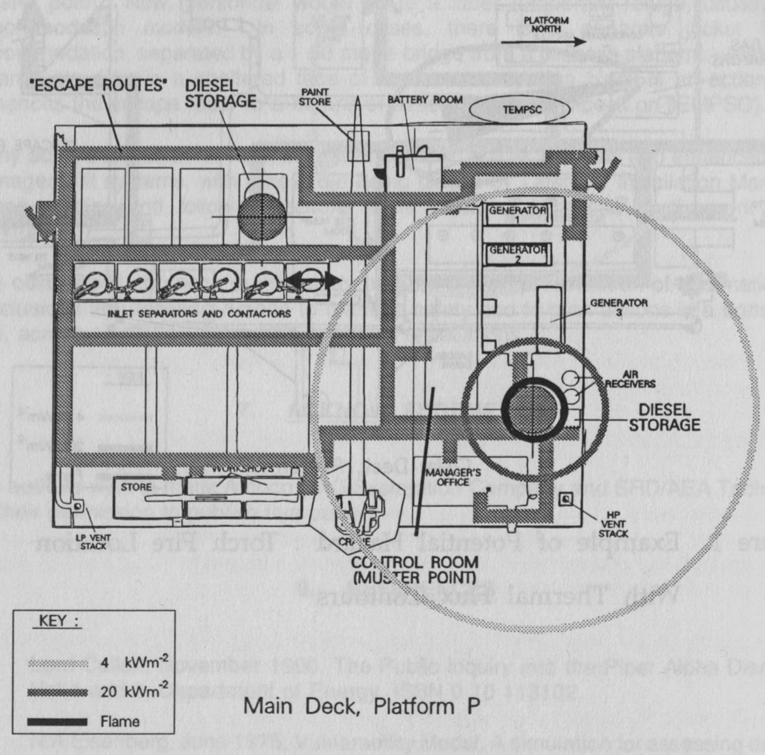

Main Deck, Platform P

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:-

(i) The formal command structure for the control of an emergency affecting the installation;

(ii) The likely availability and capacity of helicopters, whether-in-field or otherwise, for the evacuation of personnel;

(iii) The types, numbers, locations and accessibility of totally enclosed motor propelled survival craft (TEMPSC) available for the evacuation of personnel from (a) the Temporary Refuge (TR) and (b) other parts of the installation from which access to the Temporary Refuge is not readily available;

(iv) The types, numbers, and locations of life rafts and other facilities provided as means of escape to the sea;

(v) The specification (including speed, sea capability and accommodation), location and functions of the standby vessel and other vessels available for the rescue of personnel;

(vi) The types, numbers, locations and availability of fast rescue craft, whether stationed on the installation or on the standby or other vessels; and

(vii) The types, numbers and locations of personal survival and escape equipment

The report also contains many other recommendations relating to EE&R and which it is important to bear in mind when carrying out the assessment including Recommendations 55 to 61, 77 to 104.

METHODOLOGY FOR CARRYING OUT AN EVACUATION, ESCAPE & RESCUE ANALYSIS

A. New Facilities

There are a lot of possible reasons for evacuating an offshore installation including;

- a blowout
- loss of containment of a riser or subsea pipeline
- loss of containment in the process facilities
- fire in the accommodation module
- impending or actual ship collision
- helicopter collision
- extreme weather
- earthquake

Some of these causes could result in fire on or under the installation and/or explosion. In each case the resulted damage and/or the duration and severity of the event may or may be likely to interfere with the emergency life support facilities on the installation to such an extent that the Offshore Installation Manager considers it prudent to evacuate the facility. It is also possible that the incident is so severe and disastrous that it is obvious to all personnel that there is no choice but escape by the only choice available to him/her. In this case personnel must make use of the evacuation and escape facilities immediately available to them without waiting for instructions.

Perhaps I should define what I mean by some of these terms.

Precautionary Evacuation	:	a planned and controlled removal of personnel from the facility
Evacuation	:	The controlled removal of personnel from a facility by TEMPSC or a dry evacuation route to a ship
Escape	:	The uncontrolled departure of personnel from a facility by liferaft or into the sea
Rescue	:	Recovery of personnel from TEMPSC, liferaft or the sea to a safe location

Figure 1 shows the steps which should be given considered when carrying out an assessment of the EE&R facilities needed for a new facility. The rest of this paper discusses the detail of the assessment of various EE&R facilities and recent developments and the results of research to improve the success rate.

