



INQUIRY INTO FLOATING LNG SAFETY

SHELL SUBMISSION



Economics and Industry Standing Committee
Parliament of Western Australia

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Safety in Shell

At Shell, the protection of people and the environment is our priority. Our goal is to achieve zero harm to people and the environment.

All of Shell's operations are conducted in accordance with Shell's Health, Safety, Security and Environment (HSSE) and Social Performance (SP) Control Framework, a comprehensive corporate management framework. This framework contains the HSSE and SP requirements that apply to every Shell company, contractor and joint venture under Shell's operational control. It contains a clear and consistent set of mandatory requirements that define high level HSSE and SP principles and expectations, which are documented in a set of supporting manuals. This material is shared with all our contractors.

Supplementing the Control Framework is a rigorous Asset Integrity Process Safety Management (AIPSM) process across all stages of an asset's lifecycle. This AIPSM process ensures that assets are designed and built such that process safety risks are As Low As Reasonably Practicable (ALARP), and safety critical equipment is operated and maintained accordingly. The AIPSM process dovetails seamlessly with the Safety Case and ensures compliance with all relevant Australian, International and Shell corporate standards and regulations.

Furthermore, each safety critical element is defined with a set of performance standards that dictate the relevant international and industry codes and standards that shall be applied to the design, construction and installation of that element. Each of these standards has an appointed technical authority to provide assurance of effective implementation. This selection of standards is then validated by an independent body, in the case of Prelude FLNG Lloyd's Register, who then provide assurance to regulators that the correct codes and standards are selected and that these have been complied with through the project phases.

