OFFSHORE TECHNOLOGY REPORT - OTO 97 068

Approaches to Hazard Identification

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Approaches to Hazard Identification

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SUMMARY

Ambion Consultants were appointed by the HSE to carry out a pilot study to determine the range of hazard identification techniques actually applied in Offshore Safety Cases. From the discussions a “snap-shot” review of the current position with regard to Hazard Identification (HAZID) has been developed, highlighting:

- the techniques used (including combinations of techniques)
- typical depth and time of study, duration of study
- the type of follow up of HAZID into Quantitative Risk Analysis and risk management
- typical team compositions, personnel make-up and competency
- difficulties experienced and ideas on how to improve technique

HAZID is seen as an important element of the Safety Case Regulations in the UKCS. The review shows that a relatively small number of HAZID techniques are actually in use in industry, the dominant methods being the generic hazard checklist approach and Hazard and Operability Studies (HAZOP).

The Generic Checklist approach is almost invariably used as a feeder to Quantitative Risk Analysis (QRA). In cases where formal sessions were held to identify hazards, discussions indicate that the range of 1/2 to 5 days is typical depending on the depth of study. The majority of formal HAZID reviews were held in “HAZOP style” sessions with a chairman and secretary, these lasting around 2 to 3 days. As a general finding it was felt that the HAZID process was dominated by Safety and Loss Prevention type personnel from Operators, Contractors or Consultancies. The level of competency of personnel selected for such duties was felt to be an issue of general concern in the Industry at the present time.

HAZOP was quoted as a key HAZID technique, indeed it was felt by some parties that HAZOP was a more useful and powerful tool than any other HAZID process. This view was held by Chemical Engineers familiar with the technique, it is less certain as to whether different disciplines would hold similar views. It is true that HAZOP would not help identify a number of offshore MAH events (i.e. dropped objects) as they would not be process related. In terms of “time expended” HAZOP was by far the most dominant technique. There was however no obvious link between HAZOP findings and the HAZID results apparent in the Cases. Indeed it is apparent that the Industry does not see the HAZOP technique as being a main feeder for the QRA, the HAZOP being essentially a different safety related process than the “HAZID” within the Safety Case environment.

It was felt by many parties that it is important that more effort is put into HAZID up front of any QRA or risk management procedures to streamline the overall safety management process.

It is recommended that at this point in time there would be real and substantial benefits to industry from a research programme which would generate, as it’s prime deliverable, a definitive “Guide to Offshore HAZID”. This guide should be generated in consultation with all interested parties through a Joint Industry Project (JIP).
ACKNOWLEDGEMENTS

Ambion Consultants would like to acknowledge the invaluable contributions and assistance of the following Organisations and people in the development of this work. It is stressed that the views and summaries of all contributions and discussions given in this report are those of Ambion Consultants alone and are not in anyway meant as statements of policy of those organisations and people consulted.

BP Exploration and Production (UK) Ltd

Det Norske Veritas

Elf Exploration UK PLC

Health and Safety Executive

Ranger Oil (UK) Ltd

Shell (UK) Exploration and Production

Sun Oil

Dr Andy Rushton, Loughborough University

Frank Crawley, Strathclyde University and Consultant for WS Atkins

Dr. Hani Raafat, Aston University

Prof. Stephen Richardson, Imperial College, London University

Chris Whetton, Sheffield University and EC Consultant
1. INTRODUCTION

1.1 Structure of Report

This report is structured in the following manner:

1. Introduction

2. Methodology
   This discusses the information sought from bodies, the types of organisation and safety cases reviewed.

3. HAZID Approaches Applied to Offshore Safety Cases
   The main findings of the work.

4. HAZID Perspective Out-with the Duty Holder
   The views of HAZID from academic institutions were sought as a precursor to future developments in the field.

5. Discussion
   Summaries of views and findings as a result of the study are discussed.

6. Conclusions and Recommendations
   Main conclusions and possible ways forward.

1.2 Scope

The Management of Health and Safety at Work (MHSW) Regulations [1] require that an employer should make suitable and sufficient assessment of risks to employees and other people arising from the conduct of work activities. The Offshore Installations (Safety Case) Regulations [2] supplement the requirements of the MHSW Regulations by requiring that, for various phases of design, construction, commissioning and operation offshore all foreseeable hazards which have the potential to cause a major accident are identified. The full scope of the Safety Case regulations is not under review in this study and as such it is recommended that clarification of the intent of the regulations is sought separately by the reader.

