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Analysis of the preparedness for pipeline emergencies

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1 Introduction

In 1995 Statoil carried out an emergency preparedness analysis (EPA) for all the major gas and oil pipelines that are operated by the company. 17 existing and future pipelines (mainly subsea) with a total length of more than 5000 km were analysed.

The reason for this exercise was not any major damage or hazardous situation related to a pipeline, but rather the realization that the economic consequences of the disruption of the transport in one of these pipelines could be very serious.

The overall objectives of the emergency preparedness are to avoid harmful effects on people and the environment, and to secure reliable gas and oil deliveries to our customers.

In order to assess the risk of pipeline damage several risk analyses were reviewed. This review revealed great variations in the data that are employed in the analyses. It is also clear that the risk is greatly overestimated in some of the earlier studies. However, based on up-to-date statistics, we can still conclude that we could expect a damage somewhere in the pipeline system within a few years.

For this reason an emergency preparedness for pipeline damage is established.

2 Existing emergency preparedness

Before the analysis the preparedness essentially consisted of an emergency organization, which is set up to handle the initial phase of the emergency situation, a leak detection model, and the various elements of the Pipeline Repair System (PRS). The PRS is operated by the Stolt Rockwater Joint Venture on behalf of Statpipe and Oseberg Transportation System. The contract encompasses hyperbaric welding, diving services and emergency preparedness, and includes diving vessels and supporting equipment required for the preparation for and actual repair (welding) of a damaged pipeline.

A contract with Halliburton for commissioning activities in the ongoing pipeline projects was signed in 1996. Although this is not explicitly an emergency preparedness contract, recommissioning after a pipeline repair can be carried out, but no mobilization time is stipulated.

3 Emergency preparedness analysis

Formal analyses of the emergency preparedness of offshore installations have been carried out after the introduction of the *Regulations relating to emergency preparedness in the petroleum activities*, issued by the Norwegian Petroleum Directorate (NPD) in 1992. All of the Statoil operated platforms and now also the gas processing and gas receiving terminals have been analysed.

The pipeline EPA coincided with a review by NPD focusing on the vulnerability and availability of the pipeline systems.

An EPA forms a link between the risk analysis and the emergency response plan. Whereas the risk analysis identifies the hazards relating to a pipeline and assesses the probabilities and consequences of various damage scenarios, the EPA specifies the requirements to the preparedness for the same scenarios. The emergency response plan gives the detailed description of the use of the various measures identified in the EPA.

The emergency scenarios (Defined situations of hazard or accident, DSHA) are specified according to the degree of damage:

- a large leakage, one which normally would be detected quickly and/or would pose an immediate hazard for people in the vicinity
- a small leakage, which is a less serious one
- a damage without a leakage, or a leakage so small that it would only be detected during an inspection
- a temporarily hazardous situation or possible damage.

These scenarios are relevant for all pipelines, and it was therefore possible to review several pipelines with similar characteristics in parallel.

The causes for such situations are only summarized here:

- drifting vessel which may founder
- sinking vessel near or on the pipeline
- dropped object
- anchor being dropped or dragged near or over the pipeline
- material or welding defects
- internal or external corrosion
- free spans
- subsidence
- unacceptable stresses
- faulty design
- faulty operation (pressure, temperature, composition)
- sabotage.

In the EPA the Specific emergency preparedness requirements (SEPRA) for the installation in question are identified and agreed upon for each of the phases of the emergency. These phases are in this context defined as:

- alerting
- danger limitation
- normalization
  - project organization
  - repair
  - recommissioning.

To facilitate the review further, each pipeline was subdivided into segments, such as:

- riser
- platform safety zone
- landfall
- valve station
- various water depths
- continental shelf sector
- etc.

Finally, detailed preparedness measures and resources which are required for meeting the requirements are identified.

The EPA is performed by a work group made up of the relevant disciplines, such as safety, pipeline control, inspection, repair systems and diving, and pipeline commissioning. By reviewing the analysis elements described in this section, pipeline by pipeline, and comparing similarities and dissimilarities, all relevant aspects of the emergencies should be covered. The analysis method is as such similar to a Hazard and operability study (Hazop).

The results of the review are documented in a Preparedness register in the report, summarizing the various elements of the analysis. The register facilitates the use of the results for implementation in emergency response plans, planning and evaluation of exercises, updating, performance of analyses for new pipelines, etc.

All results are also entered into a database (Safety information database), which provides extensive search and sort possibilities.

4 Emergency preparedness requirements

In the course of the analysis it became apparent that it is difficult to specify clear and quantitative requirements. This is so because the dominant consequences are those related to economic risk, which in turn means that cost-benefit assessments should govern the decisions. In a few cases, however, quantified downtime requirements have been specified, and in other cases availability analyses are based on certain assumptions regarding downtime.

When it comes to safeguarding of life and the environment, the requirements are kept as close as possible to those which are applied for offshore platforms.

The requirements we have applied can be subdivided into three groups:

- Control of the hazard
  - gas leak detection
  - alerting of emergency response team
  - alerting of authorities
  - reduction of leakage rate.

- Initiation of the repair
  - ensure availability of personnel, equipment and management systems
  - mobilization time for personnel and equipment.
- Sales gas quality at start-up
  - recommissioning methods.

Apart from alerting and mobilization times the requirements are essentially qualitative. Based on cost-benefit analyses it is still possible to optimize the requirements, but some elements of the calculation are hard to quantify; in particular those related to the operator's reputation and goodwill, possible loss of future sales and consequences for Norway as a nation. These elements should, however, not be omitted.

5 Emergency preparedness measures

In addition to identifying new measures in this EPA, we have seen all the measures in connection and as a total, identified dependencies and weak elements, and looked at the overall scheduling of the activities.

