

ANALYTICAL METHODS AND WORKING EXPERIENCE WITH POST-CULLEN ANALYSIS OF EVACUATION, ESCAPE AND RESCUE

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SYNOPSIS

Evacuation, Escape and Rescue Analysis Reports have been completed for offshore oil and gas installations, as requested by the regulators and discussed in the Lord Cullen Report. This paper results from working experience, involving the offshore workforce, for eighteen Amoco Installations in the North Sea. The team included SRD Safety Engineering Consultants. A structure and methodology for this preliminary analysis of E E & R are outlined, with illustrative results and conclusions. In particular, identification of credible fire hazards and their potential threat to escape routes. The consistent approach in this work, and the unified management of E E & R information and general conclusions, are assisting Amoco to manage safety and reduce risk. This includes the planning of consistent actions, coordinated across eighteen diverse offshore installations.

Keywords: safety, offshore, hazard, evacuation, escape, Cullen

1. INTRODUCTION

1.1 Preview

This paper is based on experience gained in the development, production and practical use of analytical studies, by Amoco (UK) Exploration Company, for 18 of their Installations in the United Kingdom sector of the North Sea. The study was made by team work between consultants, (SRD Oil & Gas/AEA Technology) and Amoco, who involved many offshore staff. In particular, the Offshore Installation Managers (OIMs) were involved throughout the studies and now become the final owners of their E E & R Analysis Report, as they will become owners of their full Safety Case from 1992. The emphasis has been to **integrate** the safety related work in Amoco into day to day management of the Installations. The present studies and follow-up actions have been an opportunity for increasing involvement of the work force into safety related activities.

In 1988, prior to this E E & R analysis study, an Amoco taskforce, comprising of senior

engineers and safety specialists, reviewed its production operations and facilities. The team identified areas from which a series of safety enhancement studies were carried out. These studies developed into major offshore modifications and in 1990 Amoco spent M£110 relocating 44 emergency shutdown valves (ESDVs) on pipeline risers; installing a pipeline sub sea isolation valve (SSIV); upgrading fire protection systems; and evacuation, escape and rescue facilities. This work was a valuable source of information and ideas to the E E & R analysis, and contributed to the small number of identified impediments to safe evacuation, escape and rescue.

To assist **consistent** practices throughout Amoco, the E E & R studies were extended to ensure the utmost consistency between the 18 installations, their safety documentation, methods and facilities for E E & R. Starting with consistent analytical methods; then cross comparing results and conclusions between installations. This allowed a sharing of useful practical conclusions, with a view to enhancing safety in a well structured and uniform way for all 18 installations. Thus, each installation was encouraged to contribute plant-specific ideas and conclusions, which were shared with other OIMs. These could then be included in reports for other installations, where relevant. Several examples of "general conclusions" are presented in Section 6 of this paper, which should be applicable to many offshore installations.

This consistent and co-ordinated approach was possible, despite the wide diversity of types included in the 18 installations: large oil and gas production platforms; multi-jacket gas production, terminal, processing and compression complexes; down to smaller single-jacket gas production installations that are not normally manned.

The regulatory body requested that the 18 E E & R reports were complete by November 1991. This timescale was short, leaving less than 12 months to complete the wide ranging task. Since no E E & R Analysis Reports had existed before in the UK, the starting point was almost a clean sheet of paper.

The 18 Reports were presented to the regulatory body on time, and have been reworked extensively in 1992, to increase consistency and completeness, after another round of feedback from offshore personnel.

1.2 E E & R Definitions

To clarify the use of terms in this work, we repeat the definitions from the Lord Cullen Report (1):

- **Evacuation** refers to the planned method of leaving the installation without directly entering the sea. Successful evacuation results in those on board the installation being transferred to an onshore location or to a safe offshore location or vessel
- **Escape** refers to the process of leaving an offshore installation in the event of part or all of the evacuation system failing, whereby personnel on board make their way into the sea by various means or by jumping

- **Rescue** refers to the process by which escapees and Man Overboard (MOB) casualties are retrieved to a safe place where medical assistance is available.