Ambion Consultants were appointed by the HSE to carry out a pilot study to determine the range of hazard identification techniques actually applied in Offshore Safety Cases. Given the wide range of types of organisation, offshore operations and facility types in the North Sea UKCS, it was felt that such a review of the HAZID approaches employed in the current Safety Cases would be beneficial. Ambion Consultants considered the following areas as part of the pilot study:

- the techniques used (including combinations of techniques)
- typical depth and time of study, duration of study
- the type of follow up of HAZID into Quantitative Risk Analysis and Risk Management programmes
- typical team compositions, personnel make-up and competency
- difficulties experienced and ideas on how to improve technique
1.3 Background

The offshore industry is going through a period of widespread change. The CRINE (Cost Reduction in the New Era) initiative is changing the ways in which operators develop, manage and operate field assets. As the reliance on large operator infrastructures has declined, Engineering, Procurement, Installation and Commissioning (EPIC) Contracts, alliance contracts and leasing of assets to contracting organisations are becoming more commonplace. These changes place new and more challenging demands on industry in how to meet the new legislative regime.

The holistic approach to safety management, key in the Safety Case regime, is more difficult to attain where a number of different organisations are involved in increasingly “fast track” projects. The diverse and complex nature of many alliance contracts makes it even more critical that a recognised, solid HAZID foundation is put in place early in any concept development.

The pace of change in industry and the pace of new field developments means that research findings of how to improve the HAZID process need to be delivered to industry as soon as is practicable to have maximum impact. The HSE fully recognise this and have instigated a research program to this end.

1.4 Initial Thoughts on Current HAZID Approach

A wide range of HAZID techniques have now been developed and are available for use in the offshore industries. Such techniques include:

**Comparative Methods** -
- Documentation review
- Accident Records
- Hazard Check-lists
- Safety Reviews
- Hazard Indices

**Fundamental Methods** -
- “What-if” Methods
- Hazard and Operability studies (HAZOP)
  - Stage I (concept/checklist approach)
  - Stage II (detailed P&ID review)
- Failure Mode and Effect Analyses
- Task Analysis
- Sneak Analysis

**Failure Logic Methods** -
- Fault Tree Analyses
- Event Tree Analyses

Each of these techniques have different emphasis on design and operating risk. There are however no known guidelines on which technique, or combination of techniques to use in a specific project or operating environment. This leads to inconsistencies in approach between operators, contractors and consultants. Furthermore, there is also the potential for a wide variation in depth of hazard identification, even if applied to identical systems. Such variation might arise from HAZID methodology; team qualifications; experience and competence of HAZID team members; when the HAZID process is conducted and the depth of study.
2. METHODOLOGY

2.1 Information Sought from Duty Holders and Other Organisations

As a pilot study it was necessary to collect information from Duty Holders and Organisations in a flexible manner. The most important aspects of the reviews were to identify actual techniques applied and to reach a value judgement as to general HAZID approaches and any specific issues in the minds of those interviewed. It was decided to collect information around the following topics, in keeping with the scope of work;

- the techniques used (including combinations of techniques)
- typical depth and time of study, duration of study
- the type of follow up of HAZID into Quantitative Risk Analysis and risk management systems
- typical team compositions, personnel make-up and competency of personnel for the task
- difficulties experienced and ideas on how to improve technique

2.2 Organisations, Types of Safety Case and Types of Installation Reviewed

In discussion with the HSE, a wide range of type of Duty Holder, Safety Case type and Installation type was taken. The organisations targeted were felt to give the necessary variation in attitudes and approaches to HAZID in the current offshore UKCS.

A total of five Duty Holders were approached and kindly agreed to co-operate with the pilot study, these representing the range of;

- Major Duty Holders operating many installations in the UKCS
- Medium sized Duty Holders
- Smaller Duty Holders operating a few installations with varied exploration activity
- The activities of Mobile Offshore Drilling Units (MODUs)

The following types of Safety Case submission were reviewed;

- Design Safety Case
- Operations Safety Cases (including Construction Notifications)
- Mobile Installations Offshore Safety Cases

The following range of installation types were considered;

- Fixed, old generation platforms
- Fixed, new generation platforms, including FPSOs
- Modern Production Jack-up Platform
- MODUs

Over 10 Safety Cases were actually reviewed. The reviews were held in confidence and as such actual Safety Cases studied are not quoted directly.
Discussions were held with representatives of two major Safety Consultancies with extensive experience in HAZID and offshore risk analysis in general. Informal discussions were also held with a number of interested parties.

2.3 Academic Perspective

Academics play an essential part in looking forward to new concepts and new techniques. As part of the preliminary study the following leading academics were contacted:

1. Dr Andy Rushton, Loughborough University, recognised for his expertise on intelligent HAZOP;
2. Frank Crawley, Strathclyde University and Consultant for WS Atkins, noted for his extensive offshore experience and HAZOP expertise, both practically and in on-going development;
3. Dr. Hani Raafat, Aston University, known for practical application of risk identification and assessment techniques in the Gulf and in the North Sea;
4. Prof. Stephen Richardson Imperial College, London noted for high level expertise in all aspects of chemical engineering safety, and for use and development of the BLOWDOWN technique used offshore; and,
5. Chris Whetton Sheffield University and EC Consultant, known for THOMID expertise, and HAZID work in CIMAH related activities.

