MANUAL

DESIGN OF OFFSHORE TEMPORARY REFUGES

DEP 37.17.10.11-Gen.

March 1994

DESIGN AND ENGINEERING PRACTICE

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

PREFACE

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1. INTRODUCTION

1.1 SCOPE

This new DEP provides requirements and guidelines for the design and performance of an offshore Temporary Refuge (TR) and the associated means of escape and evacuation. This DEP defines the objective of the TR and the associated means of escape and evacuation. It describes the concept of the TR and the systems and subsystems which comprise the TR and their acceptance criteria. Guidance on how to meet the objectives is also given.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIPM, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company and to Contractors nominated by them (i.e. the distribution code is 'C' as described in DEP 00.00.05.05-Gen.).

This DEP is intended for use in offshore oil and gas exploration and production facilities:

- new and existing;
- manned and not normally manned; and
- fixed and mobile.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Acceptance criteria - requirements against which the fulfilment of an objective can be measured.

Command structure - the organisation that is provided to control an emergency.

Complex - a series of two or more bridge-linked offshore Installations.

Control point - main installation control and monitoring facility.

Emergency control point - a location providing those control, monitoring, coordination and communication functions necessary for responding to an emergency.

Endurance period - the period of time for which the relevant conditions of integrity shall be maintained.

Escape route - a route to a TR from any area of the installation that is likely to be occupied.

Evacuation route - a route from the TR leading to an embarkation point from which personnel can depart from the installation.

Installation - a fixed or mobile facility engaged in offshore oil and gas exploration or production activities.

Living quarters - permanently enclosed spaces such as cabins, dining rooms, galleys, recreation rooms, sick-bay, offices, change rooms, ablution areas and similar spaces used for the accommodation and welfare of personnel.

Manned installation - an installation which is continuously occupied by persons accommodated and living thereon.

Mobile installation - an installation which can be moved from place to place without major dismantling or modification, whether or not it has its own motive power.

Muster station - an area where personnel gather in response to instructions or change in the installation safety status.

Offshore installation manager - the person in charge of an offshore installation.

Persons on board - the number of permanent and temporary personnel on an installation at any one time.

NOTE: Temporary personnel who are accommodated on a gangway-connected mobile unit do not need to be included, so long as it is established that they are able to rejoin the mobile unit through the gangway under all incident scenarios. Such personnel would in this case muster on the mobile unit.

Temporary refuge - a place or places where personnel will be adequately protected from relevant hazards while they remain on an installation following a major incident, and from where they will have access to the communications, monitoring and control equipment necessary to ensure their personal safety, and from where, if necessary, safe and complete evacuation can be effected.

1.4 ABBREVIATIONS

ALARP	-	As low as reasonably practicable
BOP	-	Blowout preventer
ECP	-	Emergency control point
ERP	-	Emergency radio point
ESD	-	Emergency shutdown
HVAC	-	Heating, ventilation and air conditioning
HMP	-	Hazard management process
ICRP	-	International committee for radiation protection
IDLH	-	Immediate danger to life or health
IRPA	-	Individual risk per annum
LED	-	Light emitting diode
LFL	-	Lower flammable limit
OIM	-	Offshore installation manager
PLL	-	Potential loss of life
POB	-	Persons on board
QRA	-	Quantitative risk assessment
RPE	-	Respiratory protective equipment
SPS	-	Surface process shutdown
STP	-	Standard temperature and pressure
STEL	-	Short term exposure limit
TEMPSC	-	Totally enclosed and motor propelled survival craft
TPS	-	Total platform shutdown
TR	-	Temporary refuge
WHO	-	World health organisation

1.5 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (8 and 9).

2. GENERAL REQUIREMENTS

2.1 PRIMARY OBJECTIVE

Every offshore installation should have a TR.

The objective of the TR and its associated access and evacuation routes and embarkation areas is to secure the safety of persons on board (POB) in the event of a major incident affecting the installation. The system provides a secure location to enable POB to muster and possibly "sit-out" the incident; it also provides security during escape to the TR and subsequent evacuation from the TR to the point of embarkation.