1.3 Objectives and Scope

The main objectives of E E & R analysis, are the following:

- To identify impediments to safe E E & R that require immediate attention. This was to be achieved across all 18 installations, well ahead of the completion of 18 full Safety Cases, with their quantitative risk assessment (QRAs)
- To present an overview of an installation's current facilities and procedures, relevant to the E E & R analysis
- To describe the types, numbers and locations of personal survival and escape equipment
- To make a preliminary qualitative assessment of the likelihood of successful evacuation, escape and rescue during possible emergency situations, (ie potential major hazards), with a view to minimising risk to personnel
- To evaluate the likely availability of helicopters, and also the types, numbers, locations and accessibility of Totally Enclosed Motor Propelled Survival Craft (TEMPSCs), life rafts and other facilities for escape to the sea
- To detail the location, types, numbers of Standby Vessels (SBVs) and availability of Fast Rescue Craft (FRCs)
- To draw conclusions and to classify them, for further attention
- To form a first foundation for further studies and actions.

This preliminary analysis could not be a full QRA, but was a thorough method, using sample scenarios/hazards, (and their heat and smoke effects), to illustrate the "worst" effects upon escape routes and muster areas. It aimed to identify where such effects might render proposed escape routes "poor", (ie unavailable).

The preliminary analysis methods and assumptions are presented in Sections 4 and 5, with general conclusions in Section 6.

1.4 Usefulness of Early Studies

The E E & R Analysis Reports for each installation were in place for the regulator by November 1991. Until further details and advice emerge on revised E E & R regulations, Amoco have decided that these E E & R reports will be reviewed

and updated as required. For example, when significant changes are made to an installation's operations or facilities.

The E E & R Studies were essential as a preliminary analysis at the early stage in the development of the installation Safety Case. This approach allowed Amoco to identify and rectify potential major impediments to effective E E & R at an earlier stage than would have been the case if they waited for the conclusions from the Safety Case. Further E E & R studies were then made and used within the full Safety Case.

The subsequent work on E E & R Scenarios, their frequencies and potential consequences needed considerably more effort and quantification. This work, which is not within the scope of the present paper, includes analysis of the following: hazard identification; fire risk assessment and frequency results; consequence analysis; smoke and gas ingress analysis; survivability of emergency systems; safety systems; and temporary safe refuge (TSR) integrity.

The preliminary analysis documentation, and its distribution to OIMs, served as a basis for:

- Updating documentation, with involvement of on and offshore personnel
- Self-auditing of an installation
- Measuring compliance with Lord Cullen Recommendations (Reference 1).
- Information for regulatory bodies; the extent of current facilities and procedures
- Hazard scenario information for development of training and drills
- Action planning to enhance safety, including target setting for further studies

The extra benefit which has come from a preliminary analysis of 18 installations, in a relatively short period of one year, has been an overview and cross comparison of facilities, practices and conclusions across the whole field of Amoco's operations in the Northern and Southern North Sea. This work set a basis for **integrated** and **consistent** Safety Case Studies, and management of safety.

This wide preliminary study provided an **early identification** of safety related problem areas. Amoco was reassured that any immediate impediments to safe E E & R were identified rapidly, and so receive the required early attention. These studies prevented therefore an undesirable situation, where a long delay, (say into 1993), would have been possible. Attention to urgent problems did not have to wait until the completion of a detailed Safety Case for each installation. Examples of actions taken are described later in this paper.

2. INFORMATION ON FACILITIES FOR E E & R:

Their Compliance with Recommendations

The first half of the analyses was an up to date description of means of evacuation,

escape and rescue.

Information was gathered from existing documentation, questionnaires, visits offshore and interviews with specialist personnel. The draft reports were checked thoroughly by offshore personnel before they were finally issued. These communications served as a practical and effective way to involve the work force.

For all installations, a consistent method of reporting information was used, with the following structure, to describe the facilities for E E & R.

General Overview of Installation

- Geographic Location
- Platform Design and Construction.

Platform Layout

- The Platform Complex (Location of Potential TSRs and Alternative Muster Stations)
- Distribution of Personnel
- Fire and Gas Detection System
- Alarms and Emergency Shutdown
- Fire Fighting Equipment
- Passive Fire Protection.

Embarkation Points

- Helideck
- TEMPSCs (Totally Enclosed Motor Propelled Survival Craft).

Helicopters

- Military Search and Rescue (SAR) Helicopters
- Civil Search and Rescue Helicopters
- Helicopter Contractors
- Aircraft Availability for Evacuation Purposes.

