PROPOSED OFFSHORE SAFETY CASES - A COMPARISON WITH ONSHORE CIMAH SAFETY CASES

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The proposed regulatory regime for offshore installations is compared with that for major hazard installations onshore in the UK. Experience with safety cases onshore and offshore is drawn upon to provide insights into the similarities and differences between these, from the perspective of the risk assessor.

Key Words:

Safety Case, Risk Assessment, Cullen Report, Offshore Installations, CIMAH,

INTRODUCTION

The regulatory regime for onshore safety assessment and safety management for major hazards installations is relatively well established[1] and provides a basis for comparison with the continuing efforts to develop safety cases for installations offshore. Experience with both has provided insights into the similarities and differences between the two types of safety case as they presently exist and this paper reviews aspects of the reasons for and effects of those similarities and differences, from the perspective of the risk assessor.

There are obvious physical differences in terms of a harsh physical environment, geographical isolation and resulting high degree of self-reliance of the offshore installation, and the significant effects of increased space and segregation of the onshore installation. The implications of these for safety and safety assessment are less obvious but of great importance. These differences may not alter the basic principles of safety cases but do materially influence their emphasis and detailed content.

A less tangible difference between onshore and offshore safety is the likely influence of the different historical regulatory framework and, potentially, a difference in working practices and safety culture. This less tangible, and less assessable, difference could be as important as the physical differences, as long as the maintenance of high levels of safety depends so much on people, through management control, training and the use of good working practices.

The Cullen Report into the Piper Alpha Disaster[2] has put forward recommendations intended to take offshore safety into a new and more flexible culture. The older prescriptive style of offshore safety regulations will eventually be supplemented by goal setting regulations aimed at ensuring that safety measures are fit for purpose and are continuously improved in the light of technical innovation, knowledge and experience.

The central features of this new regime are the transfer of offshore safety to the HSE (the new Offshore Safety Division) and the onus on the operators of offshore installations to be 'self-regulating' in matters of safety, demonstrated by a safety case which is to be prepared and updated by operators for each new or existing installation.

The Cullen Report indicates that the requirements of the safety case should broadly follow those of the CIMAH (1984) Regulation 7, and should be underpinned by a number of specific analyses to address the key factors in ensuring the safety of personnel, i.e.

A Fire Risk Analysis
A Vulnerability of Emergency Systems Analysis
A Smoke and Gas Ingress to the Accommodation Analysis
An Evacuation, Escape and Rescue Analysis

and, finally, the central feature of the safety case, a quantified risk analysis to assess the ability of personnel to shelter from any hazard and then if required make an effective evacuation or escape to a place of safety such as a vessel alongside or helicopter.

This introduced the concept of a Temporary Safe Refuge (TSR) where people can muster, co-ordinate the emergency response and determine any subsequent evacuation.

This TSR concept has been adopted as a distinct and important aspect of the Offshore Safety Case[3], with the other analyses gathered together under the all encompassing umbrella of a Quantified Risk Analysis.

All these analyses have their equivalent for any hazardous installation onshore, especially where flammable materials are stored or processed. In principle, therefore, an offshore safety case should be no different from an onshore safety case. In practice, however, the differences between onshore and offshore installations will require different emphasis in some areas and this has implications on the assessment methods, data and approaches to be used.

GENERAL SAFETY CASE OBJECTIVES

The objectives of the offshore safety case follow those required for onshore safety regulations, i.e. to demonstrate the safety of the installation and its associated activities by:

- Identifying the potential hazards (What could go wrong?)
- Assessing those hazards (How likely? How Severe?)
- Demonstrating that adequate safeguards (design, hardware, procedures) have been provided to prevent, control or reduce the consequences of these hazards, and, finally,
- Demonstrating that adequate and effective emergency provisions and arrangements are in place to deal with a hazard should it arise and the safeguards fail to control it.

