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EMERGENCY PLANNING USING THE HSE'S EVACUATION, ESCAPE AND RESCUE (EER) HAZOP TECHNIQUE

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The Health and Safety Executive (HSE) commissioned the development of a technique (EER HAZOP) for analysing Evacuation, Escape and Rescue from offshore installations. DNV has used this technique on several installations and considers the concept could be suitable for onshore process plant. For representative accident scenarios, each stage of emergency response is considered, e.g. detection, initial command and control of the emergency, evacuation (if required), etc. Guidewords are then used to analyse what can go wrong in each stage. The technique ensures that emergency response is analysed in a structured manner and response arrangements are based on a documented, traceable process. With increased attention on emergency planning resulting from COMAH legislation, the use of such a systematic method would provide a valuable complement to emergency exercises for onshore facilities. The approach enables the specific features of the facility and its command structure to be assessed removing generic and possibly unrealistic assumptions.

Keywords: Emergency Response, HAZOP, COMAH

INTRODUCTION

Information available on the approaches to hazard identification being adopted in Evacuation, Escape and Rescue (EER) analyses for offshore safety cases indicated to the HSE that a demonstrable full consideration was not always being given to the range of potential failures and hazards that can affect emergency response. To address these concerns the HSE Offshore Safety Division commissioned a study into the development of methods that would enable a more systematic analysis and interrogation of emergency response arrangements to be provided. From this, the Evacuation, Escape and Rescue Hazard and Operability (EER HAZOP) study[1] was developed.

This paper introduces the concept and outlines its use in practice with case studies. Through practical experience it is possible to foresee wider applications of the technique particularly with respect to onshore emergency planning and testing.

The intention of the paper is to highlight the benefits of extrapolating the standard Hazard and Operability (HAZOP) format used routinely by chemical engineers and others for system design and operation, to create a tool that can offer a cost effective yet systematic evaluation of emergency response provisions. Through the common medium of HAZOP guidewords and deviations it is also hoped that a degree of standardisation can be applied to emergency response assessment promoting wider communication of hazards and lessons learnt throughout industry.

LESSONS FROM PREVIOUS ACCIDENTS

Analysis of previous accidents has shown that there are many transferable lessons to be learnt with respect to emergency planning. The HSE has provided information[2] on ten lessons learnt from major accidents in the early nineties, associated with the events at :

- Allied Colloids Limited, 21 July 1992
- Hickson and Welch Limited, 21 September 1992
- Associated Octel Company Limited, 1-2 February 1994

The main lessons are summarised as follows :

1. Procedures for summoning emergency services promptly should be incorporated into emergency plans.
2. Effective reliable public warning systems should be provided and responsibilities for sounding etc should be established.
3. Off site emergency plans should state how environmental contamination is managed, with nominated responsibilities and methods of informing external parties.
4. Companies should ensure they are able to advise emergency services/ external authorities of the potential toxicity of products of combustion from mixed chemical fires.
5. Sites where firewater run off could create a major environmental accident should consider with relevant bodies the best methods of managing the associated risks.
6. Effective communication of missing persons to the senior fire officer in charge should be undertaken and associated procedures practised routinely to ensure effectiveness at any time of the day.
7. Emergency planning and training for major hazard sites should encompass all major accident scenarios, with necessary attention given to smaller but significant risks.
8. For each major accident, those involved in planning and providing emergency response should agree the information they may require and how to access such information quickly.
9. The HSE should review associated guidance to ensure that the lessons learnt are incorporated in HSE guidance.
10. Companies and local authorities should consider providing information to the public beyond the Public Information Zone (PIZ), before and during accidents, to allay concerns.

In a study undertaken for the European Commission[3], on lessons leaned from hazardous chemical emergencies, similar themes to those identified by the HSE have been identified. Issues such as, the role of emergency planning, communication between parties involved in the emergency response, provision of information to the public and capturing of lessons learnt were all found to be important.

Both references indicate the range of the emergency response provisions and the level of reliance on parts of the process for effective emergency response. The broad range introduces the potential for failure at many points in the overall process. Recognising how failures can arise and its implications, are the first steps in assessing the effectiveness of proposed emergency plans and the EER HAZOP technique offers an effective method for identifying any potential problems.