B. Existing Facilities

The assessment of existing facilities is very similar to assessing new facilities except that you have to start by establishing exactly what you have currently available (see fig 2).

C. Establishing the Scenarios

The Fire & Explosion Risk Analysis carried out as part of the generation of a Safety Case will of course highlight a number of the scenarios to be considered when carrying out an evacuation, escape and rescue assessment. But fire and explosion are only two of the possible disastrous scenarios which can develop on an offshore installation. The introduction to this paper listed some other possible occurrences. At the start of any EE&R assessment it is essential to establish the scenarios which are being considered and then to develop their implications including frequency of occurrence, scale and duration, and likely consequences.

Temporary Refuge

The assessment of the Temporary Refuge (TR) is a separate operation from the EE&R assessment, however, it looks at the endurance time required for TR during which all life support and emergency control facilities must continue to function and involves a Quantified Risk Assessment of likelihood of the integrity of the TR being breached. However, other aspects of evacuation do involve the TR and hence it must be included in the EE&R assessment.

The aspects which must be considered include;

1. How notification of the emergency is made to all personnel on the facility and how secure this system is in all the emergency scenarios

2. The mustering of all personnel to the TR must be examined to ensure that it is effective and speedy

3. When the decision is made to evacuate the facility escape routes to the helideck, the TEMPSC and the means of escape to the sea must be passable. The assessment of this involves a review of the impact of each scenario on these routes and confirmation that personnel will be able to utilise at least one route from the TR to each of them. Factors to be considered include physical damage to the route, thermal radiation limitations, smoke logging, missile hazards and toxic gas levels.

   Facilities which could provide mitigation for these include:

   1. Multiplicity of routes
   2. Physical protection of routes by radiation and/or missile shields
   3. Provision of water spray protection, low level self powered lights and signs, etc
   4. Personal survival kit such as fireproof clothes, smoke hoods, torches, etc.

   Where there is doubt about the adequacy of the mustering and/or escape routes it may be necessary to consider the use of computer modelling techniques. This involves developing a computer model of the facility, definition of the distribution of personnel and then the simulation of the personnel moving round the network of routes and assessing the time required to achieve a full muster or use of the relevant evacuation or escape facility. The effects of bunching of personnel and blockage of routes must be modelled and it is essential that the programme does not utilise the optimum choices because people are not like that and they will make mistakes and on occasion use the poorest choice or even attempt to use an obstructed route leading to overuse of some routes or longer transit times than necessary. A fuller discussion of this aspect is given in references 2 and 3.

Helicopter Evacuation

The preferred choice for an evacuation of an installation, assuming a bridge to an adjacent facility is not available, is by helicopter. To assess the capability of this evacuation route it is necessary to consider;

a) what field helicopter coverage is available throughout the 24 hours on each day of the week?

b) what commercial helicopter traffic is available and when?

c) is there an offshore based helicopter within range, if so what is its availability and response time?

d) what is the shore based civil helicopter availability and response time?

e) what is the response time for the civil and military Search and Rescue (SAR) helicopters?

However, the availability of helicopters is only one aspect of this assessment, other factors include;

a) what receptor facilities are available for evacuated personnel and what is the range.

b) what helicopter refuelling capabilities are available?

These factors must be considered to allow a realistic calculation to be made of the rate of personnel transfers achievable. References 3 and 4 discuss this calculation and the limitations on helicopter evacuation. In addition some computer programmes (see reference 5) which model helicopter evacuation are available. In addition to these factors governing helicopter availability, limitations in helicopter operations such as fog, icing and storms, must be considered.

TEMPSC and Other Methods of Dry Evacuation

Work by the Dept of Energy Emergency Evacuation Steering Committee established a number of years ago that the chances of successful evacuation by TEMPSC varied significantly with the weather conditions. The limitations are due to:

1. Wind induced motion causing the TEMPSC to collide with the structure during lowering.

2. Failure of the falls to release.

3. Waves washing the TEMPSC back into the platform structure before headway is achieved.

Because of these factors the Steering Committee has encouraged the development of enhanced means of launching TEMPSC and other dry evacuating systems. These include:

1. Free fall lifeboats
2. Preferred Orientation and Displacement Unit (PROD) which uses a boom and tag line to stabilise the descent, point the craft away from the platform and provide initial velocity.
3. Seascape which uses an A-frame to lower the craft into the water over 50 ft away from the platform.
4. Davit launched liferaft (special unit) on to deck of a dynamically positioned supply boat.

In addition, some other devices have been considered but still require major development effort before viability could be proven.

