Development of Emergency Response Plan
for a Crude Oil Supply System Involving an SPM

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Abstract:
In this paper, development of an emergency response plan (ERP) for a project involving an onshore crude oil terminal, onshore and sub-sea pipelines, and a single point mooring (SPM) is described. Following internationally accepted approach to ERP development, a comprehensive set of supportive studies have been undertaken, including HAZOP, HAZID, qualitative and quantitative risk assessment and ship mooring simulation. As a result, a total of 9 scenarios were identified to form the basis for ERP. For each scenario, detailed action plans (DAP's) were developed in which the hazardous events effects and effect zones, emergency planning, response organization and responsibilities, availability of emergency equipment, communication plan, and evacuation guidelines are defined.

Key words: Emergency response, ERP, SPM, risk assessment

1. Introduction
1.1. Piper-Alpha Disaster
The explosions and disastrous fire on the Piper Alpha offshore platform on 6 July 1988 resulted in the deaths of 167 men and the loss of the complete installation. The Inquiry after the Piper Alpha disaster has been of crucial importance in the development of the offshore safety regime in the UK sector of the North Sea. The Inquiry made 106 recommendations for fundamental changes to the offshore safety regime. All the recommendations were accepted by the British government [1].

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The first of these recommendations says that the operator should be required by regulations to submit to the regulatory body a Safety Case in respect of each of its installations. The safety case should show that a number of objectives have been met, including that the safety management system of both the company and the installation are adequate to ensure that the design and operation of the installation are safe; that the potential major hazards have been identified and appropriate controls provided [2] The requirements is usually developed into what is called an Emergency Response Plan.

1.2. Regulations and Standards

In 1992, the Norwegian petroleum Directorate (NPD) issued a regulation on emergency preparedness (safety barriers). The most important elements of this regulation were that [3,4]:

- The emergency preparedness of the activity in question shall be established on the basis of some defined situations of hazard and accident (i.e. scenarios definitions)

- The operator shall define specific requirements relating to the effectiveness (performance standards) of the emergency preparedness measures

- Analyses shall be carried out as a basis for the design of the emergency preparedness system.

New regulations replaced the old in 2002, but the main requirements related to risk analysis were maintained. However, a stronger focus has been placed on the context and the use of risk analysis, as well as on assessment and monitoring of barrier performance. One of main elements of the Norwegian Standard Z-013 is establishment of risk analysis and the relation between the risk and Emergency Preparedness Analysis (EPA) [5].

The Offshore Safety case Regulations of UK (OSCR) [6], which are the cornerstone of the offshore health and safety regime, require duty holders to demonstrate their ability to comply with the objectives set by other health and safety legislation applying to the control of major accident risks offshore. This includes the relevant parts of Prevention of Fire and Explosion, and Emergency Response Regulations (PFEER). PFEER requires measures to secure effective emergency response.

Another established international standard for emergency management requirements is BS ISO 15544:2000. This standard is based on an approach where the selection of measures for emergency response is determined by an identification and evaluation of hazards on the offshore installation. The methodologies employed in this assessment and the resultant recommendations will differ depending on the complexity of the production process and facilities, type of facility (i.e. open or enclosed), manning levels, and the environmental conditions associated with the area of operation [7].

1.3. Project Description

Qeshm Oil Investment Company intends to install an SPM (Single Point Mooring) terminal in the south of Qeshm Island and construct onshore and subsea pipelines for transferring heavy crude oil from VLCC tankers via Qeshm Island to B.A. Refinery tank farm. SPM is floated on water surface and it provides the link between the subsea Pipeline End Manifold (PLEM) and the crude oil tanker.

Crude oil is delivered to Qeshm Island through a 4.1-km, 48” sub-sea pipeline. An on-off valve s
considered at the end of the 4.1-km pipeline that operates on downstream. The crude oil is then transferred to storage facilities located 8 km from Qeshm south coast through an 8-km 48” buried pipeline. An emergency shutdown valve is considered at the end of the 8-km pipeline that will be activated when liquid level in either of four downstream storage tanks becomes high and one tank level becomes high-high. By the time of valve closure downstream booster pumps will be shut-off.

Heavy crude oil from pump station is routed to launching area in order to be sent to Bandar Abbas Refinery, through a 32” pipeline. An emergency shutdown valve is considered to shut off the pipeline in case of emergency shutdown. One high-high pressure switch at the beginning of 32” pipeline will stop pumps to prevent overpressure.