EER HAZOP METHODOLOGY

An EER HAZOP is undertaken in a similar manner to a traditional Hazard and Operability (HAZOP) study. A facilitator (Chair), assisted by a recorder (secretary) leads the team through the discussions in a structured manner. Depending on circumstances, the team is comprised of representatives from design disciplines, maintenance staff, emergency controllers/commanders, external assistance bodies, safety/environment personnel etc.

The main area of difference in method is in the structure. With the traditional HAZOP the structure is built in through nodes, guidewords and deviations. For the EER HAZOP the structure is provided by accident scenarios, EER stages, property words and guidewords. The EER HAZOP process is summarised in Figure 1.

For each accident scenario and each EER stage, the guidewords are applied in logical combinations with the relevant property words. Possible causes of such failures derived from property/guideword combinations are then identified by the review team. Having identified all causes, the team assesses the consequences, safeguards and need for action for each cause in turn. Once all causes have been discussed a new property word/guideword combination is raised and associated causes identified and the assessment process repeated. Having exhausted all logical combinations of property and guideword under a stage of the emergency response process the team then moves on to the next stage and repeats until the full emergency response process has been assessed. The overall process can then be repeated for the next accident scenario as outlined in Figure 1.

Accident scenarios

The EER HAZOP method can be applied to all credible accidents and this provides the highest level of structure within the study. Typical accident scenarios for the offshore industry include: explosions, jet fires, pool fires, toxic gas dispersion, ship-platform collision etc. Further experiences on accident selection and its application within an EER HAZOP study are offered through reference to case studies below.

EER Stages

In the EER HAZOP technique for offshore installations, the complete emergency response process is broken down into 7 stages as follows:

1. Detection of an incident and communication of the emergency
2. Access to muster areas
3. Mustering and the command and control of the emergency
4. Egress from muster points to the evacuation points
5. Evacuation, leaving the installation by the preferred means of disembarkation
6. Escape, if the evacuation points are inaccessible other means of leaving the installation are used
7. Rescue and subsequent recovery, where personnel are brought to a place of safety.

Each stage represents the next level of structure within the EER HAZOP Study. Figure 2 shows these seven stages in the form of a flow diagram. In principal there is no reason why emergency response in other industries should not be represented in a similar manner.

Property words

At each of these stages there are an associated number of property words. These are outlined in Table 1. The property words represent both hardware and human response aspects associated with each stage of the emergency response process. Note that the same property words are used for access to muster areas and egress from muster points to evacuation points. Different sets of property words have been developed for helicopter and lifeboat evacuation.

Table 1 Offshore EER HAZOP Property Words

Stage Number	EER Stage	Property Words
1	Alarm and detection/communication	Alarm system
		Communication system
		Response
2/4	Access/ Egress	Escape route
		Decision
		Movement
3	Muster	Muster point
		Communication
		Registration
		Survival equipment
5	Helicopter evacuation	Availability
		Approach
		Landing
		Take off
		Helideck
		Boarding
		Communication
		Equipment
5	Lifeboat evacuation	Boat availability
		Launch system
		Crew
		Communication
		Navigation
		Drop zone
		Survival equipment
6	Escape directly to sea	Escape devices
		Decision
		Movement
		Survival equipment
		Drop zone
7	Rescue and subsequent recovery	Availability
		Search
		Recover
		Sustain life

Guidewords

Property words are then combined with guidewords to create an equivalent to the traditional HAZOP guideword. EER guidewords, and examples of their usage when combined with property words, are provided in Table 2.

Table 2 Guidewords and Example Usage

Guideword	Example Combination
Failed	Communication Failed
Impaired/damaged	Escape route impaired
Fails during	Boat fails during use
Not done	Registration not undertaken (done)
Inadequate/ Insufficient	Inadequate survival equipment
Incorrect/inappropriate	Incorrect communication (of information)
Too late/soon	Decision to use boats too late
Congested/overloaded	Communication channels overloaded

CASE STUDIES

DNV has currently applied the EER HAZOP technique on several offshore installations including, an operational overseas bridge linked oil and gas complex, a design phase UK Floating Production Storage and Offloading installation (FPSO) and an overseas design phase FPSO. This section provides an insight into the application of the method on the overseas FPSO illustrating the nature of the review process through selected records. In each case a level of work had already been undertaken which indicated the range of major accident events and potential consequences. The method has been applied without a legislative requirement to do so and in each case was concluded to offer a valuable method of assessing and testing emergency response arrangements. Despite the relatively limited experience in application, certain insights on use have been identified along with possibilities for use in other industry sectors.