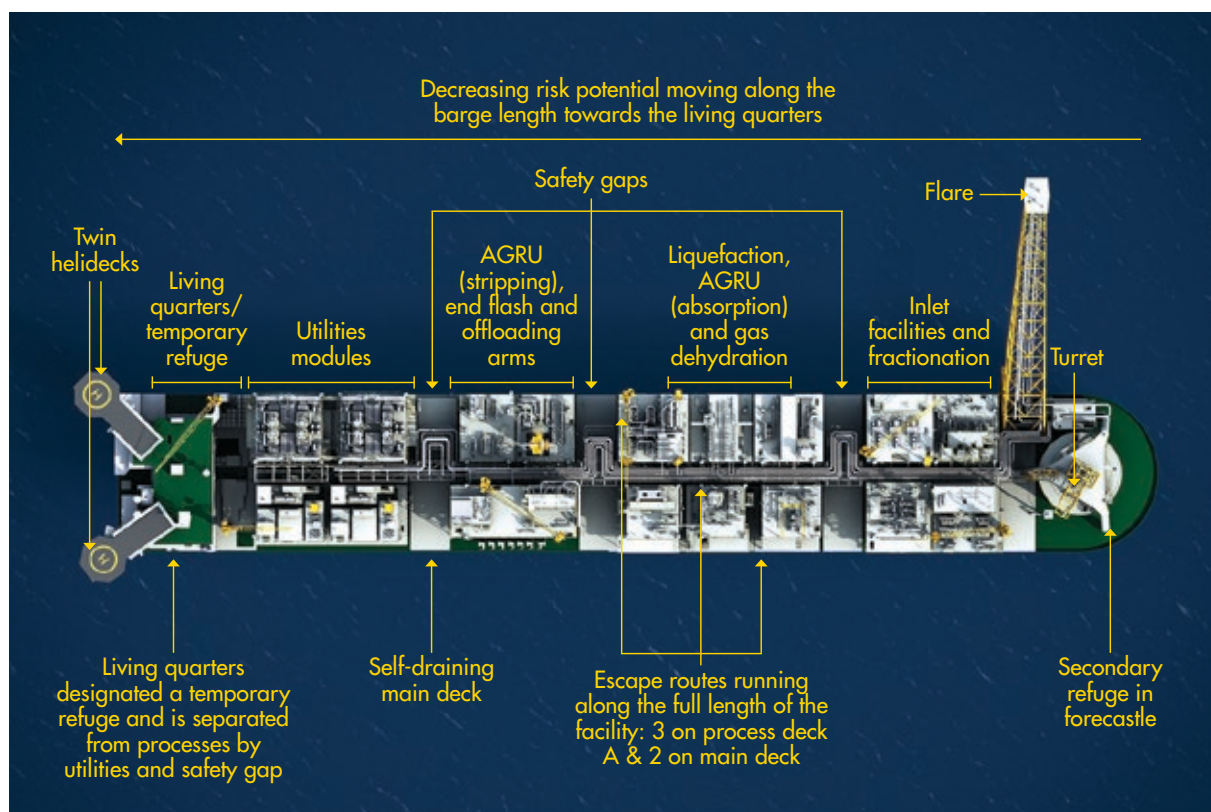


Safety in FLNG Design

Shell has been developing and improving all aspects of its Floating LNG (FLNG) design since the mid 1990s. Shell FLNG is a mature design, with more than two million man-hours invested in research, detailed design, development and integration of existing LNG technologies. Shell's FLNG design incorporates a number of proven and tested technologies that have been in use in existing LNG plants and offshore facilities for many years.

Shell's objectives are that FLNG is safe, robust, cost efficient, and with a high availability to enable continuous and stable LNG supply. Safety is the primary focus, with multiple, formal safety assessments completed and recommendations incorporated into the design to ensure the design and risk levels are ALARP.

Quantitative risk assessments were repeatedly conducted by Shell at the concept design stage, the basis of design stage and again at the detailed design stage to validate the design. This process has ensured the design of the FLNG facility is as safe and reliable as modern floating production and storage facilities (FPSOs) and offshore production facilities currently in operation.



LAYOUT OF THE PRELUDE FLNG DESIGN.

Safety Features

TURRET MOORING SYSTEM

The FLNG turret mooring system is an important safety feature which ensures that the FLNG facility remains securely on location in the field. The FLNG facility will be moored near to the field location by four groups of mooring chains which connect at the turret. Each of these groups consists of four mooring chains, which will be held to the sea floor by driven steel piles each 65m long and 5.5m in diameter. The turret structure itself is more than 30 metres in diameter, 93 metres high and weighs almost 12,000 tonnes.

The turret's swivel design enables the facility to 'weather vane' whilst the mooring lines remain fixed to the sea floor. This feature enables the facility to rotate according to weather and sea conditions. The ability to weather vane matched with the facility's sheer size and weight creates stability and ensures safe and effective offloading can take place at sea. This is further supported by dynamic thrusters which can 'hold' the facility in the optimum position for berthing and offloading.



A MODULE OF THE PRELUDE FLNG TURRET MOORING SYSTEM UNDER CONSTRUCTION

THE HULL AND STORAGE TANKS

The design of the FLNG hull is based on decades of maritime experience. The hull is a key element in the facility's ability to withstand severe weather. The design of the Prelude hull has taken into account the experience of FPSOs located in the North Sea, in particular the fields west of Shetland where 100 year significant wave heights are in the order of 18 metres, equivalent to the 10,000 year weather condition at the Prelude location.

A key design requirement has been to minimise motions as far as practicable to minimise the effects on people



DUAL STORAGE TANK DESIGN VS SINGLE ROW TANK DESIGN

and equipment. The target was to ensure that the facility exhibits motions comparable or lower than those encountered by FPSOs located in areas of the world where fixed facilities are not de-manned during severe weather conditions.

There are ballast tanks within the hull that will be filled with sea water to achieve the optimal draft at all times. This maintains the stability of the facility. The ballast tanks regulate (fill and empty) according to the amount of product in the storage tanks.