The UK Offshore Operators' Association commissioned a study of ways of upgrading the TEMPSC provision on a hypothetical existing production platform. This study gives the results shown in Table 2.

TABLE 2: EFFECTS OF LIFEBOAT UPGRADE OPTIONS

Lifeboat Upgrade Option	Risk Reduction %	Cost Benefit
1. Larger boats	9.4	4.62
2. More boats near existing ones	10.2	1.49
3. More boats near accommodation	13.0	1.41
4. Relocation	3.5	11.30
5. Reorientation	8.9	3.43
6. Protected boarding	35.2	1.12
7. Improved Procedures and training	33.9	2.58

These risk reductions have been set against the costs involved in each option, based on data supplied by UKOOA members. These results are included in Table 2, expressed as costs per statistical fatality averted. Compared to a commonly expressed view that an appropriate value of life for decision making on risk reduction measures is in the region of £2m, the following measures would be regarded as reasonably practicable or nearly so:

- Additional lifeboats up to 200% of Personnel On Board (POB) (Options 2 and 3)
- Protected boarding (Option 6)
- Improved procedures and training (Option 7)

These conclusions are highly sensitive to several aspects of the design of the representative platform, so it is concluded that analyses should be conducted for a specific platform before drawing firm conclusions about the options.

The Emergency Evacuation Steering Committee also looked at ways of improving the design of TEMPSC to improve the chance of successful evacuation and made the following recommendations (see reference 6);

1. Install effective internal lighting in TEMPSC
2. Electric start arrangements for the engine should be encouraged.
3. The interior of the TEMPSC should be kept warm and dry to avoid the adverse effects of condensation, whilst stored in the davits.
4. The coxswain's seat should be such that he is comfortable and is well-supported, and that he has good all-round horizontal visibility and be able to see the falls' wires. He should be able to see inside the boat. The boat's consul and controls should be ergonomically designed. The compass should be mounted directly in front of the coxswain, and not too far below his horizontal field of vision.
5. A secure body harness and some form of head protection is required at every passenger place.
6. Suitable handholds should be provided within the craft to aid personnel movement.

There remains a big question mark about how long personnel can safely stay in a TEMPSC. Reference 6 contains the following recommendations for improving the situation inside the TEMPSC.

1. Effective means for replenishing lost body fluids, and thus reducing dehydration, are required. Suitable water containers should be provided for each seating position.
2. Noise insulation should be installed around the engine box.
3. Arrangements are required which allow the sea anchor to be deployed from within the craft without putting personnel at risk from falling overboard. It is necessary that the sea anchor can be detached from inside the boat.
4. Arrangements are required to prevent engine and exhaust fumes escaping within the TEMPSC, including a requirement that the exhaust system should be installed clear of the bilges.
5. A central gully should be incorporated into the bottom of the boat leading to a sump which can be pumped out. A washrail system should be provided with two flexible hoses to enable the washing down of the boat or fouled clothing. This facility would require suitable pumping arrangements.
6. A system of improving the ventilation of the boat is required. A 'Dorade box' would assist in satisfying this requirement.
7. Further work is required to identify a realistic policy with respect to wearing immersion suits in TEMPSC and to provide suitable design features within the TEMPSC to reduce the thermal stress to the wearer.

Rescue from TEMPSC

Of course it will be necessary at some stage to recover the personnel from the TEMPSC. Trials in Canada have shown that it is possible to fit an 'A' frame to a TEMPSC allowing it to be picked up fully loaded by a suitable crane. The same trials also indicated that it was possible to safely tow TEMPSC provided suitable facilities are fitted to the TEMPSC (see reference 7). The Evacuation Steering Committee commissioned trials to find improved methods of recovering personnel from TEMPSC by helicopters (see reference 8). The trials showed the necessity of suitable hatches to aid helicopter winching. There should either be a top hatch and no cable snagging points on the roof of the canopy or better still, the craft should have an open protected cockpit at the rear.

The trials reported in reference 6 also recommended that the preferred method of recovering personnel from a TEMPSC was by Fast Rescue Craft (FRC shuttling to a rescue vessel). The use of FRC is greatly simplified in rough weather by the creation of a suitable lee for the TEMPSC and FRC. Trials carried out by the Emergency Evacuation Steering Committee have demonstrated that it is possible to create a much larger lee by driving a vessel, preferably a large supply boat, in circles round the TEMPSC. The diameter of the circle and the speed of the vessel are governed by weather. The only limit on this technique appears to be the ability of the circling vessel to stand up to the punishment meted out by the sea (see reference 8). The results of this work have been written up in the form of advice to ships masters and issued to the industry for distribution to the supply and standby vessels.

