Second Annual Symposium, Mary Kay O'Connor Process Safety Center
"Beyond Regulatory Compliance: Making Safety Second Nature"
Reed Arena, Texas A&M University, College Station, Texas
October 30-31, 2001

Offshore Risk Assessment - Simple or Complex?

John Alderman
Mike Johnson, Advantica Technologies
Risk, Reliability and Safety Engineering
2525 S Shore Blvd Suite 206
League City TX 775732988

Phone: (281) 334-4220
Email: john@rrseng.com

ABSTRACT

Risk assessment for offshore facilities began shortly after the Piper Alpha incident in 1988. At this time, the UK Health and Safety Executive issued rules for Safety Cases for offshore installations. Safety Cases are now required in many other parts of the world. Operations in the Gulf of Mexico (GOM) are becoming larger, more complex and in deeper water. The potential exists for future regulations that require some type of Safety Case or risk assessment in the GOM.

Risk assessments in the North Sea have historically been very complex and costly, with suspect benefit other than meeting a regulatory requirement. Companies are now recognizing that performing a risk assessment on new and existing offshore facilities is a good business practice. A risk assessment performed during the design phase can reduce both capital and expense costs, and result in a safer facility.

This paper will discuss past experience in risk assessments in the North Sea and apply the lessons learned to a streamlined approach to risk assessments for GOM and other areas. More importantly, the paper will discuss how companies are currently using risk assessments that are tailored to the hazard or desired outcome to make sound business decisions. Examples of techniques used to simplify the risk assessment process will be given.

Offshore Risk Assessment - Simple or Complex?

John A. Alderman, *Managing Director*, Risk, Reliability and Safety Engineering

Mike Johnson, *Offshore Risk Manager*, Advantica Technologies

1.0 Introduction

Risk assessment for offshore facilities began shortly after the Piper Alpha incident[1] in 1988. At this time, the UK Health and Safety Executive (HSE) issued rules for Safety Cases for offshore installations. As part of the preparation of a Safety Case in the UK, an operator must consider the risks to personnel. Such risk assessments in the North Sea have historically been very complex and costly, with limited benefit other than meeting a regulatory requirement. However, risk assessments can be utilized to determine optimum design and performance standards that achieve risk reductions. As a result, companies are now recognizing that performing a risk assessment on new and existing offshore facilities is a *good business practice.*

In addition to the HSE Safety Case requirements in the North Sea, risk assessments are now required in many other parts of the world. Today, there are over 140 new offshore facilities a year in the Gulf of Mexico (GOM), with about 30 of these manned. Operations in the GOM are becoming larger, more complex and in deeper water. The potential exists for future regulations that require some type of Safety Case or risk assessment in the GOM.

As operators begin to address conducting risk assessments in the GOM, it is essential to utilize lessons-learned in conducting risk assessments in the North Sea and other parts of the world. Whether it is simplifying a complex approach or gaining cost-benefit, risk assessments have many facets, that when used correctly can help an operator go beyond regulatory compliance. A risk assessment performed during the design phase can reduce both capital and expense costs, and result in a safer facility.

Before we discuss the main focus of the paper, it is important to review the basic elements of offshore risk assessments. Section 2.0 describes the objectives and elements of risk assessment. Lessons-learned, methods to simplify complex risk assessment processes, and gaining cost-benefit are discussed in Section 3.0. Conclusions are contained in Section 4.0.

2.0 Risk Assessment

Risk assessment is a process where the results of a risk analysis are used to make decisions, either through a risk ranking of hazard reduction strategies or through comparison to target risk levels[2]. The process consists of a series of steps as illustrated in Figure 1. Each step in the risk assessment process is discussed in the following sections.

---

[1] Offshore platform fire and explosion, July 6, 1988 resulting in 167 fatalities and total loss of the platform.
[2] "A Guide to Quantitative Risk Assessment for Offshore Installations", ISBN 1 870553 365, CMPT, 1999