The FLNG hull has been created with low hydrodynamic drag which together with the ballasting philosophy results in very low motions in severe weather conditions. This limits the stress on equipment, ensuring the facility remains habitable and also minimises movement of the products in the storage tanks. The hull has been designed with a high freeboard (the distance between the water line and the deck level) to prevent large amounts of "green

water" reaching the deck, and it is also arranged with a significantly higher forecastle (the front section of the FLNG where the turret is located). This coupled with the particular bow shape and the deck barrier design will effectively reduce green water hitting the more exposed deck at the bow. This design protects employees onboard from swell and also limits the amount of sea water reaching the processing facilities.

The depth of the hull, paired with the significant ballast capacity, reduces movement at the forward and aft ends of the facility due to swell, minimising 'slam occurrences' which typically occur when a hull hits a wave and rises with it, then drops as the wave moves past. The structural capacity of the hull is provided by a complete double hull design incorporating a double bottom, double side and double deck configuration. This provides strength and in the unlikely event of a collision, the hull's integrity is unlikely to be compromised. The hull is further reinforced by a centre line double plate bulkhead, forming a substantial centre girder which efficiently balances the topsides weight against hull buoyancy forces, creating further stability for the facility.

Consideration has also been given to the directional stability of the hull, which resulted in the adopted bow and stern shapes which have proven dynamic directional stability, ensuring the facility strongly "weather vanes" against the prevailing conditions in a stable manner. Weather vaning is critical for stability, and also allows for safe approach from product carriers and for safe offloading of LNG and LPG.

For the side-by-side offloading arrangement, the effect of motion, both of the FLNG facility and the LNG/LPG carrier alongside, were repeatedly tested through all design phases. Testing used actual metocean conditions in basin model tests, and a full-scale rig test was carried out with a real loading arm early in 2014.

The product storage tanks are located within the hull and they have been designed to handle sloshing – the movement of the LNG, LPG and condensate within the hull – during either filling, or due to environmental conditions (e.g. swell). FLNG requires a different approach to containment of liquids on board of the facility compared to conventional LNG carriers. The chosen configuration of the tank replaces the

standard single row of tanks with pairs of side-by-side tanks. This gives the FLNG facility much greater ability to withstand effects of liquid motion. By splitting the liquids into side-by-side tanks, the impact of the movement due to sloshing is reduced. The shifting of the weight due to sloshing is also distributed between the side-by-side tanks, providing balance (rather than the weight moving to one side of a larger tank). This technology was developed with Gaztransport & Technigaz (GTT), who are specialists in the design of containment systems.

PROCESS EQUIPMENT LAYOUT

Process safety management is about prevention of incidents (such as fire or explosion), resulting from unintentional release of energy or hazardous substances. Process safety has been the single most important guiding principle for developing the FLNG facility's layout. This is primarily managed by adherence to the relevant international and industry process safety standards, and by the evaluation of the layout and process through multiple formal safety assessment and quantitative risk assessments, performed at relevant design phases of the project. The overall aim is not only to reduce the risk for personnel operating the facility, but also to be able to demonstrate that the design choices made demonstrably satisfy ALARP criteria when assessing any risks.

The living quarters, the helidecks, the control room and the workshop are located at the back of the FLNG facility. These areas, where people may be working or resting, are by design furthest away from the turret and processing facilities. These processing facilities are further separated by relatively low risk equipment and utilities.

There are open and uncongested 20 metre safety gaps across the full width of the facility between the main processing modules. In the unlikely event of an incident, the safety gaps would reduce the risk of escalation by:

- physically separating the equipment
- improving the dispersion of any leaked gas through free air circulation, reducing the size of any potential gas cloud caused by such an incident
- in the unlikely case of a gas cloud igniting, reducing

flame acceleration along the entire length of the process area, hence decreasing the overpressure levels.

On the facility's deck and the main process deck, full length escape routes that lead to temporary refuges are provided at both the starboard and port side. The central alley on the process deck level between the port and starboard side modules provides another escape way. There is also an alternative escape route on the starboard mooring deck, which connects the secondary refuge (forward) with the temporary refuge (aft).