Each was asked for their opinions on the definition of a hazard and the HAZID techniques they consider of most importance. The interview then allowed a free discussion of HAZID techniques they used or advised on the use of. These discussions covered advantages and disadvantages of the HAZID techniques, and appropriate follow up techniques for risk assessment and management.
3. HAZID APPROACHES APPLIED TO OFFSHORE SAFETY CASES

3.1 Techniques Used

This pilot study has reviewed the HAZID approaches taken in over 10 Safety Cases submitted under the Safety Case legislation. The breadth of Safety Cases and Operator types chosen gave a reasonable basis to make judgements as to HAZID techniques applied and approaches taken.

Detailed descriptions of techniques applied in each case are not given as this information is not considered to be appropriate in such a pilot study. However, in order to portray the findings of the reviews a matrix of technique versus Safety Case application has been developed. Table 3.1 gives this matrix and presents four levels of “importance” of each technique for each application.

The four levels of importance chosen were:

- **Highly Used**
  
  Technique was used for HAZID for the majority of Cases reviewed.

- **Frequently Used**

  Referenced in the Cases as part of the HAZID process but not seen as a key driver in the HAZID (i.e. a referenced study) by the Surveyor

- **In-Frequently Used**

  Seen in a few Cases and mentioned as technique used either in the Case itself or mentioned in discussion with the Surveyor

- **Not Found in Survey**

  Technique not found.

It was recognised that the small sample of cases, in comparison to the total number of over 220 current in the UKCS, could only give an indication of usage of technique. Therefore discussions were held with Duty Holders and Consultants to ensure that a balanced and representative picture was developed. In particular a degree of judgement had to be employed as to the level of importance of a particular technique, in order to give meaningful information in the study conclusions.

This Table 3.1 shows clearly that although a fairly wide range of techniques have been, and are employed in carrying out HAZID, there are a core of techniques almost always employed:

1. Application of a Generic Hazard Checklist;
2. Hazard and Operability Studies;
3. Safety Reviews.
Table 3.1: Summary Influence Diagram of the HAZID Approaches Indicated through All Discussion and Review

<table>
<thead>
<tr>
<th>HAZID Techniques</th>
<th>Type of Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design</td>
</tr>
<tr>
<td>Comparative</td>
<td></td>
</tr>
<tr>
<td>Methods</td>
<td>Document Review</td>
</tr>
<tr>
<td></td>
<td>Accident Records</td>
</tr>
<tr>
<td>Fundamental</td>
<td>HAZOP</td>
</tr>
<tr>
<td>Methods</td>
<td></td>
</tr>
<tr>
<td>Logic</td>
<td>Fault Tree Analysis</td>
</tr>
</tbody>
</table>

Key:

<table>
<thead>
<tr>
<th>Use</th>
<th>Very High</th>
<th>Frequent Use</th>
<th>In-Frequent Use</th>
<th>Not Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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The Generic Checklist Approach

The generic checklist is a convenient means of carrying out a HAZID in a logical manner. This is almost always used, in some manner, to generate a list of hazards. Historically, Quantitative Risk Analysis has been based upon a generic list of major accident hazards from which QRA can be carried out.

The Safety Case Regulations support this approach by effectively giving a checklist of Major Accident Hazards (MAHs) in guidance on the range of hazard possibilities which need to be considered, these being;

1. A fire, explosion or the release of a dangerous substance involving death or serious personal injury to persons on the installation or engaged in an activity in connection with it.

2. Any event involving major damage to the structure of the installation or plant affixed thereto or any loss in stability of the installation.

3. The collision of a helicopter with the installation.

4. The failure of life support systems for diving operations in connection with the installation, the detachment of a diving bell used for such operations or the trapping of a diver in a diving bell or other subsea chamber used for such operations.

5. Any other event arising from a work activity involving death or serious personal injury to five or more persons on the installation or engaged in an activity in connection with it.

This list was quoted directly, in some form in most of the Cases reviewed.

Some of the Cases reviewed largely concentrated on this list as a basis for the HAZID. Others recognised that it was necessary to identify all hazards with the potential to generate MAHs and then to screen to lead to the MAH list.

In a few Cases the Duty Holder started at a higher level in the HAZID process and identified hazards at a level which could have the potential to cause a Major Accidental Hazard. This was in recognition of the guidance to Para 90 in the Safety Case Guidance.