The onshore safety case needs to consider all activities on and around the installation and address the potential hazards to people (workforce and the public) and the environment. However, onshore CIMAH legislation specifically includes the need to ensure that members of the public are not put unduly at risk whereas offshore legislation primarily addresses the safety of the workforce, i.e. onsite vs. offsite risk. Also, the need to constantly monitor and update the safety case throughout the lifecycle of the installation is an aspect explicitly laid down in the proposed offshore regulations[3] whereas the CIMAH requirements have been less specific in this area.

CIMAH safety cases are placing a growing emphasis on environmental safety. Both normal operation of onshore and offshore plant as well as accidents involving these installations may adversely affect the environment. Onshore such an effect may be more apparent because of the relative proximity of the public to the installation, and the generally reduced scope for dispersion, dilution and natural degradation of pollutants. However, the environmental effect of offshore activities is not well determined and therefore cannot be neglected. Environmental issues offshore are likely to include the disposal of toxic drilling fluids, flaring of produced gases and hydrocarbon spills, including pipeline incidents, especially if these have the potential to reach land or other environmentally sensitive areas such as fish spawning grounds. In addition, the regulatory framework offshore is potentially more complicated because of international interests and requirements.

MAIN PHYSICAL DIFFERENCES

It is worth briefly describing some of the fundamental physical differences and similarities between onshore and offshore installations, and the resulting safety implications.

A typical onshore major hazard site would be laid out to segregate hazardous plant areas from each other, from control and administration centres, and from the public offsite. It would have access to emergency services such as the police, ambulance and fire brigade to assist in the event of an incident. The workforce would only spend its working hours onsite, and most people would live some distance from the site.

In extreme incidents there could be the potential to harm members of the public in nearby housing or other areas or at adjacent industrial units. Planning controls would be used to limit development near the site and to reduce public risk to at least tolerable levels.

A typical offshore installation may be handling similar hydrocarbons at similar or even higher pressures than, for example, onshore or land fall terminals. However, the economics of hydrocarbon extraction and production mean that space is limited. The installation must also provide all its own services (power, lighting, water), back ups and emergency services (fire teams, medics).

The practicalities of working sometimes hundreds of miles from the mainland also means that personnel live and work on the installations; usually on a one or two week rota. This means that workers are exposed to any risk for a greater proportion of time than an offshore worker (typically 4000 hours per year; cf 2000 hours onshore). Also, the transport of the workforce to and from the place of work is necessarily more closely integrated with the offshore operation and potentially less flexible and more hazardous than the comparable arrangements onshore.

An offshore installation can be described as a hotel, heliport, dock, 'refinery', pipeline terminal, power station and drilling unit all located on the same island - often smaller than a football field. In addition, the installation could be supported on the sea bed by a structure 100-200 metres high, or on a floating barge where in either case it is subjected to some of the worst seas and weather in UK waters.

These factors together mean that very careful design and layout is needed to ensure safety. There is less flexibility to segregate process areas and living areas, and the isolated 'island' location means that the movement of personnel to and from the installation is limited, and perhaps particularly in an emergency when it is needed most.

The implications for personnel safety in the event of an incident can therefore be severe on an offshore installation. Ensuring safety requires a clear understanding of how hazards could occur and propagate and what effect they can have on the installation and the ability to shelter and evacuate.

These physical differences are considered further under the topics of structural integrity, layout segregation and escape and evacuation.

Structural integrity

A sound foundation and support structure is fundamental to ensuring the integrity of any installation. Onshore the relevant building regulations and experience should ensure adequate design for normal and exceptional environmental loads such as snow and wind loadings.

Offshore the greater severity and uncertainties of environmental conditions place a high demand on the structures and their foundations. This, coupled with the large size and complexity of these structures, the relatively small number of installation years experience offshore, and the severe economic constraints of over-conservative design, mean that the overall structural performance plays a more significant role in ensuring safety than for a land based installation, and this is likely to be a key structural integrity issue.

The safety case needs to address how the structure is likely to respond to extreme sea and wind conditions beyond the design return period (typically 100 years) or to movement of the sea bed/foundation, and how the effects of ageing (corrosion, erosion and fatigue, etc.) could reduce performance.