Survival Craft (TEMPSCs)

- Location and Capacity
- Equipment and Maintenance
- Davit Orientation.

Access to Sea

- Life Rafts
- Ropes, Ladders and Nets
- Other Devices.

Rescue

- Standby Vessels (SBVs)
- Fast rescue Craft (FRCs)
- Availability of Medical Facilities Following a Rescue.

Personal Survival and Escape Equipment

- Survival Suits
- Life Jackets
- Smoke Hoods
- Other Equipment.

Communication Systems

- Microwave
- VHF/UHF/HF Fixed
- VHF/UHF Portable
- Telephone
- Other Systems.

The E E & R Analysis Report used many coloured illustrations to show the types, numbers and locations of personal survival and escape equipment.

Escape route plans were used later in the analysis, where the addition of sample fire hazard sources and heat flux zones were superimposed on the plans.

This early information gathering was the basis of further work within the Safety Case.

A comprehensive and revised document control and management system was essential to this work, to ensure that the large volume of data and documents could be stored and retrieved, to a thorough quality assured standard.

Compliance with Recommendations

Compliance with established recommendations for the provision of key equipment could be evaluated, as a percentage of the nominal maximum number of people on board (POB). Table 1 is a generic sample table presenting results for an installation. A sample maximum POB of 24 is used here.

Item	Number	Seating Capacity	% of POB
TEMPSC	2	69	>250
Life rafts	4	80	>300
Life jackets	80	-	>300
Smoke Hoods	26	-	>100
Gloves	24	-	100
Torches	24	-	100
Survival suits	24	-	100 ¹

Table 1: Personal Survival and Escape Equipment (POB 24)

In Table 1, survival suits¹ are given as 100% of POB, because each person arrives with an issued immersion, (or survival), suit.

From this example table, the conclusions would be that there is good coverage for TEMPSCs, life rafts and life jackets.

Criteria at present suggest that % of POB should be at least 150% for TEMPSC, 100% for life rafts and at least 100% for other personal survival equipment. However, there is a need to establish that the distribution of equipment, around the platform, should be adequate for major hazard scenarios.

In particular, the effect of this analysis has been an extensive review and selective enhancement of provisions. For example, many extra smoke hoods have been installed in strategic locations. A typical smoke hood gives up to 20 minutes protection.

3. PERSONNEL RESPONSES: STRATEGY FOR E E & R

3.1 Philosophy and Strategy of E E & R

This paper recognises the key role that Safety Management Systems, personnel responses and human factors play in survival from a major hazard. However, this part of the preliminary analysis is not detailed here. The following aspects were identified and commented on, in the E E & R Reports:

Formal Command and Control Structure

- OIM Communications with Key Personnel, on the platform
- Duties of Other Key Personnel in an Emergency
- OIM external Communications with Coastguard, Shore and Other Installations.

Emergency Response Actions

- Emergency Procedures and Station Bill
- Emergency Procedures for Evacuation
- Emergency Procedures for Escape and Rescue.

3.2 Training Courses and Drills

For all installations, a consistent policy of training and drills is defined in the Amoco Safety Management System.

The scenarios of importance in the E E & R Studies can be the basis for development of more realistic drills and training exercises.

4. METHODOLOGY AND APPLICATION: PRELIMINARY ANALYSIS OF MAIN HAZARD SOURCE ZONES

4.1 Identification of Main Scenarios, for Credible Hazardous Events

Torch Fires

Torch fires are associated with gas leakages. The size and duration of a torch fire depend on the gas itself, the amount, its pressure and the diameter of the leak.

The impact of a 2070 kPa methane release from a 25 mm diameter orifice has been evaluated and applied; for use in generic preliminary analyses, to show the effects on the escape routes, to and from a primary muster station.

Pool Fires

It is possible for pool fires to occur where there is a large quantity of flammable liquid (usually a hydrocarbon, for example diesel) that may have leaked from a vessel. It is not possible for such a pool to form on a grating floor.

The analysis evaluated the impact of 2 m, 5 m or 10 m diameter pools, (depending on the size of the source), on the escape routes to and from a primary muster station.

Smoke

Smoke is liable to affect large areas of the installation. Wind direction will determine which areas are affected.

Gas Clouds

Gas clouds have been considered to have similar effects on escape routes as smoke. The open nature of the decks makes them unlikely.