Table 3.2 gives an example of a more detailed list of generic hazards used in a Safety Case, from which the MAHs were derived through screening.
TABLE 3.2: Example of Complete List of Generic Keywords Used in the HAZID Process

<table>
<thead>
<tr>
<th>Key Word used in HAZID</th>
<th>Example of Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Fire</td>
<td>Ignited Blow-out</td>
</tr>
<tr>
<td></td>
<td>Ignited Process Fire</td>
</tr>
<tr>
<td></td>
<td>Fire in Paint Store</td>
</tr>
<tr>
<td>Loss of Breathable Atmosphere</td>
<td>Smoke Ingress from HVAC</td>
</tr>
<tr>
<td></td>
<td>Asphyxiation</td>
</tr>
<tr>
<td>Direct Toxic</td>
<td>Toxic Gas Release</td>
</tr>
<tr>
<td>Explosion Overpressure</td>
<td>Explosion from Process Gas Leak</td>
</tr>
<tr>
<td>Dropped Objects</td>
<td>Dropped Load from Crane</td>
</tr>
<tr>
<td></td>
<td>Swinging Load hit to Process</td>
</tr>
<tr>
<td>Vehicle Collision</td>
<td>Helicopter Crash</td>
</tr>
<tr>
<td></td>
<td>Ship Collision to Legs</td>
</tr>
<tr>
<td>Structural Collapse</td>
<td>Crane Collapse</td>
</tr>
<tr>
<td></td>
<td>Leg Failure in Design Load</td>
</tr>
<tr>
<td></td>
<td>Extreme Weather</td>
</tr>
<tr>
<td>Mechanical Failure</td>
<td>GT Rotor Blade Failure</td>
</tr>
<tr>
<td>Electrocution</td>
<td>Occupational Accident</td>
</tr>
<tr>
<td>Pressure/Loss of Containment</td>
<td>Air Receiver Failure</td>
</tr>
<tr>
<td></td>
<td>Unignited Pressure Vessel Failure</td>
</tr>
<tr>
<td>Water/Drowning</td>
<td>Deluge in Process</td>
</tr>
<tr>
<td></td>
<td>Man-Overboard</td>
</tr>
<tr>
<td>Direct Chemical</td>
<td>Drilling Chemical Leak</td>
</tr>
<tr>
<td></td>
<td>Lab Chemical Exposure</td>
</tr>
<tr>
<td>Occupational Accidents</td>
<td>Trips, falls</td>
</tr>
<tr>
<td>Hydrocarbon Leak</td>
<td>Diesel Tank Failure</td>
</tr>
<tr>
<td>General</td>
<td>Process Leak</td>
</tr>
</tbody>
</table>

From this process, hazards were grouped into initiating hazards and screened down, using various safety studies to a final list of MAHs which were then quoted in the Case directly.

The HAZOP Approach

HAZOP (Hazard and Operability Study) is a requirement in many major companies. The technique analyses process design, from early concept design to P&ID level, to identify systematically any process safety and operability issues which necessitate design change. Classical HAZOPs are carried out largely by process engineers and do not consider direct hazards for non-process related hazards. It is known that variations on the HAZOP technique are now being applied to Offshore installations, notably:

- Drillers HAZOP; studying drilling programme risks
- EER HAZOP; studying emergency procedures and evacuation systems

The technique was often quoted as a HAZID technique in the Cases, although the linkage to the HAZID overall was not always explicit.
In discussions it became apparent that some people in industry feel that HAZOP is the dominant HAZID technique and that other methods such as checklists are its poorer brother. There was however a lack of obvious connection between the HAZOP findings and the QRA, for instance no specific hazards were listed in the Cases as coming out of HAZOP directly. This point is discussed later in Section 5.

Accident Experience

It was clear from discussions that some Duty Holders, and particularly Consultants, take account of accident experience in generating the HAZID. The level of formality of this process was not however clear.

Safety Reviews

Desktop Safety Reviews were quoted in a number of cases. It is not known to what extent such reviews generated actual list of hazards. In a few key cases safety reviews were used to build the hazard picture rather than have formal checklist generation of hazards.

In MODU HAZID assessments great use is made of Site Inspections as part of the HAZID process. This was a strong element in generating realism into the process. Site inspections were also featured in the few existing Installation Operations Safety Cases reviewed.

Logic Methods

In a number of cases, and in general discussion, it became apparent that logic methods such as fault tree analysis, event tree analysis, escalation analysis and task (human error) analysis were quoted as being HAZID techniques used in the studies.

Ambion consider that the degree of actual identification of hazards coming from such studies was limited. In fact, the techniques were mainly used once the base hazard was identified, i.e. fire effects resulting from an ignited release.