Whilst a good deal of research has been carried out into many of these aspects individually there is a need to pull these together to allow a well-based probabilistic assessment of structures and foundations to be made so that improvements can be focused into the key areas leading to safer, more cost effective design, construction and through life inspection and maintenance.

These aspects are further complicated for floating installations where aspects such as buoyancy, listing, moving off station, loss of anchors, etc., can have an input on structural integrity and safety.

Finally, the effect of other hazards on the structure needs to be assessed. These include impacts from ships or helicopters or dropped/swung objects from cranes or collapsing topside structures such as drilling derricks, vent stacks and communication towers. Fires and explosion can also damage the structure. An understanding of these hazards and the likely structural response is needed to ensure the structural integrity is maintained, or the consequences of any failures minimised.

It should be noted that the draft regulations require quantification of risks affecting the TSR (Temporary Safe Refuge) for offshore installations. A key aspect of this is the structure supporting the TSR as well as the TSR itself, and this will lead to a particular need to be able to assess the likelihood and consequences of structural failure.

A second structural integrity issue arises from the need in risk assessment to quantify leakage rates and locations and the lower tolerance to uncertainties in this for offshore installations because of their relatively higher concentrations of plant and people and the greater challenge offshore of providing adequate shelter or evacuation. The use of information derived from onshore research and data collection, supplemented by the even more limited information from specific offshore experience is a reasonable basis but will almost certainly lead to some assessed risks being higher than is either desirable or realistic. The large uncertainties may also mask the relative importance of contributors to leaks and risk, particularly when onshore information may be less relevant and offshore information lacking. Examples could include flexible couplings, pipes or vessels subject to extensive rework or exposed to unusually harsh environments, and components such as large ESD valves where relevant operational expertise may be limited.

A related issue which links structural integrity and escalation is that of ignition of leaks of flammable materials, especially gases and vapours. The accepted principle, mainly from onshore experience, is that larger leaks have a higher chance of ignition. Whilst the same principle should hold offshore, the concentration of plant and potential ignition sources suggests that the scale of 'large and small' should be reviewed if the principle is to be carried over in a quantitative manner. This again highlights the need for establishing accurate leak rates for different items of process equipment, but also has more general implications for assessing the effectiveness of shielding ignition sources and monitoring leaks.

Layout segregation and escalation

The economics of offshore exploration and extraction have led to a need for support structures and topsides equipment to be both lightweight and compact.

Unlike land based plant there is not the room to segregate to any significant extent hazardous sections of plant from each other or from control rooms and living areas to minimise the damage in an accident. The safety of the installation and its personnel is therefore heavily influenced by the ability to contain an incident such as a fire or explosion, and to prevent spreading to other areas of the installation.

This relies on minimising the severity of the initial hazard and on safety systems to resist its spread such as water deluges, fire walls, blast walls, etc. This has been clearly recognised in the Cullen Report and has led to the recommendation for a fire risk analysis to assess these aspects of fire fighting and control.

Effective prevention of escalation requires an understanding of how escalation can occur, in particular how process equipment, walls, decks and structures respond to fires and explosions, and how they could fail in these circumstances. It also requires a more detailed understanding of the damage potential of any fires and explosions.

In the past research has tended to concentrate on the far-field effects of fires and explosions, and associated gas dispersion, as these issues are key to assessing and controlling offsite risks on land based plant. Offshore the complexity and compactness requires an understanding of the near-field effects of these hazards. The near-field effects of explosions are particularly difficult to assess, and this has led to recent research being focused towards 'near-field' investigations.

Gas dispersion presents a similar problem. Previous research has focused on heavy gas dispersion, as this is most

likely to present a large downwind hazard for land based plant, and most hazardous gases are or behave as though they were heavier than air. Offshore, methane is the predominant gas. It is processed and stored at high pressure at ambient or warmer temperatures. Its dispersion is complicated by the installation itself, obstructing and channelling the gas as it spreads. It is difficult, therefore, to easily predict the spread of gas from a leak on an offshore installation, and to establish which areas of the cloud are likely to be within explosive or flammable limits. This has implications for assessing the severity of any fire or explosion and for assessing the likelihood and timing of ignition.