Explosions

Explosions may happen in process areas where a gas/vapour cloud can accumulate and when ignition is delayed. They are less likely to occur on open decks.

A detailed analysis of the effects of an explosion was beyond the scope of a preliminary analysis, since generic conclusions are more difficult to apply than in the cases above for torch and pool fires. Further analysis of explosion is however included in the Safety Case, but is not discussed here.

4.2 Hazard Location

The hazards identified above are not applicable to all locations on the installation. For the preliminary analysis, a range of potential hazard scenarios was chosen specifically for each installation. The examples of hazard locations and torch directions were chosen to illustrate the "worst" effects upon escape route availability.

Ten to fifteen scenarios were chosen, depending on the size of installation and are used in the analysis as outlined in Section 5. Sample Table 2 is given below.

Location	Hazard	Possible Cause
Platform D, helideck	Helifuel: 10 m pool fire	Helicopter crash
Platform D, cellar deck, wellhead	Gas: Torch fire ** 4 horizontal 1 vertical	Blow-out
Platform P, main deck, diesel storage (Figure 2)	Diesel: 5 m pool fire 5 m pool fire	Diesel spillage Diesel spillage
inlet separators	Gas: Torch fire ** 2 horizontal	Flange failure
Platform P, cellar deck, slug interceptors	Gas: Torch fire ** 1 horizontal	Flange failure
Platform P, cellar deck, fuel gas separators (Figure 1)	Gas: Torch fire ** 1 horizontal	Flange failure
Platform T, main deck	Gas: Torch fire ** 2 horizontal	Flange failure

Table 2: Summary of Typical Hazard Locations, for a sample installation, which has three jackets/platform (D,P and T) connected by two bridges; where D, P and T represent Drilling, Production and Terminal.

** Standard methane torch, 2070 kPa and 25 mm hole.

4.3 Hazard Range Models

This section introduces example models of generic torch fires, pool fires and smoke release zones. They were used to show the typical impact of the hazard upon the surrounding areas, as required for systematic preliminary analysis.

Torch Fires for Application of Generic Method

Radiative heat flux levels and contours were computed for hydrocarbon gas torch fires from the following.

- Gas mass discharge rate
- Torch geometry specification
- View factors
- Atmospheric radiative attenuation/transmissivity.

Example

Figure 1 shows the cellar deck of platform P with a torch fire resulting from a methane gas release from a 25 mm diameter hole at a pressure of 2070 kPa, from the fuel gas separator unit. This was considered appropriate with regards to the operation of the platform.

The flame length, and the 4 and 20 kWm⁻² heat flux contours are shown. These were projected on each deck plan, at potential fire locations to demonstrate the hazard zones. Section 4.4 discusses flux level damage criteria.

Pool Fires for Application of Generic Method

The following variables were considered for the analysis of the heat flux contours:

- Mass discharge rate
- Mass burning rate for a given fuel
- View factor
- Atmospheric radiative attenuation/transmissivity.

Heat flux contours were computed for a pool fire and have been projected onto deck plans at potential fire locations.

Example

Figure 2 shows potential pool fire locations at the diesel storage tanks, platform P. The 4 and 20 kWm⁻² heat flux contours (at the appropriate scale) are indicated for a 5 m pool fire.

Smoke Release

The effect of smoke emanating from pool fires was considered. Smoke generated by a hydrocarbon pool fire reduces visibility and contains toxic gases that would quickly affect people attempting to pass through it.

Smoke generation has been computed, predicting fire characteristics arising on offshore installations.

These results are based on the following conditions and assumptions:

- Material involved is condensate (or light oil)

- Pool sizes of diameters 5 m and 10 m are considered
- The deck is open.

Results for smoke generation confirmed that, (for a typical platform module or partially enclosed deck), smoke generation makes an area uninhabitable within a few minutes.

4.4 Damage Criteria for Thermal Radiation

Table 3 shows the damage criteria for various levels of thermal radiation to which personnel and structures are liable to be exposed.