What was interesting was that these techniques were perceived by some to be identification techniques. This point is discussed further in Section 5.

3.2 Depth and Duration of Studies

Depth of Study

As might be expected the depth of study depended on:

- the scale of Installation;
- Project status at time of study;
- The Duty Holder analysis procedures;
- The Contractors/Alliance Members' procedures carrying out safety work on behalf of the Duty Holder.

There was however no obvious correlation in technique used or depth according to these factors. The checklists employed, mainly MAH lists, seemed to be the dominant factor in setting the depth of study.
Existing installations had relatively few (one or two maximum) main HAZID study reports referred to in the case. This would be consistent with a single operator organising studies under the legislation on a known concept.

It was noted that in one new project, with a number of design contractors involved, a number of separate HAZID studies relating to different sections of the Installation were carried out. This indicated a potential degree of separation between different aspects of the design process and the HAZID process. In these cases safety reviews may have been used to link the separate HAZID studies into a cohesive unit although this was not directly obvious. The mechanisms for cross correlation between separate hazard reviews were not apparent in any of the Cases reviewed.

In a few Cases reviewed, novel technology was being employed and the Duty Holders had expended a much greater amount of effort in identifying the new hazards involved. This process however was still centred around the basic checklist approach.

Overall, in terms of depth of study it was felt that there was very little difference in actual quoted hazards in the cases from design case through to operations case. The main depth change seemed to be more location detail, in Cases where a location approach was taken rather than a system approach.

**Duration of Study**

In cases where formal sessions were held using a *generic checklist* approach to identify hazards, discussions indicate that the range of 1/2 to 5 days is typical depending on the depth of study. The majority of formal HAZID reviews were held in HAZOP style sessions with a chairman and secretary, these lasting around 2 to 3 days.

It was not possible to determine the times spent on hazard reviews as these were largely ad-hoc in nature and not recorded explicitly in the Safety Case process.

In cases where HAZOP was employed, such reviews could take many man-weeks and detailed estimates of times were again not available.

**3.3 HAZID Study Management**

**Team Compositions**

Where formal HAZID sessions were employed, sessions were run in the style of HAZOP sessions. Sessions were held by an Independent Chairman and a generic checklist used to develop a hazard list either on an area-by-area basis or a system basis. Process and Layout drawings were the key documents being used in the reviews. A team of personnel from the Project or Operating Group would attend the sessions.

Typically there would be an independent chairman, a secretary and various team members representing process and other disciplines. Records of these sessions were not in the Safety Cases reviewed. It was evident from discussions that around 4 to 6 people may be in a HAZID session with ad-hoc advice given from experts in particular areas. This was similar to HAZOP sessions.
HAZID sessions members were typically from QRA, Loss Prevention and Operations backgrounds as a base. Teams were often supplemented by disciplines such as Process, Drilling, Mechanical, E&I and Structures as felt necessary.

There was some evidence that a few duty holders had a predetermined view on the content of the HAZID team although this was not directly evident from cases.

As a general finding it was felt that the HAZID process was dominated by Safety and Loss Prevention type personnel from Operators, Contractors or Consultancies. The next most involved group were Process Engineers.

**Competency**

The competency of personnel, and particularly the Chairman, was not discussed in any Safety Case reviewed. General competency of all work within the Case was described in only two Cases reviewed. This finding indicates that the guidance in BS8444 Part 3 on Risk Analysis [4] that “The expertise of the working group should be specified and recorded” is not been adhered to.

In general discussion it was obvious that there was an awareness that the Chairman should have a degree of independence from the Project. In some cases the experience level of a chairman was indicated but no hard and fast rules were evident from most organisations.

As a general point, a number of companies have procedures which give guidance as to the type of HAZID studies to be done and the form of output. Companies, particularly the main Consultancies and major Duty Holders, with formal procedures for Risk Analysis and Formal Safety Assessment had this document as a matter of course. However, in review of Safety Cases and in general discussions it was apparent that these documents were not always followed in detail and in some cases not at all.

One Duty holder has instigated a formal system of HAZID chairman approval, looking at qualifications directly related to HAZID technique, and methods before being able to carry out such work. In the Organisation a HAZID Chairman must be approved to carry out work on behalf of this Duty Holder.

3.4 **Follow Up of HAZID into Quantitative Risk Analysis (QRA) and Risk Management Systems**

**Follow Up into QRA**

In most Cases the basis of the QRA was stated to be the list of identified hazards. The level of completeness of this linkage was not however obvious due to a lack of detail lists in many of Cases.