FPSOs are becoming an increasingly common method for recovering offshore oil and gas reserves. These installations employ moored oil tanker based structures where hydrocarbons are processed from subsea wells via flowlines and risers to a turret system. From the turret hydrocarbons flow to oil separation and gas processing facilities. Oil is then stored in the vessel hull for periodic offloading to shuttle tankers. Gas is used for power, reinjected, or flared.

Figures 3 and 4 illustrate the overseas FPSO in side and plan view showing a fore to aft arrangement of quarters, turret, process, utilities (power etc). The facility is equipped with peripheral escape tunnels (port, starboard and aft) and has 3 lifeboats, 2 forward and 1 aft.

For the FPSO, consideration was given to a range of accidental events that would offer an effective test of the emergency response provisions. For an FPSO a particularly testing event would be a large hydrocarbon release in the turret area as this could create oil and gas fires, high radiation heat loads over wide areas, explosions, smoke, escalation possibilities within the timescales for emergency response and possible damage to systems required for effective response.

The following tables, 3 to 7 show a selection of property words/ guidewords and summaries of the discussions that these prompted. Tables 3 to 5 were in the context of the major turret fire/explosion and Tables 6 and 7 were of general reference to all hazards.

Table 3. Large Turret Fire/Explosion – Alarm

Property word/ Guideword	Causes	Consequences	Safeguards	Recommendations
Alarm/ detection inadequate	Inaudible (e.g. during flaring, or through being close to the release)	Delays in personnel mustering. Increased exposure to hazards	Designated noisy areas have visible alarm signals. Human perception/ visualisation of the hazard.	Action 6. Areas of high noise potential, arising from normal or emergency conditions, should be re-examined throughout the installation to ensure that sufficient visual alarms are provided so enabling an appropriate emergency response.

Table 4. Large Turret Fire/Explosion – Access to Muster Point

Property word/ Guideword	Causes	Consequences	Safeguards	Recommendations
Escape route failure	Smoke	Possibility of smoke in 1 egress tunnel. Impairment of both very unlikely.	There are 4 smoke hoods at every entrance to the egress tunnels. There are 4 routes to get to the accommodation muster point; the 2 main egress tunnels and 2 routes via the process deck.	Action 8. Consider the need to provide smoke hoods for crane drivers.

Table 5. Large Turret Fire/Explosion – Access to Muster Point

Property word/ Guideword	Causes	Consequences	Safeguards	Recommendations
Egress route inadequate : stretcher access	It is envisaged that stretcher egress from the turret would take a long period of time.	Delayed recovery of person.		Action 11. Review provision of winch/hoists on turret for aiding stretcher recovery from both upper and lower turret sections.

Table 6 Evacuation

Property word/ Guideword	Causes	Consequences	Safeguards	Recommendations
Lifeboat availability inadequate	Maintenance strops left on lifeboat	The lifeboat will not descend to sea. Delay in safe descent Increase risk of injury	Lifeboat can be wound back up manually using hand-crank.	Action 20. Ensure high visibility of strops and develop procedures such that they will not be left on when not required.

Table 7 Rescue and Recovery

Property word/ Guideword	Causes	Consequences	Safeguards	Recommendations
Search failed	Fog/weather/sea state	Fast Rescue Craft (FRC) not launched Inability to recover people quickly Increase search time (as Stand-by Vessel used which is slower than FRCs)	Dacon scoop available	Action 27. Assess the need for Personal Locator Beacons given prevalence of fog (2-3 months per year). Also need to assess requirement for search lights on the FRCs.

It should be noted that the majority of property word/guideword combinations applied did not lead to recommendations as the existing safeguards were deemed sufficient. The above examples have been chosen with recommendations as they are of generally more interest.

This particular EER HAZOP outlined above took place towards the end of detailed design and hence most of the fundamental emergency response issues had already been addressed and resolved. Hence, the recommendations were generally quite detailed and often took the form of recommended reviews/checks by design and operations staff that measures had indeed been implemented.

EXPERIENCES WITH THE EER HAZOP TECHNIQUE

Most of the participants in the EER HAZOPs felt that the technique had ensured a far more systematic review of emergency response arrangements than if the group had purely brainstormed ideas with a “blank sheet of paper”.