Flux Level kWm ⁻²	Damage
4.0**	30 seconds to blistering of human skin No damage to structures
20.0	5 seconds to blistering of human skin. 50% chance of fatality if exposed for 40 seconds Pilot ignition of cellulosic material possible for prolonged exposure (greater than 2 minutes)
40.0	Instantaneous burning of human skin. 50% chance of fatality if exposed for 15 seconds Spontaneous ignition of cellulosic material possible if exposed for more than 30 seconds Damage to structures during prolonged exposure
100.0	99% chance of fatality if exposed for 10 seconds Damage to major steel structural supports expected within 15 minutes of exposure

Table 3: Damage Criteria for Thermal Radiation (2,3)

- ** A flux level of 4 kWm⁻² has been taken as the limit of safe passage, on a short escape route, for the purposes of this E E & R Analysis.

5. ANALYSIS OF ESCAPE ROUTES AVAILABILITY: FOR SAMPLE SET OF INCIDENT SCENARIOS

The analysis involved careful and systematic examination of the availability of escape routes during certain scenarios.

5.1 Objectives

The objectives of this analysis were to determine:

- The availability of the escape routes from various parts of the installation to the muster points, immediately after an incident has occurred, (ie approximately 5 minutes).
- The alternative routes and mustering points as appropriate.
- The escape routes from the primary muster station to embarkation points, for TEMPSCs and helideck.

5.2 Assumptions

To perform the preliminary analysis, the following assumptions were made:

- There is no escalation of an incident
- Personnel are distributed throughout the installation and no area is unoccupied
- Ignition sources to ignite the gas and liquid releases are always present. Ignition occurs without prior warning to personnel
- No protection of escape routes is afforded by the surrounding process equipment or grating floors
- Dividing walls will give no protection from the effects of an incident unless they are fire rated
- An incident is confined to a single deck level where the ceilings and floors are continuous (eg welded steel plate)
- Pool fires would not form on open grating
- There are two types of incidents namely, torch fire (heat) and pool fire

(heat/smoke)

- Smoke production is from the area of the fire and will move in the direction of the prevailing wind
- Smoke from pool fires would make escape routes impassable without adequate personal protection
- A heat flux of 4 kWm^{-2} is the limit of safe passage on an escape route. (See Table 3).
- Explosions and gas clouds are not considered specifically. On open decks the overpressures from explosion are not expected to cause damage to affect escape route availability

5.3 Method of Analysis

The analysis considers several scenarios at various locations, (see example Table 2 in Section 4).

The hazards considered in this analysis are:

- Gas torch fires (heat)
- Hydrocarbon pool fires (heat/smoke).

The effects of radiant heat are considered in relation to the positions of stairways, walkways, ladders, doors and buildings. The areas affected were determined by plotting the heat flux contours, for torch and pool fires of the relevant size, and at the appropriate scale, and overlaying them on a plan of the deck at the chosen release point.

5.4 Results

The escape route availability to and from primary muster points was analysed and presented in a detailed tabular form. These sets of tables of results were summarised and discussed, using a set of summary tables, one for each platform, as outlined in Table 4.

Sample Production Platform Scenarios

The sample summary table below summarises the effectiveness of available escape routes to the control room muster point on sample production platform P, main deck (Figure 2). This sample case study is hypothetical, for illustration in this paper.

Escape From	Routes to Control Room			
	Route	Torch Fire	Pool Fire	
			Heat	Smoke
Main deck	North	Moderate	Poor	Poor
	South	Poor	Poor	Poor
	East	Moderate	Poor	Poor
	West	Poor	Poor	Poor
	Central	Poor	Poor	Poor
Cellar deck	North	Moderate	N/A	N/A
	South	Poor	N/A	N/A
	East	Poor	N/A	N/A
	West	Poor	N/A	N/A
	Central	Poor	N/A	N/A

Table 4 Escape Routes to Control Room Muster Point on Main Deck (North)

Good

Direct route available after incident.

Moderate

Alternative route available that is moderately indirect for a period after incident.

Poor

Very indirect route available or may be unavailable immediately after incident.

N/A (Not Applicable).

Where a hazard has been judged not to have a significant bearing on the escape route.

The pool fire scenarios analysed for platform P main deck indicate that the chances of

escape on this deck to the control room are poor. For torch fire scenarios on the main deck, the accessibility of the control room is dependent upon the torch direction. Generally, the chances of escape to the control room for scenarios on the main deck are poor to moderate.

Pool and torch fires highlight problems where access to and from the control room is impossible due to heat flux levels. An action that received further investigation was that a door positioned in the North wall of the control room, would provide alternative access for mustering if circumstances required.