2.2 FUNCTIONAL REQUIREMENTS

The main function of the TR shall be to provide a place where the total POB can muster without undue risk and still have access to the communications, monitoring and control equipment necessary to ensure their personal safety, and from where, if necessary, safe and complete evacuation can be effected.

The functions of the escape and evacuation routes and the embarkation areas are the provision, without undue risk to POB, of:

- secure means of escape to the TR; and
- secure means for a complete evacuation from the TR.

2.3 DESIGN BASIS

The measures required to meet the objectives and acceptance criteria are installation specific and shall cover the range of major incident scenarios which are applicable to it. The HMP (6.2) should be used to identify and manage the range of major incident scenarios.

Two categories of acceptance criteria are defined. These are:

- Conditions required for integrity (5.1);
- Endurance period (5.2) - the period of time for which the conditions required for integrity shall be maintained.

The design of the TR shall be considered in relation to the overall design of the installation so as to achieve the optimum design. In particular the locations of the TR, escape and evacuation routes, embarkation points and other common facilities and utilities need to be integrated into the overall installation design.

The QRA technique should be used, particularly on manned installations, to estimate the PLL and IRPA on the installation with the objective of identifying areas of risk which can be further reduced. These areas may include the TR, the escape and evacuation routes, the points of embarkation, and the means of evacuation themselves.

Protection of the TR, escape and evacuation routes by active protection systems should only be considered where analysis has indicated a significant risk to their integrity and the necessary improvements cannot be achieved by passive means.

3. TR CONFIGURATION CONCEPTS

3.1 PRIMARY TR

The TR shall be viewed as a system rather than simply a protected space. There is no standard configuration for providing a TR. Depending on the installation and potential incident hazard scenarios, different concepts may be acceptable. Examples include an open area or a platform in a series of bridge-linked platforms.

Further to HMP (6.2) analysis, the TR may need to be distributed in several locations. One principal location will be the primary TR and shall provide all main command support functions. Other locations will form secondary TRs (3.2).

3.1.1 Living quarters as TR

On manned installations, due to the compatibility between several of their respective functions, part of or the entire living quarters may provide the basis of the provision of a TR. However, this is not the only concept and consideration should be given to other TR configurations.

3.1.2 Incident dependant variable TR

Different TR configurations may be required for different incident scenarios. This concept may be appropriate on mobile installations where the planned response to loss of buoyancy may be different from that adopted for other circumstances. This concept should be avoided unless essential.

3.1.3 Joint operations

It is acceptable and may be necessary to have different TR configurations when installations are temporarily linked in joint operations. Examples include flotels, work barges and drilling tenders alongside a fixed installation (i.e. connected by a gangway). All likely modes of operation should be identified and assessed.

3.2 SECONDARY TR

If it is demonstrated by HMP (6.2) that escape to the primary TR may not be possible from a particular area, one option is the establishment of a secondary TR.

All practical measures should be taken to avoid having to establish a secondary TR on an installation, as it will place an additional burden on TR facilities and installation management. Such measures include steps to mitigate the effects of incidents and/or the provision of alternative escape and evacuation routes.

A secondary TR should be subordinate to the main TR, with a lesser requirement for the provision of communications, monitoring and control facilities. It shall have a secure means of communication with the main TR and a means of monitoring the designated evacuation route.

Secondary TRs shall have independent means of evacuation.

3.3 CAPACITY

The primary TR shall have capacity for the POB. If access routes are available, all personnel should go to the primary TR. Individuals should not be assigned to secondary TRs prior to an incident.

NOTE: The above does not apply to joint operations (3.1.3), where personnel accommodated on the mobile unit should normally muster at the TR of the mobile unit.

Secondary TRs shall be able to accommodate all individuals potentially isolated from the primary TR as derived from the HMP analysis, plus a contingency. The contingency shall be individually determined for each case, considering the margin of error in the anticipated numbers.

3.4 TR SPACE REQUIREMENT

An evacuation strategy should be in place to address the use of the TR space during an incident, including consideration of the mustering requirement.

If personnel are gathered within the TR in groups of more than 20, then an area of 1.25 m^2 per person should be provided. This is based upon 50 percent seated and 50 percent standing, without baggage and allowing for cross-flows.