There was little evidence found for a direct link between HAZOP outputs and the QRA. In the Cases reviewed and in discussion it became apparent that HAZOP is seen largely as a separate exercise, carried out as part of the design confirmation process. The evidence of linkage into the QRA was simply not reported as such or did not occur. The likelihood of such a link would depend upon how the HAZOPs and QRA studies were managed and who carried them out.
Follow Up into Risk Management Systems

The follow-up of hazards identified into actual risk management systems applied offshore was not at all evident from the cases or from discussions with personnel. This is felt to be a significant finding. In only one Safety Case reviewed was there a specific linkage from identified hazards made to actual hazard management systems and procedures offshore, outwith the PFEER [5] regulations. References to performance standards and written schemes of examination relating back to the HAZID were evident in some Cases but not as strongly as might be expected.

All Cases reviewed preceded the DCR legislation and so the concept of Safety Critical Elements did not feature. However this issue was discussed with Duty Holders and Consultants and it was evident that such reference will need to be addressed in part in new case issues.
HAZID PERSPECTIVE OUT-WITH THE DUTY HOLDER

Discussions with academics and other interested parties revealed that there are a number of distinct views on how HAZID should be undertaken. What became apparent was that the difference between HAZID and hazard assessment techniques is not clear in many peoples minds and this leads to potential pitfalls in the HAZID process.

A number saw the HAZOP “model” as being the main way forward, and that development of the existing technique would offer a sufficiently flexible approach to HAZID in most situations.

The following sections summarise the opinions of individuals and add thoughts as to possible ways to improve HAZID. It is stressed that these are personal opinions of the individuals as summarised by Ambion from the discussions and are not in any way seen as definitive statements or as views directly endorsed by Ambion Consultants or the HSE.

- The use of preliminary and/or general hazard analysis techniques should be enhanced by more detailed techniques such as Sneak Analysis as used in the aircraft industry.
- A more general approach to HAZID was thought to be of value, over prescriptive techniques not easily integrating in meeting the varied legislative requirements now required. It was felt that undertaking specific HAZID studies under the Safety Case requirements could undermine the effectiveness of other risk assessments being carried out to meet other Regulations.
- Variations in human response to any one system cannot yet be built into the risk model in an effective manner, although this area is now receiving more focus.

Overall HAZID Approach

It was felt that there is a need for a more co-ordinated approach to HAZID. This is valid especially in the context of UKCS Installations and if addressed could lead to a top-down process driven by a holistic view of the Installations risk assessment and hazard management. At present there is little or no co-ordination between hazard identification process for say the Safety Case requirements and those of say the Management of Health and Safety at Work Regulations.

The HAZOP Technique

All were in agreement that the most effective HAZOPs were carried out by experienced trained personnel with carefully selected personnel participating. It was argued that the HAZOP team should not be afraid of seeking information from any level of personnel external to the exercise, and this lead to a discussion of how focused the HAZOP needed to be. It was acknowledged the evolution of HAZOP over the years has tended towards a more outward focus although any major improvement in the HAZOP process would be limited until management of risks and human failure aspects can be properly accommodated in the HAZOP process.

In conclusion, all parties were in agreement that a more flexible approach to HAZID was needed; this ranged from further development of HAZOP to one of providing a menu of options any of which could be employed given a demonstrated need.
5. DISCUSSION

The following sections give a discussion of general findings derived through the whole process. It is important to stress that this report makes no attempt to judge the HAZID process of individual Safety Cases and the views expressed are meant as a positive critique of the findings to stimulate discussion as to ways to move forward and improve current thinking. In some cases the views expressed are contentious and would be open for debate, they are however all borne out of direct discussions with a wide range of respected members of industry.

5.1 General Findings from Pilot Study

Importance of HAZID within the Regulations

HAZID is a key part of every Safety Case and as such this is recognised in all Safety Cases reviewed. As required in Regulation 8.1(c) of the Safety Case regulations the identification process of Major Accident Hazards is invariably referred to. It is not always the case, however, that the hazard list is fully detailed in the actual Safety Cases.

A review of the Safety Case regulations revealed the following additional references to HAZID requirements:

1. Fixed Installation Design Safety Case - Schedule 1 Para 12
2. Fixed Installation Operations Safety Case - Schedule 2 Para 11
3. Mobile Installation Operations Safety Case - Schedule 3 Para 9
4. Combined Operations Safety Case - Schedule Paras 2 and 3
5. Abandonment Safety Case - Schedule 5

and through notifications;

7. Construction Activity Notifications - Schedule 7 Para 5

The PFEER [5] legislation also requires HAZID implicitly as part of assessment of major hazards, this being heavily linked to the above. There is however also implicitly a requirement to HAZID non-major accident hazards in order to complete the emergency response parts of the regulations.

The degree of detail of HAZID in each of these Cases, where reviewed was very variable and certainly not consistent.