An option available to personnel could be to cross a bridge to an adjacent platform, in this sample multi-jacket platform.

The accessibility of the five escape routes off the cellar deck to the control room is highly dependent upon the torch direction. The torch fire scenarios indicate a poor chance of escape to the control room from platform P cellar deck.

For multi-jacket installations the option to leave the platform where the fire occurs, across a bridge is a preferred option. The option is most valuable when a TSR exists on a dedicated separate accommodation platform or where an open space can be utilised as a safe refuge and hence meet the criteria for TSR standards set by the regulator in their draft safety case regulations.

Table 5 details results for three scenarios, A, B and C, and shows an analysis table format that was found to be useful. These thorough analyses were checked by personnel offshore, to confirm their practical applications.

Figures 1 and 2 complement Table 5, illustrating the selected fire locations and the most affected escape routes, for a production platform, main and cellar deck. An arrow shows the location and direction of a selected torch fire; and a shaded circle indicates the source of a 5-metre pool fire (eg diesel storage to the North and West of the Main deck). Typical heat flux contours are included at sample hazard locations.

HAZARD	ROUTES		REMARKS
	CLOSED	ALTERNATIVE	
(A) 5 m pool fire at diesel storage tank	South and West entrances to control room	None	Control room inaccessible North and South stairways down to cellar deck available, then on to P/D bridge Fire/smoke emanating from pool could make P/T bridge inaccessible
(B) 5 m pool fire at glycol storage tank (now converted to diesel tank)	South and West entrances to control room South stairway off main deck to cellar deck	None	North stairway off main deck to cellar deck available onto P/D bridge Control room inaccessible
(C) Horizontal torch fire emanating North from inlet separators	South and West entrances to control room	None	Control room inaccessible North and South stairways down to cellar deck available, then on to P/D bridge Control room inaccessible

Table 5: Escape Routes on Sample Production Platform P, Main Deck to Control Room, for Scenarios A, B and C

Later quantification showed that, although these incidents could occur and could affect escape routes, the frequencies of these events is relatively low. In particular the pool fires on the main deck were judged not to lead to a major hazard.

Similar detailed analysis was done for the routes from the muster station.

Throughout the analysis, where a "poor" availability was indicated, then a conclusion was raised for further consideration. For example, conclusions were made in certain cases to show that an extra door in an accommodation module would lead to a more direct escape route to a TEMPSC or helideck, that was less exposed to heat radiation from a potential fire.

This sample production platform and the sample results are hypothetical, though they are typical examples based on the E & R Reports. In specific installations, remedial actions have been implemented to improve the availability of escape routes.

A further aspect of the preliminary analysis was the integrity and suitability of the potential TSR, (or TSRs). A first review was made of the following factors, to be studied further in the detailed Safety Case work:

- Location and escape to and from, (as discussed above)
- Fire rating and blastwall protection
- Ventilation facilities (gas/smoke detection and damper shutdown)
- Control facilities, for emergency monitoring and some emergency control (eg shutdown or blowdown)
- Power supplies with alternatives
- Communication, on and off installation.

6. GENERAL CONCLUSIONS FROM E E & R ANALYSIS

In this paper only a brief review can be given of the resulting conclusions from 18 installations.

To manage the responses to the preliminary conclusions, there had to be consistency throughout Amoco installations.

The conclusions were classified and grouped systematically into three priority classes; they were given a simple code NXY-n, where:

N is the priority:

- 1 = Impediment to safe E E & R
- 2 = Cullen recommendation
- 3 = Risk reduction - Medium priority

X is the conclusion area:

- P = Procedural/policy change
- H = Hardware/equipment change

Y is the conclusion type:

- I = In depth investigation
- C = Change (or install) procedure or hardware.

n is a sequential number, assigned in the order in which the related subject appears in the main body of the EE&R report.

The results of the analysis were presented to give a balanced report, including both positive and negative conclusions. There was found to be a high compliance with a checklist of forty recommendations for effective E E & R.

A cross-reference to Lord Cullen Recommendations was made in each conclusion, if appropriate.

Table 1 also showed where there is good coverage for TEMPSCs, life rafts and life jackets, as well as a need for investigating the distribution of smoke hoods around an installation.