Involving design and operational personnel especially towards the end of the design period, is a very effective method for transferring valuable information between project phases. It provides operational staff with a deeper understanding of the design intent and highlights possible difficulties at the interfaces of project teams. The process is however considered to be suitable for application at various periods in the lifecycle of plant development and operation. At the concept design stage it could be used to highlight fundamental emergency response issues and during operations it could be used as an audit tool.

In each case the technique highlighted possibilities that had not been expected. It enabled specific design and operational/ management features to be assessed and is easily tailored to the specifics of a facility.

With respect to the many accident scenarios that would cause an emergency the technique provides considerable flexibility. Exact calculations on consequences and possible escalation scenarios do not have to be available to enable the team to use the technique appropriately. Knowing that it is possible to have a large fire in a location for greater than 30 minutes for example can be sufficient. This provides an assessment that reflects the flexible decision making required for emergency response in practice.

As with traditional HAZOP, a level of preparation is required before the review can be undertaken. This is necessary to identify the scope of the review, identify key inputs that may be required and necessary personnel. However this initial investment proves to be an effective use of time and resource. The review process can be lengthy and requires appropriate planning to ensure it can be undertaken correctly. Full and effective review of the development of the emergency process for 1 major accident event, can take 1 full day of HAZOP. This is however relatively small when compared with the resource requirements for exercises/tests.

The quality of the output is related to the time and effort expended, although experience has indicated that there is possibility for some optimisation. By considering an accident that tests all stages of the emergency response as an "exemplar" event, many of the key issues will be identified. Other events that can offer significantly different outcomes can then be tested in a faster "by exception" EER HAZOP approach. By experience, it is better to cover 1 stage of the emergency response process for the exemplar event, then conduct a "by exception" review for other accidents, before moving on to the next stage of the emergency response process. This enables the team to remain focused on the key issues associated with that stage.

Common issues arise for each application such as the possible problems if fire and gas detection system inhibits are not controlled through procedure/permit that could lead to errors or failures in incident detection.

Most participants considered the technique/ method to be an interesting method for assessing arrangements and could see its potential for use in emergency response desktop exercises. The technique also lends itself to discrete applications where only part of the emergency response process, for example mustering, is assessed against a potential accident. This would enable a range of potential accidents to be assessed over a period of time or as part of a rolling programme to keep the focus fresh and up to date with facility/operational developments.

WIDER APPLICATIONS OF EER HAZOP

The ERR HAZOP technique offers a valuable and cost effective method of testing and assessing emergency response provisions for offshore emergencies. It lends itself to tabletop exercises that can be used to complement drills and full-scale tests.

In undertaking the reviews it has become obvious that through customisation the technique could be applied in other industry sectors. With the implementation of Control of Major Accident Hazards (COMAH)[4] legislation within the UK, there is a requirement to effectively test emergency plans and it is believed a suitably tailored technique could offer benefits to the onshore process industry. COMAH introduces additional environmental considerations and it is believed that an adapted EER HAZOP technique can also enable these issues to be addressed. Some initial indications of required changes are outlined as follows:

Stages of the Emergency Response Process

The 7 stages used to represent emergency response offshore will need to be changed to reflect onshore facilities. The ability for external emergency resources to access facilities would require specific consideration. However, it is judged perfectly feasible to develop a generic framework analogous to the one shown in Figure 2.

Property words/guidewords

More specific property words could be developed to cater for additional onshore features. In developing relevant words consideration should be given to the lessons learnt in previous accidents (Ref 2 and 3). For example in the alarm stage consideration will need to be given to the local population, neighbouring facilities, etc.

Media

Specific consideration will need to be given to the ability to manage the media and its influence on the local population throughout the entire response process, possibly through additional property and guidewords.

Environment

The offshore EER HAZOP process does not specifically address the environment. This does not reflect lack of industry concern for environmental issues but simply indicates the scope under which the method was originally developed. Inclusion of environmental concerns through additional property words and guidewords could look at issues such as firewater runoff.

Toxic Threats

In considering offshore hazards, toxic threats are largely confined to sour gas (hydrogen sulphide) issues. Onshore facilities can include a far greater range of toxic hazards and this again would need to be accommodated through definition of suitable accidental events for the HAZOP to review and relevant prompts.