The flare is on the opposite side of the facility to where LNG and LPG is offloaded, to minimize any impact of radiation on the LNG or LPG carrier and offloading operation.

There are two helidecks located at the aft, nearby the accommodation and temporary refuge. They are also located well away from the process areas.

LIVING QUARTERS AND TEMPORARY REFUGES

The living quarters double up as the temporary refuge. The living quarters can house up to 340 people and have direct access to all means of evacuation – via helicopter, freefall lifeboats (located aft) and integrated chute-based life rafts. The wall facing the processing equipment is blast rated and has passive fire protection.

SAFE OFFLOADING

Shell collaborated with FMC Technologies to develop LNG offloading arms to transfer LNG and LPG from the facility to ships moored alongside. Traditionally, LNG is offloaded from a wharf to a ship, however FLNG will require offloading to occur between two floating (therefore moving) structures. The design is a double-counterweight loading arm that can extend down as far as 10m to reach the LNG or LPG carriers. This means the arm can adjust and cope with movement from both the facility and carrier during offloading. A new coupling design allows for the arms and carrier to connect safely despite the movement. These two features are the only additions on an otherwise conventional loading arm design which has been proven on LNG operations for decades. Thrusters will also assist in securing the facility's position during the offloading.

After construction was complete on the first Prelude FLNG loading arm, its full capabilities were tested. This involved simulating the actual movement of both the loading arm and the receiving arm of an LNG carrier and nitrogen (which simulated the extreme cold of LNG) was transferred between the two safely. The testing was a success and the design performed as expected.



PRELUDE FLNG LOADING ARMS UNDERGOING FACTORY ACCEPTANCE TESTING IN SENS, FRANCE.

FIRE AND COLD SPILL PROTECTIVE COATINGS

A key part of the overall fire, explosion and cold spill strategy is the use of passive protection. These are coatings that do not require intervention by systems or people to perform. This occurs through a specialized protective coating that will be applied to the main deck, structural elements and escalation critical processing equipment. The coating minimises the impact from both fires and cryogenic loss of containment. Key valves, for example the riser emergency shutdown valves, are also coated for passive protection.

Safety in Construction

Prelude FLNG construction activities are taking place across worldwide locations. Shell has provided significant resources to influence the safety culture and to monitor quality at these locations. Below is a list of the major works being carried out and their respective locations.

- **Geoje** FLNG construction (hull and topsides)
- **Dubai** Turret mooring system fabrication
- **Malaysia** Wellheads and christmas trees
- **Singapore** Infield support vessels (ISVs)
- **Japan** Steam boilers
- **Darwin** Prelude Onshore Supply Base
- **Browse Basin** Production drilling and subsea installation
- **Broome** Aviation and marine base for drilling
- **Perth** Corporate headquarters

Each location is focused on a “Safety First” culture which is achieved through rigorous training, oversight, motivation, information and, where necessary, consequence management. Compliance with Shell’s “12 Lifesaving Rules” is mandatory. Dedicated safety supervisors provide constant onsite supervision across all locations. In Geoje for example, where up to 20,000 people have worked on the FLNG construction, every single person has undertaken a thorough HSSE induction.

In Dubai, where the turret is under construction, and in Darwin where the Prelude Onshore Supply Base has been under construction, there are fewer numbers of contractors, however the absolute commitment to safety and quality still exists. In every Shell and Prelude FLNG location, Shell staff and contractors are inducted and trained in Shell’s rigorous HSSE management process, which is applied to the contracts pre-award and post-award. In addition, how processes are applied in all locations is reviewed and audited in compliance with Shell’s internal assurance processes.

Shell's Life-Saving Rules set out clear and simple "dos and don'ts" covering activities with the highest potential safety risk. All Shell employees and contractors must comply with the 12 rules at all times.