If personnel are gathered in groups of 20 or less, such as in multiple muster stations, an area of 0.8 m^2 per person should be provided. This is based upon 25 percent seated and 75 percent standing, without significant cross-flows.

These are clear areas, including loose furniture but excluding fixed furniture and fittings.

3.5 STAND ALONE/ INTEGRATED MONITORING

Where the main installation control point is not part of the primary TR, there shall be an emergency control point (ECP) located in the primary TR. Where the main installation radio room is not part of the primary TR, there shall be an emergency radio point (ERP) located in the primary TR. All the essential command support functions (5.1.3.1) shall be available in either the ECP or the ERP.

The ECP and ERP should be adjacent to each other, or integrated with each other, to facilitate effective management of incidents. The command support functions within the ECP/ERP should be secured against unauthorised use.

The HMP should identify the major incidents by which the main installation control point may be threatened and for which retreat to the TR may be necessary.

Additional command support functions may be required in the ECP or the ERP (5.1.3.1). Determination of these functions will depend on the ability of these functions to be maintained from the main installation control point following an incident.

4. SYSTEMS

The systems required to meet the primary objective of the TR (2.1) are:

- life support;
- structural support;
- command support; and
- escape and evacuation.

The acceptance criteria for the various systems are given in (5).

4.1 LIFE SUPPORT SYSTEM

The function of the life support system is to maintain an environment which is not hazardous to personnel and which maintains their ability to take rational action.

The scope and extent of the life support system will vary, from little or no specific provision (where environmental conditions are predicted to be largely unaffected) to a purpose designed enclosure incorporating specialist environmental control facilities.

4.2 STRUCTURAL SUPPORT SYSTEM

Various components of the topsides and substructure are essential for maintaining the structural integrity of the TR and the associated means of escape and evacuation. These together comprise the structural support system and include:

- TR structure, including bulkheads and decks;
- supporting structures, including bulkheads and decks;
- components providing for buoyancy, stability and station keeping (in mobile units).

Structures directly and indirectly supporting escape and evacuation routes and survival craft embarkation areas are covered as part of the escape and evacuation system.

Where applicable, the requirements for bulkheads and decks shall also apply to doors, windows, penetrations and connections.

Adjacent structures which could collapse onto and significantly damage the TR or its systems, or could obstruct escape and evacuation routes, shall also be evaluated. These may include derricks, cranes, helidecks, flares, vents, masts, and smaller structures such as walkways, stairways and platforms.

4.3 COMMAND SUPPORT SYSTEM

The command support system is the range of communications, monitoring and control functions that are provided for the management of potential incidents. Certain functions are critical in meeting the primary objective (2.1), while other functions may not be. To provide a basis to differentiate between them they have been categorised as either essential functions or additional functions.

The essential command support functions are those whose loss or impairment are deemed to constitute direct loss of integrity of the TR, escape routes, evacuation routes or points of embarkation. The essential functions are listed in (5.1.3.1). They provide communications and monitoring which shall ensure that:

- sufficient quality, quantity and range of information is available to allow necessary decisions to be taken, particularly those concerning escape and evacuation;
- an effective installation command structure (organisation) can be maintained;
- outside assistance can be requested; and
- loss of integrity of the TR, escape routes, evacuation routes, or points of embarkation, as defined by the acceptance criteria, does not occur within the required endurance periods.

The additional command support functions are those whose loss or impairment would not necessarily compromise the integrity of the TR, escape or evacuation routes, or points of embarkation but are beneficial to the effective management of all incident scenarios. The additional functions are listed in (5.1.3.2).

The secondary TRs essential command support functions shall provide:

- a means of communication with the main TR, primarily for the relay of information regarding the whereabouts and numbers of personnel unable to reach the primary TR and to receive information regarding evacuation. This is intended to assist in accounting for personnel; and
- a means of monitoring the designated evacuation route.

Further guidance on the command support system is given in EP 55000-39 (Emergency response).