Of course, it is necessary to find the TEMPSC. Recommendations contained in reference 6 include;

1. Marine VHF radio sets should be provided in TEMPSC, suitably rated for the harsh environmental atmosphere. This would encourage the development of more reliable 'weatherproof' VHF sets.

   A quick flashing white light is required on the canopy of TEMPSC. The light should be self contained, ie, with its own power source, and controlled from inside the boat by an on-off switch.

Escape to the Sea

In my opinion there is a need for two different types of escape to sea facilities, catering for very different circumstances.

1. At any time during an emergency the situation could deteriorate catastrophically so that it is essential for all personnel remaining on an installation to escape immediately to the sea. These devices have to be suitable for use by large numbers of personnel and be located at easily accessible and clearly defined locations.

2. The emergency response team who are trying to contain the emergency may have to abandon the installation from any location and hence devices suitable for their use must be portable and able to be used from any height.

   The range of multiple use devices include:

   Davit Launched Liferaft
   Fixed Stairs

   Ladders on the Legs
   Folding Stairs
   Net escape chute
   Controlled rate descending rope type of device
   Knotted rope and scramble net

   In addition, a fire resistant tubular chute is under development. The only single use devices available at present are all based on abseiling devices.

   When selecting escape to the sea devices I recommend a mix of types being chosen on the basis of an evaluation of each possible device against the specific installation, scenarios and location considering the following aspects;

   Training requirements
   Location limitations
   Vulnerability to damage
   Vulnerability of personnel during use
   Transfer rate
   Effort required for use
   Maintenance requirements
   Suitability for use by injured personnel
   Compatibility for use with survival clothing

Survival in the Sea

To help the person to survive the initial immersion and their prolonged exposure to the sea, it is necessary to provide:

1. A system to permit breathing until the persons airway is clear of the water.
2. A buoyancy system which will support the person in the optimum position, if necessary, turn him face up quickly and maintain his airway clear of the sea.
3. A body heat retention system to prevent drop of body temperature and the onset of hypothermia.
4. A built in recovery system which will allow the survivor to be recovered without imposing undue stress on his system (reference 6).
5. Facilities to assist in locating the survivor such as strobe lights and reflective strips.

Radio or radar enhancing reflection devices are currently being developed.

Recovery from the Sea

The rescue facilities will take time to be mobilised and reach the site of the incident. The survivors then have to be located and recovered from the sea. If hypothermia personnel are lifted in a vertical position drainage of the blood to the legs can cause death. Facilities currently available to lift personnel out of the sea in a horizontal position onto a large vessel include:

1. A device with specially spaced rings that lock into position to prevent squeezing of the body when lifting a horizontal body.

2. A rescue net basket which is deployed over the side of the rescue vessel.

The only alternative is use of a Fast Rescue Craft.

Having recovered the survivor it is essential to treat him properly to ensure that recovery is sustained and post immersion shock does not cause death (see reference 10 and 11).

Human Factors

One of the most important aspects of evacuation which has received scant attention until recently is Human Factors. Human behaviour under the stress involved in major emergencies is obviously extremely important when providing facilities and systems to cope with the situation. Unfortunately not a lot of research work has been carried out on this topic and little guidance is available to designers and managers.

In an emergency many people consider that "panic" or irrational behaviour is the cause of many people acting in the incorrect manner and contributory to injury and death. In fact, studies of a number of recent incidents such as Kings Cross (see Ref 18) have indicated that the errors made were not due to panic but rational if inappropriate decisions which were made because of a vareity of reasons including:

Ambiguity and confusion
Incoherent instructions
Time wasting actions
Lack of appropriate instructions
Misunderstanding of the nature of the emergency
Lack of acceptance of the authority of a source of instructions

In practice people behave socially and make decisions remarkably close to those that can be seen in ordinary daily behaviour. This suggests that training of management, a recognised and accepted chain of command and the pre-planning carried out to deal with emergencies, are critical to effective emergency evacuation and escape.

A paper by P Fitzgerald et al (reference 12) which I have come across deals with behaviour in emergency situations and recommends that the following issues which must be considered;

Human Behaviour Issues

* Provision of information about the incident upon which escape actions can be based.
* Clear definition of command structure so that no matter who is removed it is always clear who will step into breach.
* Strong leadership and guidance.
* Clear definitions of actions in event of alarms and of alternative actions if no alarms are given. (Simple summary cards to be included in survival packs).
* Fear of use / reticence to use will influence the effectiveness of chutes, controlled descent devices, etc. The number of chutes provided must consider this. Strong leadership will ease the situation, as it has been shown that people tend to do exactly what they are told by recognised "officials" under emergencies.

