Maximising Workforce Involvement in HSE Case Development

Unlike the onshore LNG industry and the marine LNG carriers which enjoy an excellent and established Health, Safety and Environmental (HSE) record, the safety performance of Floating LNG (FLNG) concepts is still very much an unwritten book. In view of the negative publicity and criticism FLNG installations have received in some parts of the world, the HSE Case, which is a requirement imposed on many Oil & Gas facilities by regulators and stakeholders, should be used as an instrument to objectively report and assess the HSE hazards associated with FLNG installations. It is important to maximise the interface with the workforce in order to develop and maintain a comprehensive HSE Case throughout the life of the installation. DNV has successfully applied a combination of Hazard and Effects Management Process (HEMP) and a tailored intranet solution encapsulating HEMP and its deliverables.

How Safe is the LNG Industry?

Is there a need to pay specific attention to HSE issues associated with FLNG concepts? Is it not true the LNG industry has one of the best safety records on the books?

Though the safety record of LNG activities in general is in line with that of the Oil & Gas industry as a whole, there has been an outcry by Non Governmental Organisations (NGOs) and other public organisations in the USA against the construction of LNG Terminals onshore and offshore. The focus of these organisations' attacks has been on the high third party safety risk of these terminals, though the potential for global warming effects is also used as an argument against building terminals on the US shorelines or offshore.

Statistics show that there have been no onshore accidents with LNG with serious public exposure over the last 30 years. Accidents have happened, but the impact has been within the plant boundaries. E.g. a recent large process incident occurred in Skikda (Algeria) in February 2004, when an explosion and large fire in a liquefaction unit caused substantial material damage, killed 27 and wounded 80.

For offshore and marine facilities the incident records available are solely for LNG carriers. However, none of the serious incidents that occurred led to Loss of Containment, mostly due to the double hull design of LNG ships. This design feature significantly enhances the inherent safety compared to other flammable liquid carriers.

Hazards Associated with FLNG Installations

For offshore located FLNG installations can we expect the same impeccable safety performance as LNG ships? Table 1 provides an overview of MAH applicable to FLNG facilities.

From the table it can be concluded that the hazards are not dissimilar from those for other floating Oil & Gas production concepts. However, there are some salient aspects that are specific for FLNG installations and the properties of LNG when acci-

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dentally released, testimony to the areas of research associated with Floating LNG concepts. Broadly speaking, the following key HSE issues / areas have been (and still are) subject to a considerable research and development effort:

Hazard Category	Comment
Well fluids	Subsea facilities and flowlines, marine risers, turret area
Process Releases	Cold process – cryogenic releases, increased risk of brittle fracture Gas, liquid (condensate)
Cargo tanks	Over filling of cargo tanks External impact from dropped objects or ship collisions
	Sloshing Gas releases through tank vents
Export facilities	Export header, (novel design) offloading facilities
Ship collisions	Affecting position of vessel or integrity of LNG storage tanks, marine risers LNG Carrier
Marine	Loss of position/ station keeping failure / mooring failure Loss of stability or buoyancy Flammable hazards posed by adjacent LNG Carrier
Transportation of crew	Helicopter, crew boat
Occupational	Not fundamentally different from FPSO/offshore processing plant Flare radiation – impact on deck operations

*In terms of hazard and risk potential for a FLNG concept there is no considerable difference between a Floating Storage Recovery Unit (FSRU) and a Floating Production, Storage and Offloading (FPSO) facility for LNG

Table 1: Typical Safety Hazards for FLNG Installations

1. **External Impact of Storage Tanks (Ship Collision)**
   Most LNG carriers have either Moss or membrane type storage tanks. Moss spheres are physically stronger than membranes, but membranes are possibly more ductile than spheres. Spheres have single containment, membranes have double containment. Membrane ships are structurally more rigid than Moss vessels.
   Impact modelling (mostly based on Finite Element Modelling) has been performed by various parties (and is still ongoing) to predict the energy absorption for different tank types, and to find specific damage patterns (i.e. hole size and shape). Also, there has been considerable research in the speed distribution of colliding vessels at impact.