Crude is transferred to north coast through a 21.3-km 32” buried pipeline and then routed from the Khuran Strait crossing through a 10-km subsea pipeline. Two line break valves (LBV’s) have been installed at the end of each pipeline for protecting the unit and pipeline in cases where a breakage or tremendous leakage occur through the pipeline or any other conditions that causes tremendous pressure decrease through the pipeline. In these cases, LBV’s will be closed according to the condition. Heavy Crude oil is delivered to Bandar Abbas refinery, which is located 25.3 km away from south shore.

Fig. 1. A Single Point Mooring Terminal during Loading/Unloading
1.4. Emergency Response Plan

There are many possible incidents that may occur during constructional and operational activities of the project and may pose significant safety and/or environmental implications. It is necessary to devise ways to deal with these hazards.

An Emergency Response Plan is prepared to address various threats pertaining to the Project. The majority of the plan is dedicated to the hazard scenarios that seamlessly and neatly cover major emergencies based on previous risk assessment studies. The final outcome of the said scenarios can be seen either in process area, onshore and offshore pipelines, on SPM and PLEM, or even beyond the Project boundaries.

The latter includes neighbor sites and residential areas in Qeshm Island and Bandar Abbas, although the Plan presents only onsite response structure that should be implemented for the emergencies happen within the Project boundaries.

The plan contains procedures to handle the final specific scenarios or similar events that are covered by them in order to keep them from being developed into disasters. The plan only covers planning before and response to the identified emergencies and not the recovery operations. Regarding the project capacity, operations can be continued for 6 days if storage tanks are full at incident time.

The plan covers the following elements:

- Hazardous events effects and effect zones
- Emergency planning and response organization and responsibilities
- Availability of emergency equipment
- Communication plan
- Evacuation guidelines
- Implementation, updating and training

2. Objective

The primary purpose of Emergency Response Plan is to outline required response for the predicted emergency situations in construction, installation and operation phases of the Project.

The plan was prepared to ensure appropriate emergency management system is available and when activated in any emergency situation, it effectively minimizes harmful effects to life, environment, assets and company reputation.
3. Risk Assessment

Several studies are done to identify and evaluate the hazards involved in this project. Figure 2 shows an outline of these studies and the scope of this paper.

The scenarios are identified in a comprehensive HAZOP study that was conducted by a team composed of client and consultant. The study was followed by a detailed qualitative and quantitative risk assessment. Risk assessment enabled the project team to screen over all hazard scenarios to a final set of representative emergency situations. The goal was to minimize the number of scenarios in order to facilitate training and optimize its budget.

**Fig. 2. Outline of the project and supporting studies**
4. Accident Scenarios

Emergency situations are a selection of possible scenarios, which are basis for establishing the emergency preparedness for Project activities. Emergency scenarios are identified and screened during several risk assessment studies.

The following are considered serious emergencies during different phases of the project, namely construction, pipe-laying, installation, and operation. These scenarios are selected in the above studies as having serious safety and/or environmental consequences.

4.1. Collision; Tanker/Helicopter hits SPM

There is a risk when a tanker approaches, moored at, or departs SPM hits the SPM. The approach of a tanker to SPM is a routine operation world-wide, but collision with SPM does occur if there are any specific routing of the tankers that might make the approach more difficult or if there are any weather or tidal conditions that make the approach more likely to result in a contact. There is also risk that a helicopter crashes SPM during installation or operation phase. Possible consequences of a collision in installation phase include:

- Structural damage to the SPM
- Damage to SPM sub sea risers or to mooring system
- Damage to the tanker / helicopter
- Personnel injury
- Man over Board (MOB)
- Fire

Collision consequences become much intensive while SPM is operating, due to high risk of oil leakage/spill from SPM/tanker into the sea. After SPM commissioning and start-up, an operating vessel must be provided to be available all the time in the vicinity of SPM. This vessel must be equipped with life survival equipment, rescue boat, fire fighting facilities, certified helideck, adequate medical equipment, etc.

A collision to the SPM may result in a combination of several emergency situations e.g. oil spill, fire, and man over board. In such cases, ERC in line with ERM shall decide on priority of required emergency response and mobilize resources as required.

4.2. Fire

Fire could happen either in construction or operation phase of Project. During construction, there is no hydrocarbon in the lines and local fire fighting team can take action and manage the fire. Fire during operation phase intensifies the degree and level of emergency, so it needs higher level of response.

Operating vessel shall be equipped with suitable fire fighting equipment and have enough capacity to
extinguish fire on SPM.

As the only flammable material in the project is heavy crude oil, so there would be no explosion either in construction or operation phase.