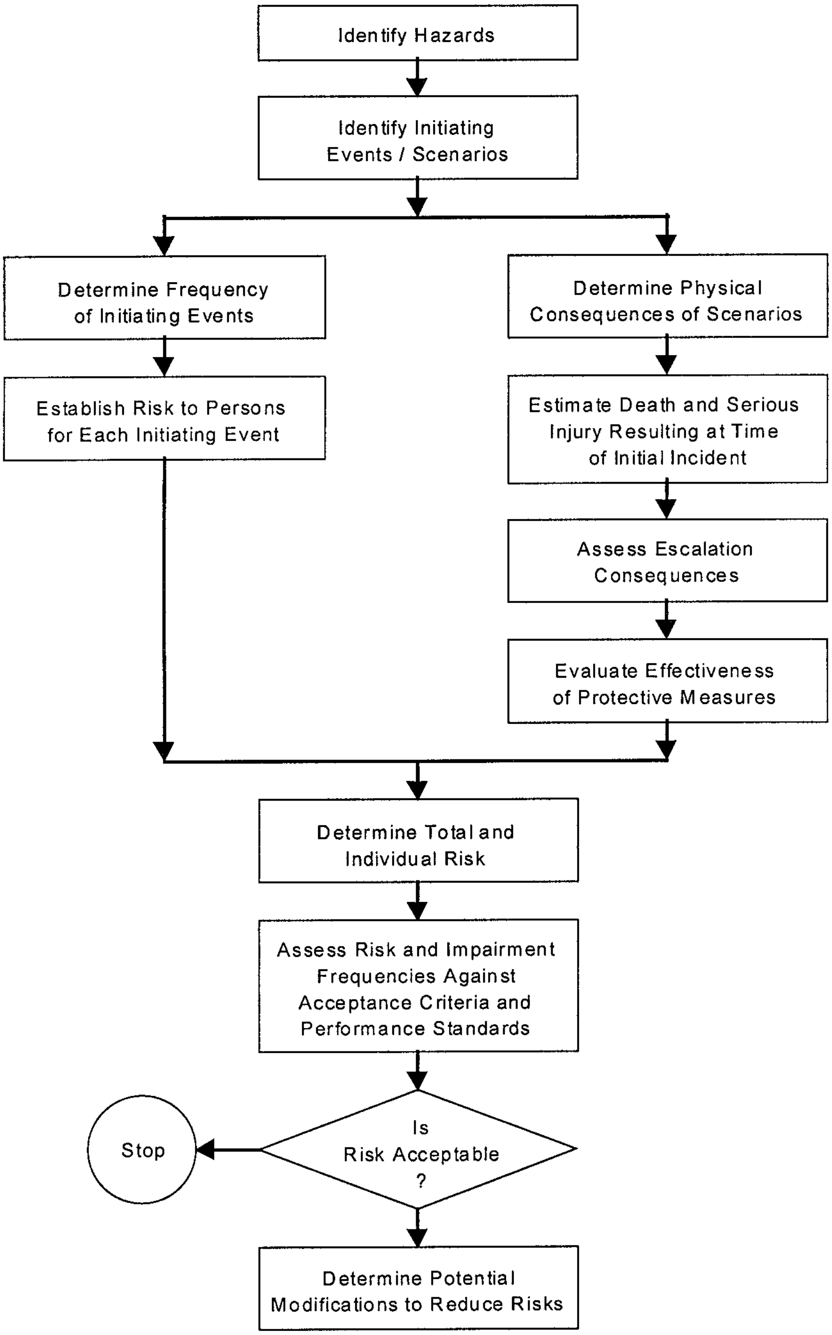


Figure 1. **Risk Assessment Process**

2.1 Hazard Identification

The first step in any performance-based approach is to identify all of the hazards that could influence the overall risk to an offshore facility. The hazard analysis techniques used to identify potential hazards are:

- HAZID
- Checklist
- What-if?
- HAZOP
- FMEA

The outcome of the hazard identification is a list of potential hazards that may occur on the offshore facility. The result of the hazard identification is a list of scenarios that are carried forward to the next steps in the risk assessment process. Table 1 shows a list of typical hazards on offshore operations.

Table 1. Typical Hazards on Offshore Operations

Typical Hazards
Fire • Pool • Jet • Electrical • Class A
Explosion
Transportation • Helicopter • Boat • Collision
Toxic Materials • Hydrogen sulfide • Smoke • Carbon dioxide
Stabilization
Structural
Slips, trips and falls
Mooring

2.2 Consequence Analysis

Consequence analysis is the process to determine the impact of the different scenarios. There is a wide range of scenarios that can affect an installation. Scenarios result in many different consequences to the installation and personnel and may include:

- Thermal loading
- Blast loading
- Toxic effects, including combustion products such as carbon monoxide
- Impairment of evacuation routes, escape equipment and temporary refuge

There are well-established methods for calculating the consequences for each scenario[3]. Depending on the number of scenarios and potential consequences, a consequence analysis could be time intensive unless a software program is utilized.