2. **Sloshing**
   Computational Fluid Dynamics (CFD) is used to assess the probability of sloshing of LNG cargo for different tank types (membrane and Moss tanks), sea states and tank inventory levels. Sloshing is not only a safety concern, it can also be an operational restraint.

3. **Behaviour of Cryogenic Fluid and Effect of Cryogenic Release**
   Cold LNG contacting water can result in a superheat "physical / mechanical" explosion also referred to as Rapid Phase Transition (RPT). The physics of RPT is not yet fully understood. Also, the spreading of LNG on water is a complicated process, with several factors affecting pool spread dynamics. Existing spread models are based on oil spill, and these do not take into consideration the boiling off LNG at the tip of the pool. These phenomena are subject to considerable research.
   LNG sea fire modelling is another area of research. Modelling so far has been for limited pool sizes (< 30 m), not reflecting the conditions that could occur in the case of a sea fire following a large spill. Another area that has triggered debate is the explosion potential of vapour clouds on free water surface because of low "pancake" type shape.

4. **Offloading Systems**
   Of all systems of the FLNG, the cryogenic offloading system probably requires the most novel technology. The offloading systems incorporate an emergency disconnect for emergencies, tied into the export shutdown system to minimise accidental release of LNG The application of novel technology could introduce "unknown" operational and safety hazards, and warrants a rigorous assessment and testing programme.

5. **Terrorist Attack**
   The images of burning oil tankers following a terrorist attack (e.g. M.T. Limburg, Yemen, October 2002) show how vulnerable tankers are.
   A successful terrorist attack on one tank of an FLNG could cause serious brittle fracture to the vessel, as well as result in fire engulfment and direct flame exposure above deck and one or

more adjacent tanks. The heat flux from engulfing fires could cause high thermal fluxes to the cargo containment system, and this could lead to over-pressurisation of adjacent tanks.

Why an HSE Case?

The development of HSE Cases (or the equivalent) demonstrating that Health, Safety and Environment and particularly Major Accident Hazard risks are being managed to an acceptable level is a requirement posed on many Oil & Gas facilities by regulators and stakeholders. Considering the hazards associated with LNG (see above), the development of an HSE Case for an FLNG installation seems appropriate. In view of the negative publicity and criticism received in some parts of the world, the HSE Case can be used as an instrument to objectively report and assess the HSE hazards associated with FLNG installations.

Essentially, the purpose of HSE Cases is to demonstrate how a company's risk management objectives are implemented in practice and how the HSE Management System applies to a specific facility or operation. The HSE Case provides a methodical and auditable reference document containing all information relevant to the protection of people, environment and asset.

When to Develop a HSE Case

Preferably the development of an HSE Case starts at the feasibility phase or latest during the Front End Engineering Design (FEED) (Phase 1). At this stage the objective of the HSE Case is to design for HSE Integrity. During the Detailed Design and construction phase the HSE Case is updated with the goal to demonstrate that the installation is being built for HSE Integrity (Phase 2).

The Operations HSE Case describes how to maintain HSE Integrity (Phase 3). This HSE Case should be regularly updated (typically every 3 to 5 years), or whenever a major change occurs to the installation or operation.

Finally, an HSE Case should be developed for the disposal / decommissioning phase, essentially describing how HSE Integrity will be maintained during and after shutdown of a project/ installation (Phase 4).

Maximising Workforce Involvement

In particular for an HSE Case developed for the operational phase (Phase 3), it is essential to involve the workforce. The workforce will be made up of representatives of operational personnel of the installation (e.g. Operations, Maintenance, Inspection, and HSE representatives). However, for HSE Cases compiled for other phases it will also be necessary to engage operational staff. E.g. when designing an offshore loading system (Phase 1 HSE Case), it will be necessary to consult marine operational staff.