We subdivide the measures into three groups: Technical, operational and organizational. The various technical measures have been extensively presented in other conferences, and it is not the intention to go into too much detail here.

5.1 Technical measures

A leakage can be detected either by visual observation or instruments. A leak detection model has been integrated in the pipeline modelling system at the Transportation Control Centre (TCC) at Bygnes, utilizing the signals from process instruments at all pipeline end-points.

The available measures for control of the hazard once a leakage has occurred are shutdown and depressurization systems. In the EPA we have demonstrated that the primary means of depressurization most often would be a maintained and, if possible, increased export to the customers. This is contrary to platform emergencies where emergency shutdown and blowdown systems would be used immediately.

Important elements for the repair preparedness have been available for several years. The Pipeline Repair System was developed already in 1986 by Statpipe and the Oseberg Transportation System partners. It consists of H-frames, a concrete removal and pipe cutting machine, a pipe cleaning tool, welding habitats and power and control units. PRS can be used for the repair of pipelines from 8 to 42 inches. The system also encompasses repair clamps, hydroplug equipment, and a 16 inch diverless connector with its own installation frame. In fact, several elements of the PRS have been developed over the last few years towards a higher degree of diverless operation.

The diverless mechanical pipe connector has been developed recently on the basis of the Morgrip connector of HydraTight. It was successfully used for the mid-line tie-in of

Haltenpipe last summer, and this method is intended to become the primary repair method for the 16 inch Haltenpipe and Troll oil pipelines.

The planned development of remotely controlled hydroplugs (installed without umbilical) would improve the preparedness for several repair scenarios since controlled flooding of the pipelines could then be unnecessary.

The recommissioning after the repair will involve pumps, compressors and means for the safe disposal of the fluids in use. The requirement for dump-lines will of course depend on the methods, in particular whether gas is used for dewatering. The long gas trunk-lines to the continent will require large pump and/or compressor spreads.

5.2 Operational measures

The EPA identified some new elements to be incorporated in the emergency response plan for the alerting and danger limitation phases. These include a guideline for interpretation of the leak detection model and tools for assessing gas dispersion and leak duration. We also stressed the need to clarify roles and responsibilities, both towards interfacing organizations at the end-points and towards authorities.

Following the analysis new procedures for depressurization will be developed, taking account of export to customers and available blowdown facilities. To simplify the recommissioning operations it is also important to avoid sucking sand and silt into the pipeline, and this must be considered during the depressurization.

To meet the requirement for a fast establishment of project management systems, we found it necessary to develop an emergency response manual for the normalization phases, relevant for each pipeline. This manual contains a general description of a project organization, the various management systems to be used (document control, project control, cost control, contract management etc.), reference to relevant contracts, and authority matters. Specific data for each pipeline with reference to operational procedures and repair methods are also included.

During the EPA we established a full overview of spare parts and various preparedness equipment, as well as qualified welding procedures. This overview is included in the normalization response plan and will be regularly updated.

Pipeline repair methods for various water depths are developed by the Stolt Rockwater Joint Venture as a part of the scope of their contract, and documented in a *Pipeline repair manual*. Repair methods for the various landfall solutions have also been identified, but some further development will be required for those areas.

Several of the pipelines have been buried and/or covered by gravel or rocks. There exists equipment for the recovery of these pipelines, but it will be essential to mobilize this equipment quickly. We will therefore identify the required equipment for the various pipelines.

A certain degree of pre-engineering for recommissioning operations should be carried out in order to ascertain a fast mobilization of the required temporary equipment. It is important to identify the possible tie-in locations to the permanent facilities at the pipeline end-points and any need to prefabricate equipment.

5.3 Organizational measures

As mentioned the organizations that will handle a pipeline emergency are:

- the emergency preparedness team, and
- the project team.

The emergency preparedness team consists of personnel in Statoil's Transportation systems unit. They have a 24 hour preparedness according to a duty roster. This team shall be able to handle the first 48 hours of the emergency, including the alerting and danger limitation phases, as well as preliminary mobilization of required contract services. The emergency manager has been given sufficient authority for all actions which might be required in these phases.

The EPA identified the requirement for mobilization of the key personnel of the project team, including manager and discipline leaders, within these 48 hours. To this end personnel or positions in the relevant Statoil units have been nominated, and their authorities and responsibilities described in the emergency response plan for normalization. Presently these are mainly personnel in pipeline projects, but the list of nominees will be kept updated regardless of the status of ongoing pipeline projects.

6 Further activities

1996 has been devoted to the development of the emergency response plan for normalization and tools for calculation of gas dispersion etc. The emergency preparedness has also been included in the discussions with NPD regarding the overall availability of the pipeline systems. It is recommended to improve the database for failure statistics, in order to arrive at more reliable risk estimates. Further, combined or closely linked risk and emergency preparedness analyses should be carried out during engineering of new pipelines to ascertain that design aspects satisfy both acceptance criteria and emergency requirements. This work will be continued in 1997.

Key activities this year will be to develop repair methods for special landfall solutions, to carry out table-top exercises for normalization activities, and to further optimize the various preparedness measures and resources, including mobilization times, possible contracts, and repair and recommissioning methods. Due to the extensive development of the pipeline systems, one should, when optimizing, consider the possible utilization of redundancy in the systems to arrive at optimal solutions.

7 Concluding remarks

The emergency preparedness analysis has proved valuable for the identification of weak or missing elements. It is a decision support tool for management, helping to give priority to activities enhancing the preparedness. By including the relevant disciplines and representatives for pipeline operations, those who are responsible for the pipelines gain a feeling of ownership to the analysis and responsibility for the implementation of the results.

The main challenges are related to the development of reliable risk analyses data as a basis for sensible criteria and preparedness requirements, and to the optimization of measures and resources.