It was apparent that there was an underlying lack of appreciation in industry of the importance of HAZID in its wider context as a key to overall hazard management and the ALARP demonstration. It was felt by a number of people that HAZID is often seen as a “crank the handle” exercise which is to be hotly followed by “the more important” elements of QRA. One telling statement through discussion was “certain individuals believe that HAZID just gets in the way of undertaking QRA”; this sentiment is not unusual in general attitude to HAZID in the overall context of QRA.
Definition of a Hazard

There seems to be a high degree of confusion throughout the industry over the definition of what is meant by "hazard". There is now some common use of nomenclature from the IChemE in this area [3] but this does not seem to be fully appreciated.

The main area of uncertainty in this regard is whether a hazard is:

- an initiating event; i.e a leak of hydrocarbon from a pressure system
- the cause of an event; i.e corrosion which causes the leak from the pipe
- the resulting consequence of an event; i.e a fire if the leak ignites

In certain cases, for instance in MODU assessments the escalation potentials of events are considered as well as causations in order to reach conclusions as to overall hazards. This approach works well for MODUs in certain regards but breaks the boundaries of the definition of a hazard.

There is particular concern in a situation where a consequence is defined as a hazard. For example, if a "hydrocarbon fire" is defined as the initiating event it is not then possible to apply the hazard management concept of avoidance, prevention, control and mitigation to that event as there is no linkage to initial cause. In such a case it is not possible to demonstrate adequate risk management.

This point is important as unless the industry as a whole sees a hazard with the same viewpoint there is the potential for confusion. In this situation there is the potential for hazards to "slip the net" and not be identified in a consistent manner, and ultimately not be managed.

5.2 HAZID Techniques Used

There are a large number of HAZID techniques available to industry, all of which are well documented. The preliminary studies show clearly that Safety Case HAZIDs are highly dominated by the use of generic checklists and HAZOPs.

Generic Checklists

The use of a hazard checklist is seen as a sensible approach by most as it gives a degree of consistency of approach and can be directly related to the list of major accident event types given as guidance in the Safety Case Regulations.

However, it is felt that there is a danger in the reliance of a generic checklist as installation specific hazards may be missed if they are not directly obvious in relation to the checklist. An example of this can be seen in an installation such as a new-build FPSO where unique hazards relating to novel turret design and ballasting systems may not appear on a conventional hazard checklist. If not, the reliance on the HAZID team to generate these hazards independently of the HAZID sessions becomes paramount.
Generic checklists are stronger on certain kinds of hazards than others. Fire/explosion hazards (hydrocarbon leak, blowouts etc) are much more carefully looked at than say structural type events (structural collapse) or mechanical design failures (Jack-up locking system failures, tensioning system failures). There is a tendency for hazard studies to therefore concentrate on the well understood hazards offshore and neglect the less understood hazards. Given the emergence of new concepts offshore this is a genuine concern in the HAZID process.

**HAZOP**

It was of interest that HAZOP was quoted as a key HAZID technique, indeed it was felt by some parties that HAZOP was a more useful and powerful tool than any other HAZID process. This view was held by Chemical Engineers familiar with the technique, it is less certain as to whether different disciplines would hold similar views. As an example, HAZOP would not help identify specific hazards related to crane handling as mechanical handling systems would not normally be covered in a HAZOP process.

In terms of “time expended” HAZOP was by far the most dominant technique. There was however no obvious link between HAZOP findings and the HAZID results apparent in the Cases. Indeed it is apparent that the Industry does not see the HAZOP technique as being a main feeder for the QRA, the HAZOP being essentially a different process than the HAZID within the Project environment. Indeed HAZOP was seen to be managed by the process department rather than the Safety group in many cases.

The increasing use of HAZOP and the obvious amalgamation of HAZOP method into the HAZID process is obviously an important area. It was felt that the familiarity of HAZOP within industry and the defined nature of team sessions, chairman and process lends itself nicely to HAZID, although the linkages into the QRA are currently vague.

**Techniques Not Used**

It is worthwhile considering those techniques not used in the Cases reviewed, notably;

- What-if
- FMEA
- Task Analysis

It is worthwhile noting that FMEA (Failure Modes Effect Analysis) techniques are applied in some form in the development of Maintenance and Inspection Programmes for facilities. The linkage between these studies and the HAZID is less well understood.

Although these techniques have their advantages they do not seem to figure thus far in the modern Safety Case regime in HAZID.

**Logic Methods**

It was felt that the use of logic methods as HAZID techniques is an example of the uncertainty in definition of a hazard.
5.3 Depth and Duration of Studies

 Typically, where generic checklist studies are being carried out they last around 2 to 3 days. Depending on the complexity of the installation and the point of study (i.e. concept, design) this may be adequate or in-adequate. In Cases where HAZOP was employed, such reviews could take many weeks.