Work with a valid work permit when required



Conduct gas tests when required



Verify isolation before work begins and use the specified life protecting equipment



Obtain authorisation before entering a confined space



Obtain authorisation before overriding or disabling safety critical equipment



Protect yourself against a fall when working at height



Wear your seat belt



Follow prescribed Journey Management Plan



Do not walk under a suspended load



Do not smoke outside designated smoking areas



No alcohol or drugs while working or driving



While driving, do not use your phone and do not exceed speed limits

Safety in Operations and Maintenance

The Prelude FLNG hull design complies with all international requirements for construction, strength and stability in offshore structures. In addition to these requirements, substantial development, analytical study and wave basin model testing have been carried out to prove the suitability of the complete facility during a range of adverse weather events up to, and including, an equivalent one in 10,000 year storm at the Prelude location. This testing and assessment confirmed that it will be safe to inhabit the facility during severe weather, and that even in the most extreme event the facilities structural integrity will not be compromised.

The detailed testing and assessment of Shell FLNG's operability and survivability has premised Shell's approach to operations and shutdowns in a range of near cyclonic or cyclonic events. In line with the Safety Case and the Emergency Response Procedures, phased responses are put in place well in advance of a future potential weather event. When a cyclone is approaching, operations will be turned down and if necessary stopped to protect the personnel and the facility. The employees on board will remain in the accommodation block until it is determined safe enough to be able to enter the decks. Usual operations will not recommence until after a complete check of all equipment. In the usual course of cyclonic events, it is expected that normal FLNG operations will be able to be carried out post cyclone.

The fact the FLNG stays on station during a severe weather event is in itself a safety feature, as it avoids the risk of transporting people by helicopter for a down-manning operation in deteriorating weather and the risks associated with disconnecting and reconnecting to the reservoir.

The ongoing safety and reliability of the FLNG relies on a robust maintenance profile. The FLNG maintenance profile is different to an onshore plant, as the scope of major shut downs for maintenance needs to be minimised

to match the limit of 340 beds available on the facility. Consequently, the philosophy is one of increased routine maintenance effort during normal operations. To ensure this is carried out safely, heavy maintenance will be scheduled outside of the cyclone season. The Prelude Onshore Supply Base is located in Darwin. The supply base will provide the equipment and spare parts warehousing and forwarding facilities for maintenance work on equipment. The base also acts as the marine port for supply boats between Darwin and the facility.

During operations, aviation support will be based out of Broome. Helicopters will take the crew out to the facility once a day. This is approximately a two-and-half-hour trip and requires a refuelling stop into the Djarindjin air strip on the Dampier Peninsula. All employees flying to and from the facility will have full helicopter emergency training. The Port of Broome will be the base port for the Prelude FLNG infield support vessels (ISVs). Two ISVs will be in the field at all times to assist with berthing product carriers and to be on standby for emergencies. The Prelude FLNG ISVs will be fitted with fire fighting equipment and small vessels for emergency response.

As with all of Shell's operations, the supporting maintenance and logistics will be carried out with safety as the priority and will adhere to all local regulations and internal Shell standards.



COMPETENCE ASSURANCE

Aligned with our Goal Zero aspiration (no harm to our people, no leaks from our operations), Shell implements a global approach to competence management. This approach provides a consistent, focused and risk-based competence assurance to demonstrate that our people working in the safety-critical roles meet the safety-critical requirements. The assurance is performed by qualified assessors, using structured evidence reviews, interviews, tests, on the job observation or external certification to confirm the skill level of the required competence. Assessment results are recorded and monitored in a global system (Shell Open University), which allows proactive notification prior to the required renewal date of assessments, giving staff sufficient time to take action. Competence assurance is one of the key enablers for the business to deliver safe production and to bring everyone home safely every day.

EVACUATION, ESCAPE AND RESCUE (EER)

The design of the FLNG facility has focused on the containment of hazards, however it also incorporates extensive mitigation and recovery measures.

One of the Formal Safety Assessments conducted through the design phase was an Evacuation, Escape and Rescue (EER) analysis. This analysis assessed the current EER provisions against the EER project goals and found that these are all satisfied.