The relatively small size of offshore installations combined with the difficulties in escaping mean that smoke can also present a serious hazard to personnel, especially if it builds up within enclosed areas such as the control room or living quarters. Research could now be focused into understanding the mechanisms of smoke spread and the effects of smoke/fumes on personnel, both toxicological and psychological.

Escape and evacuation

The need for adequate emergency provisions is vital to any hazardous installation onshore and offshore.

Onshore two elements are needed; an onsite plan and an offsite plan. Both can call upon the emergency services - police, ambulance and fire brigade. In general, people can escape by moving away from the hazard or seeking shelter. The main offsite focus is to ensure members of the public in the vicinity are aware of the hazard potential and how to react in an emergency - via the offsite emergency provisions.

On an offshore installation, it is the workforce who are at risk. The main problems stem from two aspects:

- the compact nature of the installations which may mean that the hazards can affect the whole installation or its structure - so there may be no short or long term safe area to retreat to except by leaving the installation. The hazard also has the potential to damage the emergency systems on the installation such as the fire and gas detection systems, fire water systems, isolation systems and alarm and communication systems. These systems are vital to control of the emergency.

- the remote location at sea which means that abandoning the installation is neither easy nor risk-free, and the response of external emergency services may be less rapid and less effective than in the onshore case.

Helicopters have limited capacity and could take some time to reach the installation. Lifeboats can be difficult to launch safely in bad weather and retrieving people from them is also difficult, and fires or smoke or the effects of explosions could also damage the lifeboats or helideck or prevent access to them. As a last resort people may be forced to jump into the sea. A difficult entry into cold water and possible high seas can make this extremely hazardous. Safer methods of entering the sea in a controlled manner, better access to liferaft and the use of proper abandonment suits can help. The role of standby vessels and fast rescue craft is crucial to ensure rapid retrieval of people in the sea.

Research is currently focused on investigating methods of launching lifeboats that are less likely to be affected by severe weather and at providing easier means of entering the sea. A key area for the future must be in developing systems to enable the safe retrieval of lifeboats and persons from the sea, especially in poor visibility or unfavourable sea conditions.

The Cullen Report had recognised these aspects has set down a number of recommendations to tackle them. Of particular relevance is the need for operators to carry out a number of 'forthwith' analyses which will also form part of the overall safety case. These are:

Vulnerability of Emergency Systems Analysis

This is intended to see how the key emergency systems are likely to be affected in various likely hazard scenarios on that installation, and to establish that they will be effective or remain effective for sufficient time to allow personnel to make a safe escape.

Evacuation, Escape and Rescue Analysis

This is intended to establish that the various escape routes, emergency plans and provisions are adequate to deal with the likely hazards on that installation, and to show that the crew would be able to make an effective departure from the installation if required to a place of safety such as a standby vessel or helicopter.

Cullen also sets down the concept of the temporary safe refuge (TSR) to provide a safe location in which personnel can muster and decide the appropriate response to any emergency. The TSR would need to have instrumentation facilities to monitor the hazards and any spread and to confirm the operation of key systems such as fire water deluge and the ESD system. It would also need to have communication facilities.

The capability and role of the TSR together with escape routes to it, and from it to the lifeboats is likely to be one of the key aspects of the safety case.

OVERALL MANAGEMENT OF SAFETY

The safety case for every offshore installation will require the operator to demonstrate that he has an effective Safety

Management System (SMS) in place to address the hazard potential of his activities. This will include the SMS aspects related to any onshore parts of the organisation and the SMS aspects on the installation itself. In this respect, offshore installations can be considered to be subject to similar requirements as the CIMAH "Top Tier" sites, although the emphasis in the current CIMAH regulations on the SMS is less than is likely to be the case offshore.

The Cullen Report acknowledges in particular the major role the SMS plays in ensuring safety, and recommends a number of key SMS features that need to be covered in the safety case. The selection, control and training of contractors has particular importance for the offshore industry where many of the operators and technicians are contractors. Similarly construction crews, drilling crews and many other services are provided by contract workers. Operators need to ensure that any contractors taken on are aware of the safe working systems and practices for that installation and ensure the contractors have adequate ability, knowledge, experience and training to match the task.