 Some Duty Holders did not hold a formal HAZID session as such, but developed a hazard register on the basis of various safety reviews and various other studies, such as HAZOP.

 It was felt by some that insufficient time and resources are allocated to the HAZID. Also, once a HAZID is complete there is a tendency to assume the HAZID is complete and carry on with the downstream QRA without refining the HAZID at later stages. HAZID should not be considered as a one-shot process, it should live in context with the Safety Case as a whole. In the consultation documents for the Safety Case regulations typical costs for generating a Safety Case were around £1M for a new development. It is worth noting that a HAZID study of 3 days duration may in real terms represent only 0.5% of this budget, but is in reality one of the most important elements.

 An overall concern relating to depth of study relates to the HAZID process in relation to the project management structure and contract position. In the new CRINE era it is becoming the norm in the UKCS to have Alliances of Companies developing a project on behalf of a Duty Holder, particularly when developing marginal fields. It is evident that in cases where an Alliance of Companies is given direct responsibility for carrying out safety studies there is the potential for individual members of that alliance to develop hazard lists relating to their own area of contract responsibility which may not necessarily be consistent with another member of the Alliance. This approach needs extremely careful management if the separate exercise are to be combined into a single unified hazard list, as required by the Duty Holder. The pitfalls in this area are obvious in that the most likely areas for hazards to be missed will be in the interfaces between scopes.

 5.4 Team Management

 All of the HAZID techniques discussed are very dependant on the quality of personnel using the method. The qualifications and experience of the Chairman was seen as a critical element of the process. Variability of result in relation to team composition, even with a consistent checklist, is of concern at present in terms of HAZID generation.

 If possible the method of analysis ought to be enhanced in some way to control this degree of variability. This must be done however in a manner that does not restrict the free thinking approach required to carry out HAZID.
5.5 Follow-Up into QRA and Risk Management

Follow up into QRA seems to be well defined and obvious with the cases in general. This is not surprising as this is a natural and necessary process in QRA. The links with HAZOP were less defined.

Follow-up into the wider risk management was addressed in a few cases but it is felt that this was not addressed as completely as would be expected. It is recognised that such links will become stronger with the emergence of the PFEER and DCR regulations [6].

5.6 General Observations

HAZID is generally seen as a mechanistic process and is treated as such within the industry. One telling statement through discussions was “certain individuals believe that HAZID just gets in the way of undertaking QRA”, this is both a surprising statement, but known to be prevalent in some quarters of the industry. It was felt by many parties that it is important that more effort is put into HAZID upfront of any QRA or risk management procedures to streamline the overall safety management process.
6. CONCLUSIONS

HAZID is seen as an important element of the Safety Case Regulations in the UKCS. A relatively small number of HAZID techniques are actually in use in industry, the dominant been the generic hazard checklist and HAZOP. The links between HAZOP and the QRA within the Safety Case were not however apparent.

There are however no known guidelines on the appropriate application of technique, or combination of techniques, to use in a specific project or operating environment. This has lead to inconsistencies in approach between Operators, Contractors, Consultants and Academic Bodies.

It was felt by many parties that it is important that more effort is put into HAZID upfront of any QRA to streamline the overall safety management process.
7. RECOMMENDATIONS

It is felt by Ambion that at this point in time there would be real and substantial benefits to industry from a research programme which would generate, as its prime deliverable, a definitive "Guide to Offshore HAZID". This guide should be generated in consultation with all interested parties through a Joint Industry Project (JIP).

In discussions with personnel during the survey there was a good degree of support for such a guide, particularly amongst practising safety professionals and a few of the Operators. On the counter-side there was also at least one party voicing concern that such a guide could be too strict in approach and therefore introduce inflexibility into the system.

Given the pluses and minuses, Ambion feel that the guide should be very much focused to lay out a methodology and approach to HAZID which could be directly applied by Duty Holders, Consultants and Contractors. Such a Guide would not answer all the questions, nor could any guide, but would at least set a benchmark for industry to compare its own practices against, and hopefully to lead to a more consistent basic approach to HAZID. Subsequent research could build on such a basis.

It is envisaged that the guide would need to cover two main areas:

1. Technical Approach
2. Management of HAZID Sessions

The Joint Industry Project (JIP) would provide the all parties an excellent platform to bring about the consistency and quality of HAZID ultimately desired. Key benefits would include:

- standardisation of approach allowing more efficient and focused management of the Formal Safety Assessment (FSA) process;
- eased liaison with the authorities (HSE);
- smoother implementation of the whole FSA process.
8. REFERENCES


