed towards a safe and non-exposed discharge area.
3. Forced ventilation system design.
   - Is this continuously monitored and interlocked to isolate power to the electrolyser if ventilation fails?

4. Specification of equipment if located in hazardous or electrically classified or zoned areas.
   - Formally identify any non-classified or rated equipment in classified or zoned areas.
5. Installation of hydrogen and oxygen leak detection systems.
6. Installation of flame or fire detection systems.
7. Installation of any fire suppression or extinguishing systems.
8. Spatial separation between the buildings and/or containers.
9. Identification of any overhanging structures above the installation or site.
10. Identification of separation from any overhead power lines?
11. The surface of the finished site. Is the installation located on a solid surface, i.e., not on gravel or asphalt, that provides safe drainage and reduced gas-accumulation risk?
12. Security strategy for the site, buildings, containers, etc. to prevent unauthorised access, malicious damage, theft, etc.

Water Purification Equipment

This section focuses on the water purification plant. Please provide details of the following:

1. The water supply source, e.g., town mains, pumped from a reservoir, or borehole.
   - Is any backup water supply available, including any stored volumes?
2. Has the water impurity profile been determined, and is it revalidated periodically?
3. Filtration and ion exchange media replacement.
   - Is this replaced in line with Original Equipment Manufacturer (OEM) recommendations?

Electrolyser Equipment

This section focuses on the electrolyser plant. Please provide details of the following:

1. Electrolyser type and manufacturer, including:
   - Capacity/power rating, model and required operating conditions
   - Including membrane type and if there is the presence of any precious metals.

   Note: Alternatively, please provide the electrolyser product specification.
2. Electrolyser operating experience, e.g., number of operational hours.
3. Power requirements for the electrolyser
4. Hydrogen purity assurance
   - Are hydrogen sensors installed within the oxygen stream?
   - Is there a defined method for removing oxygen from the hydrogen stream to ensure product purity and safety?
   - Are oxygen sensors installed within the hydrogen stream?
5. Safety Integrity Levels (SIL).
   - Are these as recommended by the OEM or competent person?
6. Ventilation system.
   - Is the ventilation system continuously operational during hydrogen production?
   - Will this remain operational if the process shuts down via activation of any alarm or interlock?

7. Vent outlet design and locations. Confirm the design standard.
    - Is this in line with NFPA 2, Hydrogen Technologies Code?
    - Are oxygen and hydrogen vent outlets physically separated, non-manifolded, and positioned to disperse safely away from buildings, air intakes, and each other?
    - Are oxygen and hydrogen vents protected against freezing and moisture accumulation?
    - Do vent stack heights and their discharge locations provide adequate dispersion?
    - Are vents purged with inert gas prior to start-up where required by design or OEM guidance?
8. Pressure relief system sizing.
    - Are pressure relief systems correctly sized for worst-case scenarios, including recombination events?
9. Wastewater drainage arrangements.
    - Are wastewater drains dedicated and separate from other drainage systems on site?

Hydrogen Gas Storage, Pipework and Gas Filling

This section focuses on the hydrogen gas storage, associated piping network and any gas filling arrangements. Please provide details of the following:

1. External flooring finish of the gas storage and any filling area.
    - Is the installation free from gravel or asphalt flooring that may trap hydrogen in voids?
2. Location of any gas storage (including intermediate or buffer volumes), including spatial separation between the installation and occupied buildings, chemical storage, and oxygen tanks or vents.
3. Materials used for any tanks and the pipework network.
    - Are 316 stainless steel or cupro-nickel alloys used for tanks and pipework (corrosion resistant and suitable for hydrogen service)?
    - Is the pipework design continuous with no flanges to minimise potential leak points?
    - Are all welds compliant with ASME B31.12 requirements?
4. Storage tank pressure relief arrangements including discharge location.
    - Is the relief valve bench tested and calibrated?
5. Gas and flame detection provision including device location and coverage.
    - Internal and external?
    - Is this interlocked to ensure safe automated shutdown of the process?
6. Vehicle movement assessment and vehicle-impact protection provided for tanks, pipework (including any bridges), filling and control equipment.
7. Remote operational shut off valve/devices (ROSOVs) and local manual isolation valves.
    - Are ROSOVs interlocked to close on sudden or unexpected pressure loss?
8. Are all filling points, tanker interfaces, and hose/connection types compatible and clearly identified to prevent missed or incorrect connections?

Oxygen Gas Processing and Storage

This section focuses on the oxygen gas process and storage. Please provide details of the following:

1. Oxygen arrangements. Is the oxygen vented or stored?
2. Oxygen compatible materials.
    - Are these used throughout the process/system, including oils and greases?
    - Are incompatible substances prohibited?
3. Location of ordinary combustible materials and/or storage.
    - Are these prohibited inside the process structures or any areas at risk of oxygen enrichment?

Contact Information

United Kingdom

Please visit Aviva Risk Management Solutions or email us at riskadvice@aviva.com. To speak to one of our advisors, call 0345 366 6666.*

*The cost of calls to 03 prefixed numbers are charged at national call rates (charges may vary dependent on your network provider) and are usually included in inclusive minute plans from landlines and mobiles. For our joint protection telephone calls may be recorded and/or monitored.

Canada

Please visit Aviva Risk Management Solutions | Aviva Canada or email us at arms.canada@aviva.com

Ireland

Please visit Insurance Risk Management | Business Risk Management Insurance - Aviva Ireland or Email us at armsireland@aviva.com

Specialist Partner Services

Aviva have created a network of Specialist Partners to complement our in-house capabilities and to enable our policyholders to benefit from a wide range of risk management solutions at preferential rates and terms. Together, we provide solutions to help with the significant challenges of modern-day risk management.

Note: These partner relationships are wholly for the benefit of our policyholders with no income to Aviva.

United Kingdom

For more information please visit: Aviva Risk Management Solutions – Specialist Partners

Ireland

For more information please visit: Insurance Risk Management | Business Risk Management Insurance - Aviva Ireland

Canada

For more information please visit: Our Specialist Partner Network | Aviva Canada

Standards, Sources and Useful Links

- Lower Tier COMAH / SEVESO III (5 tonnes of hydrogen)
- Upper Tier COMAH / SEVESO III (50 tonnes of hydrogen)"
- Hazardous Substances Consent UK (2 tonnes of hydrogen)
- NFPA 2 - Hydrogen Technologies Code
- Internal Safety Distances for PGS 35 (hydrogen refuelling stations)
- SAND 2009-084 Analyses to support development of risk-informed separation distances for hydrogen codes and standards
- Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres (0.2-1.8 mm hole)
- EI 3015 EI Model code of safe practice Part 15: Area classification for installations handling flammable fluids (1-10 mm hole and hazard radii for release of pure hydrogen)
- ASME B31.12 - Hydrogen Piping and Pipelines

Additional Information

Loss Prevention Standards

These documents set out best practice recommendations to help reduce the likelihood and impact of losses.

Please visit Loss Prevention Standards to view the full library.

Aviva Risks Training Solutions (United Kingdom Only)

Aviva Risk Training Solutions, delivered through our Specialist Partner, SafetyCulture, provide free, bite-sized learning modules exclusively for Aviva policyholders.

Please visit Aviva Risk Training Solutions for further guidance.

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