Rescue and Recovery

This stage of the process will differ across industries and the nature of property words will have to be modified. This will include consideration of longer timescales particularly with respect to toxic/ environmental considerations.

CONCLUSIONS

To overcome concerns in the offshore industry the HSE Offshore Safety Division encouraged the development of a method by which organisations could assess emergency response arrangements in a systematic manner based on the established HAZOP principles. Through application of the method DNV and associated project teams have recognised the benefits this technique brings. Based on experience to date it is considered desirable that the method should be adapted for use in other industry sectors. It could prove particularly helpful to organisations affected by COMAH legislation offering a cost-effective method for assessing emergency response arrangements.

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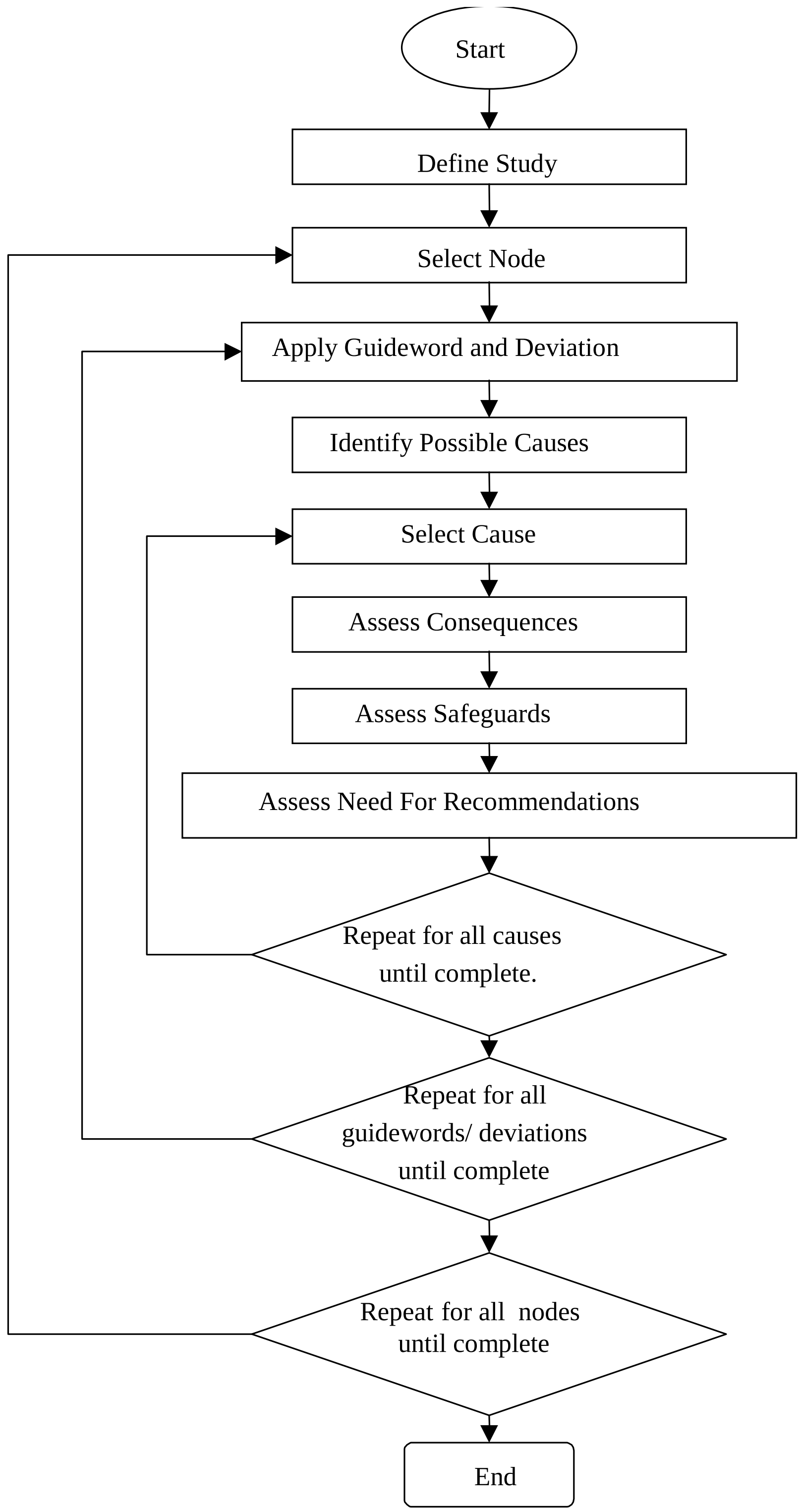