4.3. Oil spill

The emergency response plan deals mainly with spill incidents, which occur during the tanker off-loading operations at SPM and PLEM. For purpose of this project, in case of spill larger than 7 tones, a contractor shall provide additional resources to the accident scene.

4.4. Man over board

There is risk of man over board during offshore activities; pipe laying; SPM installation and operations. In case of emergency when it is noticed that one person fell into the water, first aid team should be mobilized and ready for any required help after search and rescue operation.

4.5. Personnel Injury

This emergency situation is applicable to serious accidents to the project personnel, which includes occupational accident during different phases of the Project, injuries during personnel transfer and shuttling at field, epidemical, and injuries as result of any of the emergency situations.

4.6. Third Party Damage (TPD)

The most likely cause of pipeline failure is third party activity. Material damage to the pipelines is classified by the following categories:

- **Minor damage:** Damage neither requiring repair, nor resulting in any release of hydrocarbons.
  
  Smaller dents in the steel pipe wall, e.g. up to 5% of the diameter, will not normally have any immediate influence of the operation of the lines. This limit will vary and must be evaluated for each pipe. Note however, if damage occurs then inspections and technical evaluations should be performed in order to confirm the structural integrity. Any local damage to protective coatings or anodes will not normally require repair action.

- **Moderate damage:** Damage requiring repair, but not leading to release of hydrocarbons.
  
  Dent sizes restricting internal inspection (e.g. over 5% of the diameter for steel pipelines) will usually require repair. However, the repair may be deferred for some time and the pipeline may be operated provided that the structural integrity is confirmed.

- **Major damage:** Damage leading to release of hydrocarbons or water, etc.
  
  If the pipe wall is punctured or the pipeline ruptures, pipeline operation must be stopped immediately and the line repaired. The damaged section must be removed and replaced.

During operations, damage will lead to release from small holes or rupture in the live line. In such
cases, ERT shall be immediately mobilized to minimize environmental consequences of release, and
to prevent possible fire.

Environmental consequences are established for both minor and major release scenarios that consider
polluting impacts on eco-system in the water, coastal environment, sea birds, and fish in fish farms
and related industries in the area.

4.7. Rupture

During operation phase, several causes may lead in pipeline rupture, such as: Third party activities,
mechanical failures, internal and external hazards.

After being notified of this emergency situation, emergency response team shall be immediately
mobilized and evaluate the leak/rupture condition and decide either to depressurize, isolate or
shutdown the pipelines. All effort should be made to minimize the environmental damage and to
prevent the possible fire. The damaged area can be temporarily repaired by fitting clamps until further
assistance arrive at scene.

4.8. Earthquake

Qeshm and Bandar Abbas are historically prone to having earthquakes. Most possible consequences
of earthquake in the project are:
  - Structural damage to terminal facilities
  - Rupture in buried pipelines
  - Oil leak from subsea lines
  - Fire
  - Personnel injury

Each of the above outcomes was studied in the project emergency planning and response under
separate headings.

4.9. Extreme weather

Extreme weather has intensifying effect on each of emergency situations above. It may cause flood,
sudden sinking of vessel, shifting of heavy cargo and pipes, and it can mainly result in collision to
SPM, man over board, and personnel injury.

Therefore the Emergency Response Teams should be alert all the time when weather is rough, for any
kind of emergency. Moreover, weather forecasts shall be received from two different sources to
enable ERT of good preparedness and response. Accurate weather forecast can play an important role
in the project emergencies, especially during offshore activities; pipe-laying, SPM installation and
operation.
5. Emergency Planning and Response Organization

Company should assign a number of competent personnel to take responsibility of the project Emergency Planning Committee. The committee members should include key emergency persons who have experience of work within emergency situations. This committee has overall responsibility of audit, assess and review the project response system during construction and operation phase.

The project Emergency Response Organization is defined to safely mitigate the emergencies that may occur during the project construction or/and operation phase. All ERO members shall ensure the emergency response effort is directed in order to preserve life, environment, asset, and company reputation.

Due to difference in nature of emergencies during construction/installation phase compared to the operations phase, different preparations is required for responding to incident in each phase in an organized and efficient way. Therefore Emergency Response Plan should cover different roles of response teams in the mentioned phases of the project.

6. Final Comment

When Piper Alpha disaster happened, the requirements of the Emergency Procedures Manual were disregarded. There was clearly a failure of management to provide adequate initial and continuing training, and proper supervision [2]. Therefore, it is to be noted that no emergency response plan is good enough if it is overlooked. It is always recommended that these plans be maintained, updated regularly, and put into practice.
7. References