General Conclusions

It was found useful to identify a set of general conclusions which were applicable to all or most of the 18 installations. The majority of conclusions from the E E & R analyses could be included in this set. The main subject headings for these general conclusions are summarised as follows:

- (A) Procedural Conclusions
 - Pre Offshore Emergency Training Guidelines
 - OIM Special Training and Selection Criteria
 - Offshore Emergency Procedures Manual
 - Station Bill/Presentation of Information
 - Emergency Signage and Route Information
 - Variety of Alarms.
- (B) Personal Survival and Escape Equipment
 - Additional Sets of Survival Suits, Smoke Hoods etc
 - Escape Devices - Inertia controlled descent
 - Transmitters/Detectors on Life Jackets.
- (C) Muster Point or TSR Integrity; Escape Routes and Embarkation Points
 - Choice of Potential TSRs, Integrity
 - Fire Rating of Potential TSR
 - Protection of Escape Routes, to and from Muster Points
 - Protection of Embarkation Points
 - Smoke and Gas Detectors in Accommodation or Control Room Ventilation Systems, including Fire Dampers and Shut Down Systems
 - Power Supplies to Alarms, Communication Systems.

The Way Forward

These preliminary conclusions were accepted by the OIMs and onshore field management, leading to appropriate responses. Further quantitative work in the safety case checked the preliminary E E & R conclusions outlined in this paper, in order to establish their importance and priority for further action.

Some examples are now given of remedial actions that have been taken already by Amoco in 1992, following the E E & R studies.

(A) Procedural Actions

Review and revision is ongoing for emergency signage and presentation of emergency information (eg on Station Bills). A well documented Safety Management System is in place and is self-audited by Amoco.

(B) Personal Survival and Escape Equipment

Provision of additional equipment in strategic locations on each installation (eg smoke hoods). Inertia controlled descent sets have been installed to add to the knotted ropes, for aiding access to the sea. This is most helpful where there is no spider deck for

access to the sea (ie barge platforms). More life jackets have been installed near specific TEMPSC.

(C) Primary Muster Point

Analysis has shown that certain muster points (eg a control room), are less suitable, because major hazard scenarios could threaten their integrity. Emergency procedures have therefore been changed for a specific control room which is no longer a primary muster point. Now, personnel would go to a safer temporary refuge, usually in an accommodation module. In some cases, there is a separate jacket for the accommodation, separated by a 50 metre bridge from a process platform. Installation of an extra door in a sheltered face of the accommodation block is an action which enhances the escape route to a means of evacuation (eg helideck or TEMPSC).

Many actions are under review, in light of the safety case activities and enhanced safety management systems, with a key role being played by Offshore Installation Managers. These studies and follow-up actions have involved increased involvement of the workforce.

The **consistent** approach in this study and the unified presentation of information and conclusions are assisting Amoco to manage safety and to plan actions in a **consistent** way, across 18 diverse types of gas and oil installations.

7. ACKNOWLEDGEMENTS

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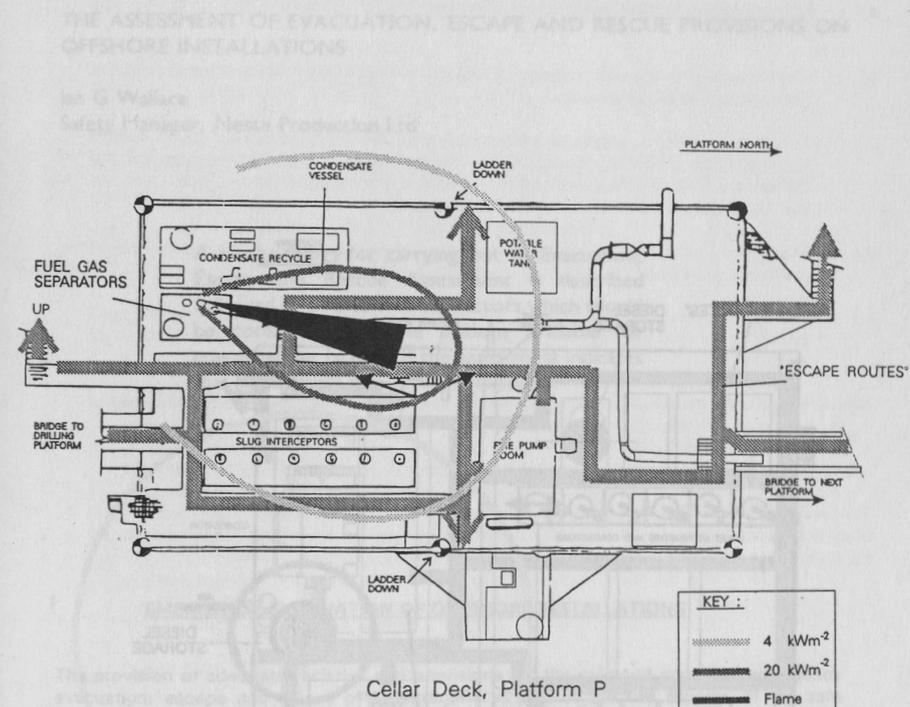