There are several programs available, such as PC-CHAOS[4] (explosion), ARAMAS[5] (explosion, fire, and toxic) PHAST[6] (fire and dispersion) and ORHAT[7]. The spreadsheet approach can be used, but the conservatisms inherent in such a simple approach may not allow cost savings or safety improvements to be recognized.

2.3 Likelihood

Design based on consequence alone would result in overprotection, increased maintenance and a core complex operation that may have unwanted shutdowns. The likelihood of a scenario must be taken into consideration to allow design decisions to be based on definable risk criteria. In determining the likelihood of a scenario, certain key information is required, such as the frequency of events, frequency of ignition, potential for escalation, and weather conditions.

The main issue associated with any frequency assessment is the appropriateness of the data used in the calculations. There are several references such as OREDA, E&P Forum, company specific sources and other industry documents. The use of different data sources can greatly affect the results and great care needs to be taken when choosing a data source. Also, encompassed in each scenario are the event and fault trees that take into account safety and mitigation systems. For example, as well as depending on the atmospheric conditions, scenarios are also dependent on whether deluge has operated and the frequency of operation (reliability) of these systems must be taken into account.

---

[3] Handbook for Fire Calculations and Fire Risk Assessment in the Process Industry, SINTEF, 3rd Edition, 1997.

[4] Advantica Technologies

[5] Ibid

[6] DNV

[7] Ibid

2.4 Risk

Risk is the product of the consequence and likelihood of each scenario. Depending on the consequences of interest, the risk calculated could be to people, business interruption, the asset, the surrounding environment, or company reputation. The risk for each scenario can be combined by specific areas or for the whole installation to obtain desired risk profiles. Because of the huge number of such scenarios, some degree of automation is needed in the calculations.

After the risk has been calculated, the results must be compared to either governmental or company criteria to determine if the risk is tolerable or acceptable. If it is acceptable, then additional hazard reduction is not required. If the level of risk does not meet the risk criteria, then additional hazard reduction measures may be required.

2.5 Safety Case

The primary goal of the Safety Case is to reduce risks to the health and safety of the workforce by thoroughly evaluating the risk and developing suitable safety systems that effectively control the risks. The operator must set the performance standards for systems they will use to meet this objective.

The Safety Case has three components:

- Facility description
- Formal safety assessment
  - Hazard identification
  - Fire and explosion analysis
  - Smoke and gas ingress
  - Dropped object
  - Emergency systems survivability
  - Escape, temporary evacuation and rescue
  - Maritime operations
  - Quantitative risk assessment
- Safety management system

3.0 Lessons-Learned

3.1 Defining Risk Assessment Objectives

Before beginning the risk assessment, it is critical that clear objectives are established for the assessment. The objectives have a significant impact on the level of detail and work required. For example, if the objective is to identify whether to provide passive fireproofing on the process vessel, then only jet and pool fires risk of escalation need to be evaluated. The risk from other hazards does not need to be included.

Typical objectives for a risk assessment are:

- Regulatory compliance
- Good business practice
- Use as management decision tool
- Ranking of alternative options for hazard reduction
- Understanding that hazard
- Evaluating design options for lowest risk

Most companies do not spend an adequate amount of time on determining the objective of the assessment. This means that the study can grow and become more complex as more details are learned. However, in many cases the objective will change during the study and the assessment will tend to grow. In each case where the study is expanded, the original objectives should be reviewed to determine if they need to be changed. A change in objectives is a management decision.

3.2 Understanding the Hazard

The UK Safety Case regulations and similar legislation in other European countries, places the duty on the operator to ensure adequate risk reduction measures are taken. In doing this, the operator must have an understanding of the potential consequences of the accidental release of hydrocarbons.

An industry sponsored project was initiated to collate information of fire and blast understanding and to develop guidance on the basis of this information[8]. While producing this guidance, the project identified that the techniques used to assess fire and blast issues offshore lacked validation at scales comparable to offshore facilities. As a result, there was considerable uncertainty associated with the magnitude of fire and blast hazards.

In order to reduce this level of uncertainty, a number of industry sponsored projects have been conducted to obtain data from full-scale experiments and to assess the performance of models

---

[8] Steel Construction Institute, Interim guidance Notes for the Design and Protection of Topside Structures Against Explosions and Fire, Report No. SCI-P-112, 1992.

against this data[9,10,11]. This work has considerably improved the ability to predict the consequences of accidental gas release.