* Adequate medical training.
* Drills to be at non-fixed times and with variation of incident, evacuation methods, etc. Key personnel training to include table top exercises. If practicable carry out annual full test of evacuation to completion.
* The inclusion of "injured" personnel, blocked routes, unavailable muster points, communication disruptions etc in the drill and the donning of smoke hoods.

Ergonomics Issues

* Information provision - blast protected PA systems and/or telephone systems, greater availability of two-way radios, perhaps individual radio receivers in personal survival packs.
* Emergency lighting of proven effectiveness, perhaps with illuminated arrows on evacuation routes.
* Width of walkways, lifeboat entrance doors, etc to be adequate to ensure desired flow rates.
* The ease of use of evacuation methods, the number of actions required for implementation must be minimised and simplified. Instructions must be clear and concise, preferably of pictorial type.
* The use of simple diagrammatic instructions. Visual (and perhaps audible) attraction to chutes and lifeboats, etc when the abandon platform alarm is sounded.
* Testing of all alarms and evacuation system design to meet ergonomic considerations.

The training required by personnel to cope with emergencies are defined in references 13 and 14. But it is also necessary to have an adequate emergency management organisation and response plan which is prepared and rehearsed (see reference 15).

Having hopefully contained and dealt with the emergency the problems are not over. The aftermath of an emergency can continue for a long time due to the psychosocial effects. The only way to reduce the impact of these effects on the organisation is to manage them just like any other aspect of the company operations and activities. The effects of high stress during the emergency are listed in Table 3 and post emergency in Table 4 (see reference 16).

TABLE 3

ACUTE REACTIONS REPORTED UNDER HIGH STRESS

	REACTIONS
Perceptual	Impaired ability to sense complex stimuli
	Blockages of Senses
	Tunnel Vission
Emotional	Fear and anxiety
	Psychic numbing
	Depression
	Aggression
	Strengthened sense of
	- Attachment
	- Community
	Shock
Cognitive	Denial
	Time perception distorted
	Confusion
	Reduced sense of danger
	Helplessness
	Hopelessness
	Disorientation
	Impaired Decision Making
	Reduced:
	- concentration
	- short-term and long term memory
	- mental fluency
	- aspiration
Psycho-Physiological Activation	Nausea
	Tremor
	Adequate (10-30%)
	Light Apathy (30-75%)
	Panic (1-3%)
	Inadequate:
	- overreaction
	- underreaction
	Performance impairment
	Psychotic reactions

TABLE 4

LATE REACTIONS REPORTED AFTER HIGH STRESS

	REACTIONS
Emotional	Anxiety
	Phobia
	Depression
	Aggression
	Grief
	Lower job satisfaction
Cognitive	Reexperiencing the event
	Flashbacks
	Thought stopping
	Difficulty in concentration
	Guilt
	Hopelessness
	Impaired memory
	Psycho-physiological Tonic activation
	Startle reactions
	Hyperactivity
Behaviourial	Need for talking about experiences
	Social withdrawal
	Numbing
	Higher sick leaves
Others	Insomnia
	Nightmares
	Change in life values
	Impaired Health
	Higher death rate
	Psychosomatic Behaviourial problems/diseases

Putting It all Together

Once the various studies have been carried out possibly using the evacuation assessment checklist described in reference 17, a matrix can be put together listing for each scenario the speed of development, its duration and whether evacuation is likely. Then show the availability of escape routes from the TSR, gangway to another installation, helideck and rate of helicopter evacuation, TEMPSC (individually), liferafts (individually), means of escape to the sea (multiple use and individual use) and the likely number of rescued personnel. If this result is not acceptable a further cycle of improvements is necessary until the chance of successful evacuation and escape to a safe location is satisfactory.

References

1. The Public Inquiry into the Piper Alpha disaster by Lord Cullen. HMSO 1990.

2. A Methodology for comparing offshore installation evacuation methods by F J Dugan and S P Whalley - Offshore Operations Post Piper Alpha, Institute of Marine Engineers Conference, February 1991.

3. The Determination of Evacuation Success by Integrated Risk Assessment by R H Jones, C J Head, K J Lewis, IBC Workshop, October 1996.