Figure 1 Example of Potential Hazard : Torch Fire Location With Thermal Flux Contours

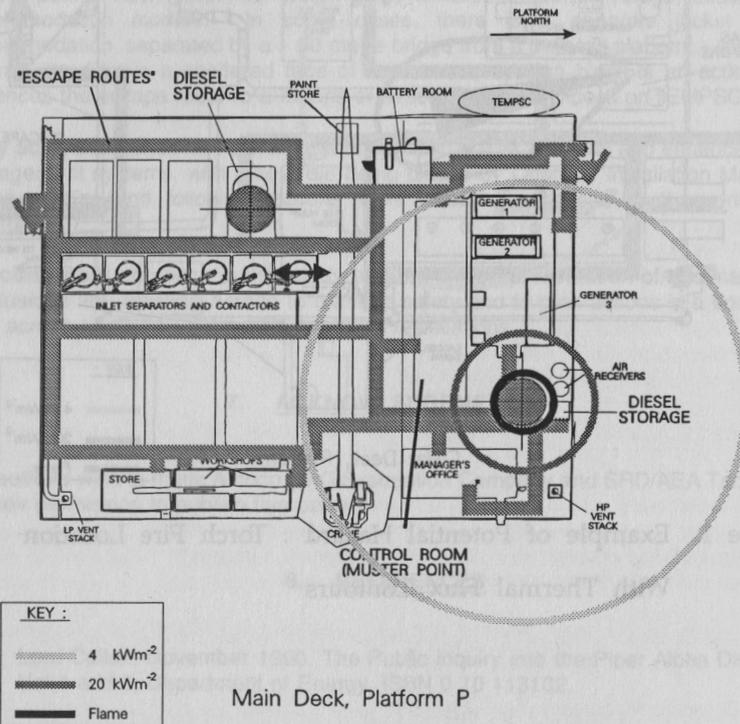


Figure 2 Example of Potential Hazard : Pool Fire Locations With Thermal Flux Contours

THE ASSESSMENT OF EVACUATION, ESCAPE AND RESCUE PROVISIONS ON OFFSHORE INSTALLATIONS

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A methodology for carrying out an Evacuation, Escape and Rescue Assessment is described followed by a review of the factors which should be considered and the options available for upgrading the facilities if the assessment indicates that the success rate is not acceptable.

EMERGENCY EVACUATION OF OFFSHORE INSTALLATIONS

The provision of adequate facilities and provisions for the safe and complete emergency evacuation, escape and rescue of all personnel is one of the key aspects of the safe operation of an offshore installation. This was recognised by Lord Cullen during the public inquiry into the Piper Alpha disaster. In fact, he considered it sufficiently important to include as one of his four recommendations requiring studies to be carried out forthwith without waiting for any change in legislation. The Inquiry Report (reference 1) contains the following as recommendation 76.

- 76. The regulatory body should ask operators which have not already done so to undertake a evacuation, escape and rescue analysis forthwith, without waiting for legislation. The timetable for completion of this analysis should be agreed between the regulatory body and the industry but should not exceed a total of 12 months, and that only for operators of a large number of installations (para 20.9).

EVACUATION, ESCAPE AND RESCUE ASSESSMENT

In the Inquiry Report Lord Cullen recommends that the assessment of Evacuation, Escape and Rescue (EE&R) provisions should be an integral part of the installations Safety Case (see Recommendation 4 (7)). He also suggests that the analysis should specify the facilities and other arrangements which would be available for the evacuation, escape and rescue of personnel in the event of an emergency which makes it necessary or advisable in the interests of safety for personnel to leave the installation (para 20.9).

In particular the analysis should specify:-