In addition to the fire and blast work, data has been collected by industry on the frequency of leakages from various sources. As a result, the ability to predict the likelihood of an incident has also improved. Combined with the work on the consequences, this gives a solid foundation for the assessment of fire and blast risks.

3.3 Simplifying Techniques

Over the years there have been several methods used to streamline the risk assessment process. This section discusses several techniques.

3.3.1 Scenario Screening

During the hazard identification, there are many scenarios developed. Some will have very significant consequences but very low likelihood. Other will have little or no consequences, but could occur every day. It is import to develop the list of scenarios carefully so that the time is spent evaluating the scenarios with the highest potential risk.

One method that can be used to reduce the number of scenarios is a risk-ranking matrix. This matrix is qualitative and can be used by the Hazard Identification (HAZID) team to screen scenarios. Another method is Design Option Safety Assessment (DOSA).[12] DOSA provides a method for 'front-end' comparative selection of the safety option from any group of possible development schemes. It can also be used to rate the elements of a single scheme in terms of their relative risk, thereby indicating where efforts could best be made for the reduction/mitigation of hazards. The method is qualitative, requiring experienced personnel for implementation, but derives a quantitative relative score for each scenario reviewed.

3.3.2 Consequence Only

In some circumstances, it may be possible to restrict the analysis to consequence analysis alone. In this case, there would be no benefit from carrying out a full quantitative risk analysis. In addition, there are many good deign practices that will reduce the likelihood and consequences of an accidental gas release.

There are two examples that almost always fall into this category. The first is explosion, thus reducing both the likelihood and consequences of an explosion. If the results of the explosion analysis indicate that the blast can do significant damage to the facility, then mitigation is generally provided. Mitigation can include installing blast walls, reducing confinement,

---

[9] Steel Construction Institute, Blast and Fire Engineering for Topside Structures, Phase 2, Final Summary Report, SCI Publication No. 253, 1998.

[10] Savvides, C. and Tam, V., Cleaver, R.P. and Darby, S., Buss, G.Y., Britter, R.E. and Connolly, S., Gas Dispersion in a Congested, Partially Confined Volume, CCPS Conference and Workshop on Modeling the Consequences of Accidental Releases of Hazardous Materials, Sept. 28 – Oct. 1, 1999, San Francisco, CA, USA.

[11] Al-Hassan, T. and Johnson, D.M, Gas Explosions in Large Scale Offshore Module Geometries: Overpressures, Mitigation and Repeatability, May 1998, OMAE 98, Lisbon.

[12] *Design Option Safety Assessment (DOSA): Method for the Assessment and Selection of Least Hazardous Design Option*, D. Jordan, Unocal Thailand Ltd., and B. R. Poblete, Hibernia Management & Development Company

arranging equipment to reduce congestion, providing water spray, etc. These good design practices may have limited cost and can therefore be applied without the need for a risk assessment.

The second is radiant heat from the flare. The radiant heat can impact personnel and equipment. Since the flare system in itself is a layer of protection, it cannot be eliminated, so mitigation is generally provided. Mitigation can include water spray on equipment, shielding of passage ways and drilling structures, redesign of flare tip, etc.

For many installations, however, design is not possible against the worst case event. In this case, it is likely that some form of risk assessment would be required for an operator to be able to demonstrate that risks are ALARP. In practice, the risk assessment can be used to determine key design parameters such as the overall structural strength and the performance standards of segregating barriers such as fire and blast walls. More advanced risk assessment techniques can also be used to determine the effectiveness of escape and evacuation provisions on a platform.

3.3.3 Computer Models

The complexity of the risk assessment process presents a challenge. There are many parameters that influence the severity of any particular incident. For example, the wind speed and direction influences gas build-up, which in turn will influence the severity of any explosion. This complexity introduces the potential for mistakes such as:

- Data input
- Inconsistent approaches by different personnel
- Difficulty in revisiting risk assessments

Some of these problems have been addressed by developing the risk assessment within a spreadsheet. This provides some control over the risk calculation approach and if properly managed, allows archiving of data inputs, assumptions and results. However, the models used to calculate the consequences of fire and explosion incidents cannot generally be run within a spreadsheet. As a result, there is often a substantial amount of transferring of information between the consequence calculations and the spreadsheet method for streamlining.