One main challenge when developing an HSE Case is inherent of its format – a report. The HSE Case tends to be a description rather than a demonstration of the operation's risk management processes and procedures. Furthermore, the document itself runs the risk of ending up in a book shelf only to be dusted off for periodical review. How do you keep an HSE Case alive?

In order to address these issues, Abu Dhabi Gas Industries Ltd (GASCO), one of the world's largest gas processing companies, turned to DNV to develop HSE Cases for all their facilities. The DNV approach included the use of Hazard and Effects Management Process (HEMP) and the development of a customised intranet solution to ensure a continuously living process. DNV believes that this concept can also be applied to FLNG installations.

HEMP is a systematic method of identifying hazards, assessing risk, putting controls in place to guard against those risks and defining recovery measures should an incident happen. The approach can be used in all phases of an operation's lifecycle; from design through operations to abandonment – the only difference is that the focus of the process changes.

A powerful and popular output of HEMP is the Bow Tie diagram (Figure 1) which is used to graphically display HSE Critical Elements & Systems and the HSE Critical Activities and Tasks (i.e. operational systems) that support them. With GASCO, HEMP

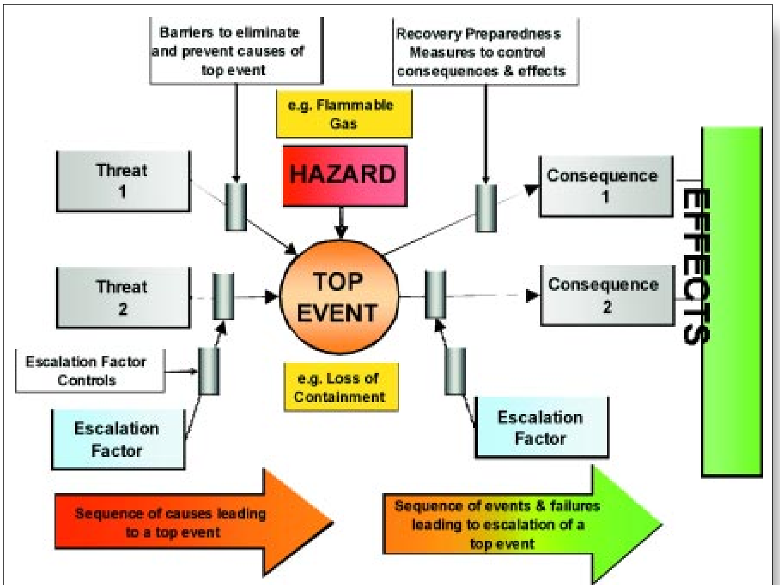


Figure 1: Bow Tie Diagram

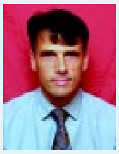
was implemented through workshops involving operation workforce from senior managers to supervisory level. The workshops promote workforce participation and ensure that the findings of HEMP are relevant and reflect actual working practice.

To ensure a living process, a dedicated GASCO intranet solution was developed (Figure 2) where all users can easily access and contribute to the electronic HSE Case without any geographical constraints. The electronic case widens the user base and creates awareness among the workforce.

Also, this solution offers the possibility of tracking and closing actions "online", and updating HEMP and its HEMP deliverables "online".

In an industry such as Oil & Gas, which has a perceived high risk factor, HSE is everybody's concern – it is holds no geographical or time constraints.

Figure 2: Intranet Solution



This publication thanks Mr. Cees de Regt for providing this paper, which was presented at FLNG Tech Asia Summit 2008, which was held in Kuala Lumpur on the 27th and 28th of November 2008. He obtained his MsC degree in Structural Engineering in 1984 at the University of Delft in the Netherlands. Over the last 16 years he has worked for Det Norske Veritas, where he has held various technical, line management, business development and project management positions across the globe. His area of expertise is in safety and reliability engineering, in particular risk management, applied in the field of HSE Management, Process Safety Management and Asset Integrity Management. He currently holds the position of Associate Director for HSE & Risk Solutions for DNV Energy and is a member of the Dutch Association of Professional Engineers (KIVI).