Figure 1 EER HAZOP Flowchart

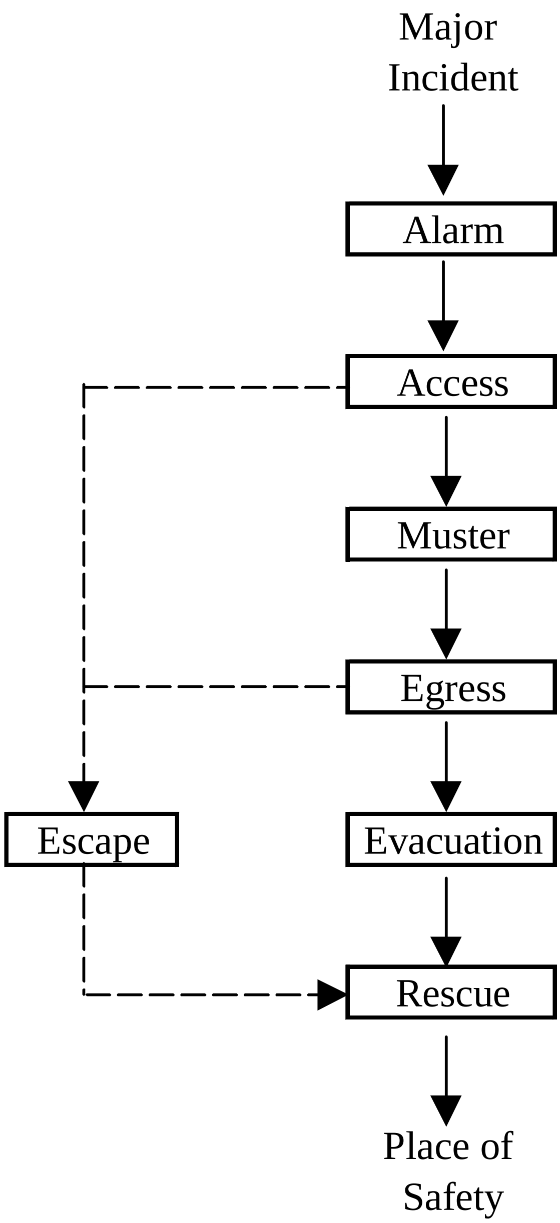

Figure 2 Emergency Response Process Flow Chart