More advanced techniques have integrated the consequence models within an overall risk framework. These techniques allow all data inputs and outputs to be recorded in a single location, delivering better quality control and making revision easier. They also significantly reduce the amount of data transfer required, increasing the efficiency of the risk assessment process. In addition, by using knowledge based algorithms that link the risk assessment structure, the approach to the risk assessment process is consistent from one user to another and meets best practice.

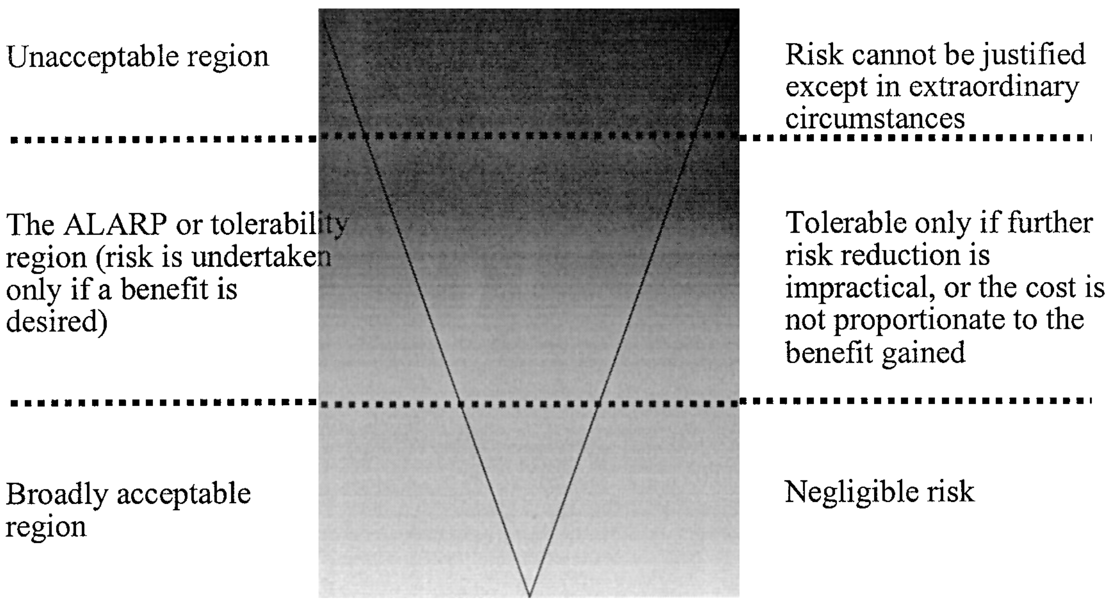
3.3.4 Experience

The experience level of the analyst is very important. The analyst will make many decisions in the analysis that can influence the outcome. In selecting the likelihood numbers it is very easy for the analyst to go to a previous report and select a frequency to use in the analysis or spend days looking for a number that does not exist. The source used and assumptions made, need to be carefully documented. Be leery of numbers that cite "internal source".

This experience level is important in hazard identification to ensure hazards are not missed or trivial scenarios are evaluated. In consequence analysis, experience is important to recognize that the numbers calculated may be wrong.

3.4 Cost-Benefit

One concept that has been used extensively in the North Sea is ALARP (as low as reasonable practical). Figure 2 shows the ALARP concept. This concept suggests that at some point the cost to mitigate a hazard is so high that it can no longer be considered and is no longer practical to implement the option. If needed, options for reducing the risk are selected and the analysis recalculated to determine the impact on the risk. In some cases, the options (for example, fire proofing on a quarter's wall to reduce impact of jet fire) provide significant risk reduction, whereas others (water spray of process vessels to protect from jet fire) have very little impact on the risk).



As the risk is reduced, the less it is necessary to spend to reduce it further. The concept diminishing proportional return is shown by the triangle

Figure 2. ALARP Concept

4.0 Conclusion

This paper addresses methods for applying lessons-learned in the North Sea, simplifying portions of the risk assessment process and gaining a cost-benefit when conducting an offshore risk assessment. Key points to remember include:

- Clearly establish the objectives for the study before beginning. If the objectives need to change, then management must be involved with that decision.
- Use a screening tool during the hazard identification step to determine the scenarios that need to be evaluated.
- There are some tools that will simplify the number crunching that is required. Ensure that they tools have been validated against full-scale test if used for consequence or widely accepted if used for risk.

Experience is the most important factor in selecting and performing simplified approaches.

- Use ALARP to identify where to get the most risk-reduction for the expenditure.