These aspects become particularly important during combined drilling and production or construction and production activities. The SMS of the host installation and the SMS of the construction team and barges or drilling rig needs to be compatible and modified to take account of potential interactions between these simultaneous activities.

It is likely that special safety cases to address these aspects will be required prior to construction or simultaneous drilling and production.

ACCEPTANCE OF SAFETY CASES

A difference between the CIMAH and proposed offshore regulations is the responsibility placed on HSE to 'accept' the safety cases for offshore installations. CIMAH cases only had to be 'submitted' to the HSE and no degree of acceptance was understood or implied but clearly comments were made where safety cases appeared to be inadequate.

Further, the proposed offshore regulations, steered by Cullen, also take the step of specifying numerical criteria for the TSR. The interpretation and use of these criteria for the TSR will no doubt develop with time, but as for all aspects of work covered by the Health and Safety at Work Act, will be underpinned by the concept of reasonable practicability.

Clearly there could be some conflicts in applying numerical criteria and reasonable practicability, but for most cases a 'common cause' solution should be achievable. Similar challenges will be faced as new goal setting regulations are brought into replace some of the older SIs. Producing true goal setting criteria aimed at promoting flexibility and improvement in standards will be a considerable challenge in itself.

CONCLUSIONS

The basic objectives, principles and approach to safety case formulation are the same whether an installation is onshore or offshore, and this is likely to be reflected in forthcoming legislation.

However, the complexity, compactness, relative isolation and an historically different safety culture of offshore installations may mean that a more thorough analysis of potential hazards and escalation paths is needed, and this will require both better data in terms of release frequencies, source terms and near-field consequence analysis and improved methods or understanding to allow the hazards to be analysed in an efficient manner. The benefits of this analysis will be a better understanding of safety and how to achieve practicable safety improvements.

The Cullen Report and subsequent offshore safety legislation is likely to set a new and higher standard than any before it. The Cullen Report embodies the widely publicised principles of managing safety but extracts the key factors in such a lucid manner that it provides a reference that should be read by all with a safety responsibility.

The implementation of the Cullen Report recommendations should take the UK offshore industry to an improved safety regime and provide a basis for reviewing and improving safety in offshore activities in the UK and elsewhere in the world.

REFERENCES

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ONE COMPANY'S EXPERIENCE OF FORMAL SAFETY ASSESSMENT & PREPARATION OF OFFSHORE SAFETY CASES

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The retrospective and simultaneous assessment of 28 installations in a short timeframe and with an industry wide shortage of expert resources is an immense challenge. The momentum was established by a pilot study then a centralised team followed by transfer to the individual installation groups. In the "forthwith" studies the analytical emphasis was placed on engineering judgement supported by proven and readily available consequence modelling. This was followed, where appropriate, by more sophisticated modelling and risk assessment. The information becoming available is enormous but the true value of the work done to date is now being realised as it provides input to assessing the need for remedial measures and making difficult and complex decisions.

Keywords: Formal Safety Assessment (FSA) Offshore Safety Case, Quantified Risk Assessment (QRA)

INTRODUCTION

BP Exploration currently operates a total of 24 hydrocarbon producing installations, a water reinjection platform and a semi-submersible emergency support vessel in the United Kingdom Continental Shelf. They range from large oil platforms, with 200 personnel onboard, to small not normally manned gas platforms.

Two further installations are under construction with several other developments at various stages of design.

For a number of years it has been appreciated within BP that reliance purely on good engineering practice, the application of approved standards and the certification and inspection regimes could not of themselves comprehensively identify and control the hazards and sequences of events that could lead to a major accident.

The benefits of techniques and tools to help systematically identify hazards, analyse consequences and assess risks have been readily appreciated and a significant investment has been made in recent years to increase our capability in this area.

An important application of this new technology has been in new developments, forming part of a more general initiative to ensure safety engineering input is fed into new developments from the very earliest stages. To achieve this effectively, it was recognised that the implementation of a fairly formal and systematic plan was appropriate.