The FLNG facility has an Evacuation, Escape and Rescue Strategy, summarised below:

- To allow personnel on Prelude to **escape** safely from an area where there is a hazardous event. Accessible means of escape are located throughout via a range of forward and aft escape routes.
- To provide **temporary refuges** in different locations (main temporary refuge aft and secondary refuge forward) on Prelude with

adequate sizing for maximum anticipated personnel and protection for as long as required to control an incident and/or effect a controlled evacuation (if necessary). Duration is one hour (which is standard for offshore facilities).

- To ensure a controlled safe **evacuation** from the installation with different means of evacuation at strategic low risk locations. There are primary, secondary and tertiary means of evacuation via helicopter, freefall lifeboats (located aft) and integrated chute-based life rafts respectively.
- To facilitate the **rescue and recovery** of personnel, once evacuation has been carried out, by external means. For example facility based infield support vessels, acting as standby vessels, and the dedicated search and rescue helicopter service located in Broome.

EMERGENCY RESPONSE PREPAREDNESS

Shell is committed to an ongoing state of emergency preparedness. Shell has an emergency response framework designed to comply with standards and regulatory requirements relevant to Australian operations, which are also aligned to Shell's global standards and based on sound emergency management principles and good industry practice. Shell Australia has a dedicated emergency response team, which is on standby 24/7 to react to any incidents as a result of our operations.

To ensure preparedness, exercises are conducted based on identified risks to specific projects and assets. These exercises provide emergency response responders with an opportunity to practice their roles and responsibilities and remain familiar with specific response plans. Major exercises and regular stakeholder engagement with government, regulators, contractors and other key service providers ensure integration between organisations, familiarisation and communication requirements. Further Shell global and regional exercises test and refine Shell's ability to respond to incidents across multiple regions and business units.

Regulatory and Legislative Environment

The Prelude field is located in Commonwealth waters and is subject to Commonwealth legislation. The principal Acts and Regulations governing petroleum operations in Commonwealth waters are as follows:

- The Environment Protection & Biodiversity Conservation Act 1999
- The Environment Protection & Biodiversity Conservation Regulations 2000
- Offshore Petroleum & Greenhouse Gas Storage Act 2006 (OPGGGS Act);
 - OPGGS (Environment) Regulations 2009
 - OPGGS (Resource Management & Administration) Regulations 2011
 - OPGGS (Safety) Regulations 2009
- Navigation Act 2012 (covers Australian owned vessels and applies until the facility becomes fixed on location).

ENVIRONMENT

An Environmental Impact Statement was prepared and submitted to DEWHA (Dept of Environment, Water, Heritage & the Arts) in July 2009, covering development drilling; installation of subsea facilities and FLNG hook-up, commissioning, operation/maintenance and decommissioning. The project received environmental approval on the 12th November, 2010 from the Federal Environment Minister and SEWPAC (Dept of Sustainability, Environment, Water, Population & Communities).

FLNG has a substantially smaller environmental footprint than onshore LNG. The key to the Prelude FLNG Project's reduced environmental footprint is that it combines the traditional offshore and onshore components of an LNG development into a single, integrated Floating LNG facility that can be located in a distant and non-sensitive environment.

In compliance to the requirements of OPGGS

(Environment) Regulations, Environmental Plans for Top holes and Production Drilling have been submitted and approved by NOPSEMA and Department of Environment (DoE).

Remaining Regulatory activities involve submissions of Environment Plans (EP) to NOPSEMA and the Department of Environment for the wells completion (including spill and monitoring modelling); subsea installation and FLNG installation and operation.

SAFETY

During Front End Engineering Design (prior to Final Investment Decision) the Prelude FLNG team proactively engaged with NOPSEMA (then NOPSA) providing a sequence of deliverables detailing the rigorous approach to safety in design. In accordance with NOPSEMA's 'Early Engagement Safety Case Assessment Policy', the above deliverables culminated in the Design Safety Case, which documented the end of FEED and included the Design Integrity and ALARP demonstration of the Prelude FLNG Facility. As per standard protocol, comments were received from NOPSEMA and responded to.