4. The Use of Helicopters in the Evacuation of Offshore Platforms in the North Sea by M C Ginn, at SPE Conference, The Hague, November 19912.

5. Options for Evacuation Offshore Installations by DH Robertson at the Contingency Planning for the Offshore Industry Conference, Aberdeen, May 1989.

6. Current Developments in Evacuation & Escape by W Ballingall at IIR Conference. The latest developments in Safe Escape, Evacuation and Rescue for Offshore Installations, Aberdeen, February 1992.

7. Canadian Initiatives to Improve Offshore Safety by SD Gill at the Contingency Planning for the Offshore Industry Conference, Aberdeen, May 1989.

8. Provision of a Lee for TEMPSC to be published by HMSO.

9. The Initial Responses to Cold Water Immersion in Man by MJ Tipton in Chemical Science, 77: 581-688 updated in Human Initial Responses to Immersion in Cold Water at Three Temperatures and after Hyperventilation by MJ Tipton, DA Stubbs and DH Elliot in American Physiological Society 1991.

10. Immersion and Drowning by Dr P Wilinshurst in Coastguard Magazine, July 1991.

11. Film on Cold Water Casualty by Inst of Naval Medicine

12. A Human Factors Approach to the Effective Design of Evacuation Systems by F P Fitgerald, MD Green, J Pennington and AJ Smith., WS Atkins Engineering Services Ltd.

13. Guidelines for Offshore Emergency Training by UK Offshore Operators' Association, 1991.

14. Guidelines for Offshore Emergency Drills and Exercises by UK Offshore Operators' Associates, 1991.

15. Emergency Management in Oil and Gas Exploration by I Heidelbrink and P Bockholts at SPE Conference, The Hague, November 1991.

16. Organisation of Psychosocial Disaster management in an Exploration and Production Company by E L Lovas and J A Leitas at SPE Conference, The Hague, November, 1991.

17. The Evacuation of Offshore Installations by I G Wallace in the Safety and Health Practitioner, May 1991.

18. Fire and Human Behavior edited by D Cantor, D Fulton Publishers.

Figure 1

E E & R ASSESSMENT FOR NEW FACILITY

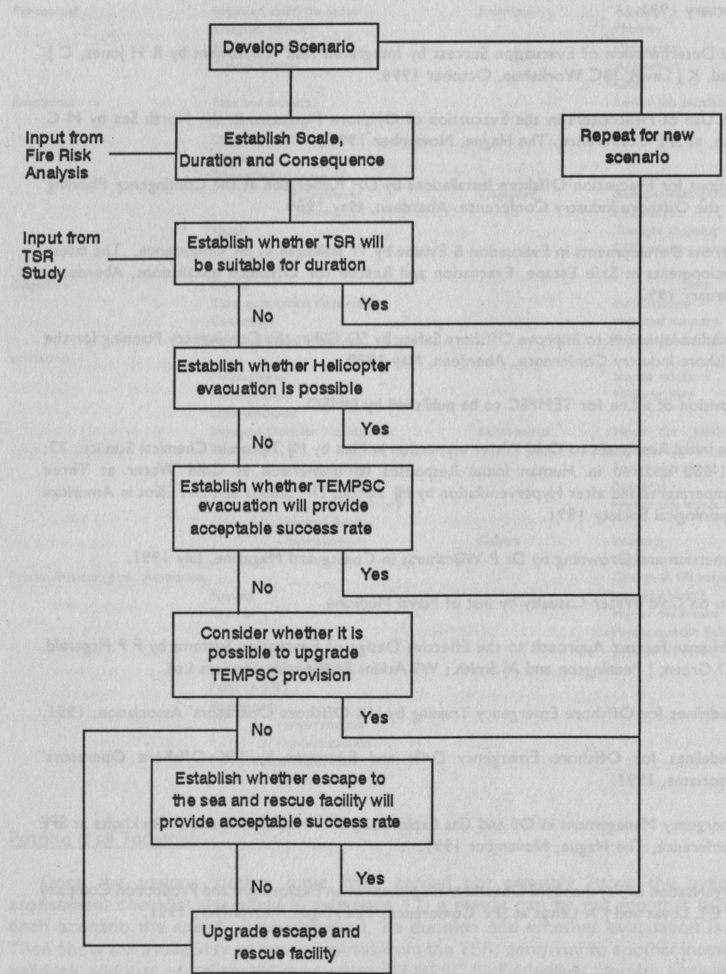

Figure 2

E E & R ASSESSMENT EXISTING FACILITY