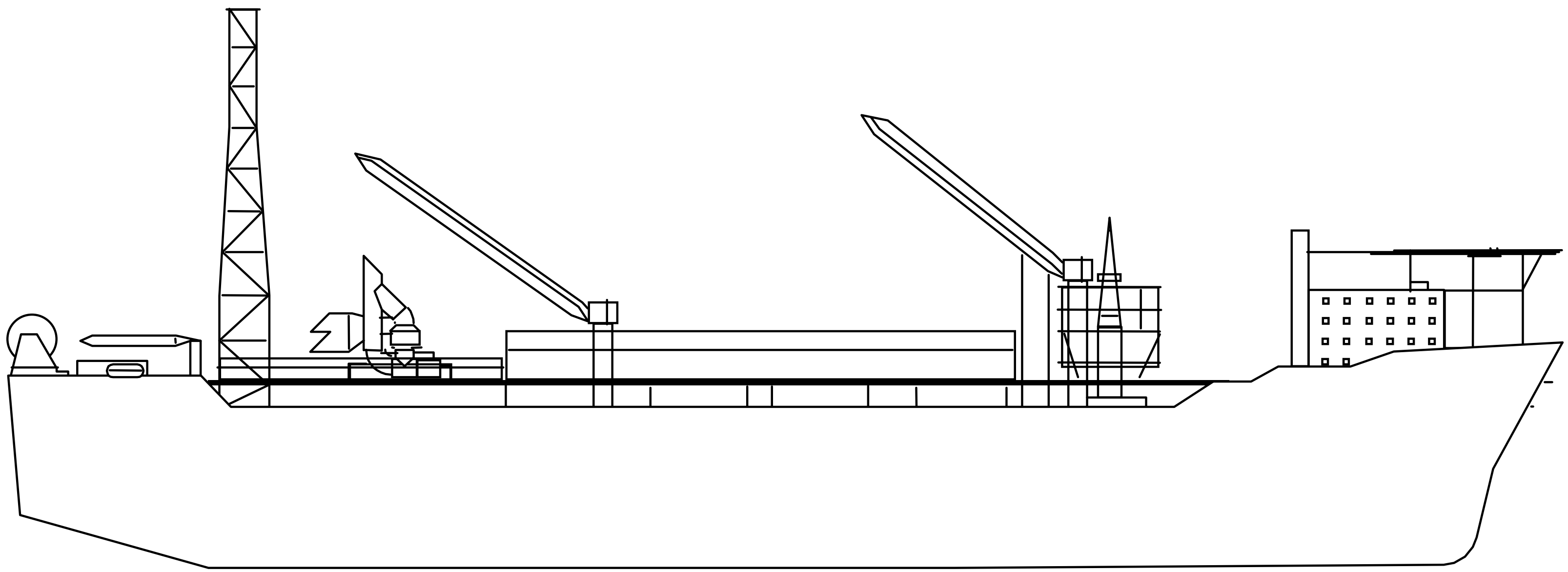

Figure 3 Overseas FPSO Side View

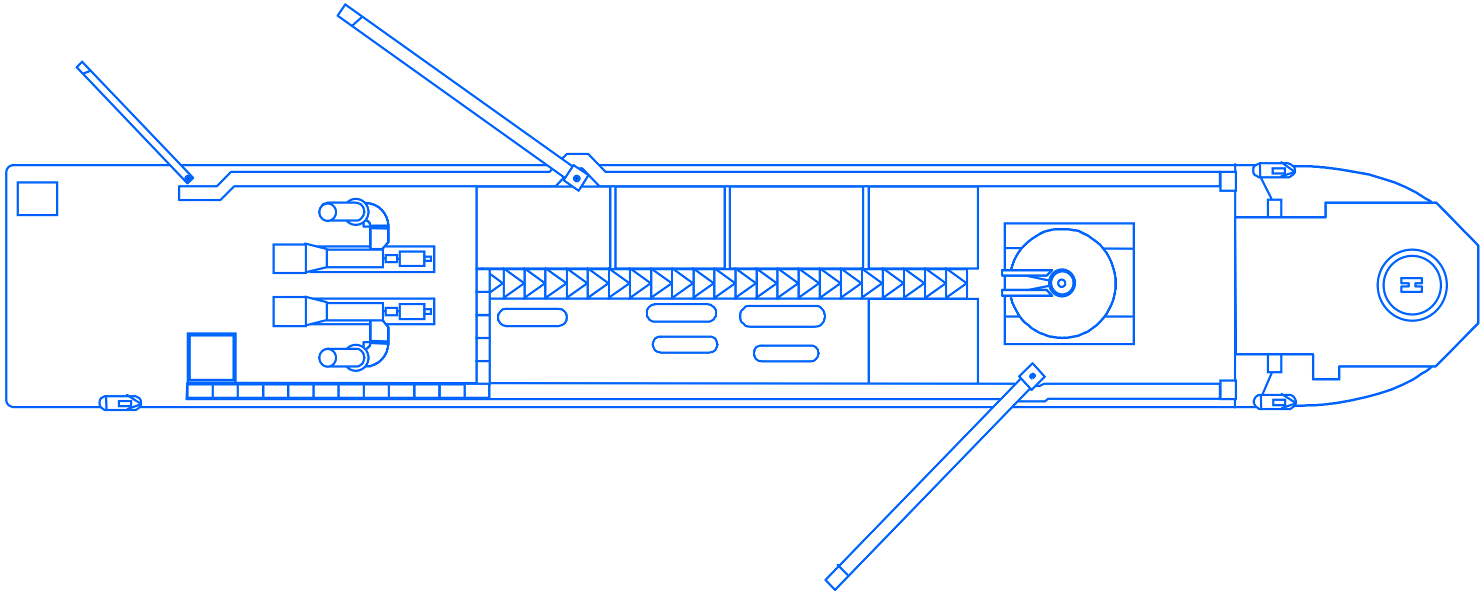

Figure 4 Overseas FPSO Plan View