The Prelude FLNG Safety Case is to be submitted in stages, with each submission fulfilling the requirements of the OPGGS and associated regulations. The scope of the first submission covers the subsea infrastructure installation scope and was submitted in April 2014. The second submission covers the FLNG hook-up and commissioning. The third and final submission specifies the technical and operational integrity controls for ready for start-up and operate phase.



Security

Security planning for the Prelude FLNG Project occurs in phases and in accordance with the Shell project planning process. These security plans and assessments are;

- Country Security Threat Assessment
- Security Philosophy
- Project Security Threat and Mitigation Assessment
- Security Strategy
- Offshore Facility Security Plan
- Security Risk Assessment

The Offshore Facility Security Plan is required under Australian legislation and is regulated by the Office of Transport Security. All other security and assessment plans are Shell plans. In addition, the contractor, Technip, is responsible for security planning and implementation up to commissioning and the Technip plans are subject to Shell assurance. For example, for critical path equipment that has to transit piracy prone waters, additional security measures are required by the contractor and these must comply with Shell security standards for transiting high risk areas.

Building Safety Capabilities in WA

Shell has been working in partnership with Challenger Institute's Australian Centre for Energy and Process Training (ACEPT) to develop a world-class FLNG training program and safety competence is a key deliverable of the initiative. Not only does this play a key role in developing a safe Prelude team, it is allowing Challenger to build its LNG and offshore safety capabilities through access to Shell's safety competence and assurance initiatives, which are based on decades of global operations experience.

Shell Australia's local contractors and partners also develop further safety capabilities as a result of working on Prelude FLNG. Through the application of HSSE and

SP Control Framework, contractors must comply with Shell's global safety standards and this in many cases significantly improves the safety performance of local companies and organisations.

Local institutions will also provide the specialised safety training required for offshore personnel, including;

- Emergency Response Training
- Helicopter Landing Officer
- Common Safety Training Program (CSTP)
- Basic Offshore Safety Induction and Emergency Training (BOSIET)
- Helicopter Underwater Emergency Training (HUET)
- Confined Space Entry
- Workplace Assessment
- Electrical Equipment in Hazardous Area inspection (EEHA)
- Radio Operator
- Dangerous Goods
- High Risk Licenses (Boilers, Crane, Rigging, Scaffolding, Turbine etc.)
- First Aid and Safety Representative
- Oil spill response training is also provided to almost 200 staff by the local AMOSC facility.



Glossary

Freeboard	Distance from the sea surface to the deck.
Green water	The sea encroaching on open deck (other than spray).
Substructure	The Hull and Living Quarters of the FLNG.
IMO	International Maritime Organisation.
Classification Society	A marine standards agency.
Statutory	Of government.
Ballast	Water taken on board the FLNG to compensate against buoyancy.
FPSO	Floating Production and Storage Offloading Unit.
LNG	Liquefied Natural Gas.
Bow shape	The shape of the front end of the barge which is exposed to the major force of the wave. The shape is designed to deflect a wave whilst maintain directional stability.
Bulwark	An extension of the side shell of the hull above the open deck to assist in deflecting a wave.
Forecastle	A raised forward superstructure designed to increase freeboard forward to protect against high waves.
Hull Girder	A term to explain that the hull of a floating structure behaves similarly to a structural girder or beam.
Draught	The depth of the hull underwater.
Slam	When the hull of the floating structure emerges from the water surface and violently drops down onto the water surface or the water surface rises with high velocity and impacts the hull.
Double hull, side deck	A structural arrangement of the FLNG hull where there is both an external hull and a secondary internal "hull".
Double plate	Similar to double hull, a structure formed by two continuous plate structures separated by a space.
Centre girder	A structural arrangement on the centre line of the FLNG which spans between the main deck and bottom of the hull and runs the full length of the cargo region.
Weather vane	To align with the prevailing weather conditions.