4.4 ESCAPE AND EVACUATION SYSTEM

4.4.1 Means of evacuation

Based on HMP and/or legal requirements, the following means of evacuation should normally be provided on manned installations:

- Primary means of evacuation: this is the normal way of access to the installation, generally involving external assistance. Examples are helicopters in remote or environmentally hostile areas, or crew boats in other areas. When a mobile unit is connected, evacuation should normally be through the gangway connecting the unit to the installation.
- Secondary means of evacuation: this is the self supporting way to evacuate the installation, typically survival craft such as TEMPSC.
- Tertiary means (for escape): back-up systems, e.g. life rafts, personal chutes, knotted ropes, etc.

NOTE: The preferred method of installation evacuation is through the gangway to a mobile unit when available. Otherwise, helicopter is the preferred method of evacuation for most incidents. The survival craft method in general will entail a higher risk of injury to personnel during the evacuation process than evacuation by helicopter. Where conditions are favourable the maximum utilisation of the available helicopters should be pursued in any offshore evacuation. However, helicopter availability, weather and helicopter access during the type of incident for which a TR is required (e.g. an uncontrollable fire) may make helicopter evacuation less reliable than using the available survival craft.

Survival craft should be close to, or directly coupled to, the TR. Survival craft shall be distributed so that sufficient capacity for the POB is readily and safely accessible from the TR during any incident. This may require the provision of more than 100 percent capacity. Where the survival craft capacity is greater than 100 percent of POB, the same survival craft need not be utilised for all incidents. If the latter applies, secure monitoring from the TR of survival craft embarkation areas shall be maintained for the TR endurance period to allow decisions regarding availability to be taken.

The facilities should allow for evacuation of non-essential personnel first, and later evacuation of remaining personnel if control measures fail. This is particularly relevant to situations where flotels, work barges or drilling tenders are alongside, i.e. connected to the installation by a gangway.

With unmanned installations, it shall be established that personnel who are present from time to time on the installation can safely evacuate in case of emergency. Evacuation would normally be by primary means, but secondary evacuation means may be required if the primary means cannot be made available in a timely manner. Such requirement should be derived from HMP analysis.

4.4.2 Escape routes

The escape routes allow personnel to join the TR following an incident on the installation. A minimum of two routes, which are independent to the extent of being unlikely to be impaired by the same incident scenario, shall be provided between each area of the installation and the TR.

Where the provision of two alternative escape routes is clearly impractical (e.g. within the legs of concrete platforms), or the level of risk is tolerable and as low as reasonably practicable (e.g. from small or normally unoccupied areas), an area may have a single exit leading from it. Special access procedures should apply to such areas.

For bridge-linked installations, if it can be demonstrated that the bridge connections are accessible and passable under all major incident scenarios, and/or the risk to loss of bridge integrity is acceptable, a single bridge may link platforms. Two routes should nevertheless lead to such a bridge and, dependent on the likely hazards, also lead from it.

4.4.3 Evacuation routes

The evacuation routes allow personnel to travel from the TR to the points of embarkation for the purpose of platform abandonment by primary means and, if applicable, secondary means. The evacuation routes should be sized for the POB.

A minimum of two evacuation routes, which are independent to the extent of being unlikely to be impaired by the same incident scenario, shall be provided from the TR to each designated point of embarkation.

4.4.4 Common aspects

Escape and evacuation routes and points of embarkation should be open instead of enclosed. One exception to this is between the TR and survival craft embarkation areas, where the distance is short and it is assessed that the increase in expenditure for an enclosed evacuation route is justified by improvements in safety.

Where escape and evacuation routes and points of embarkation are enclosed and connected to the TR, they shall be deemed to be an integral part of the TR and the TR conditions of integrity in (5.1.1) and (5.1.2) shall apply.

Escape and evacuation routes should be at least 1.2 m wide, unless analysis shows a smaller dimension to be acceptable, taking account of maximum level of occupancy, required transfer times and casualty treatment handling.

5. ACCEPTANCE CRITERIA

The two categories of acceptance criteria are:

- conditions required for integrity;
- endurance period.

NOTE: Although risk is not specifically included as an acceptance criterion, the escape and evacuation routes, the TR, and the points of embarkation should be such that the overall risk level on the installation, in terms of PLL and IRPA, is tolerable and as low as reasonably practicable (ALARP principle).

5.1 CONDITIONS REQUIRED FOR INTEGRITY

The acceptance criteria that shall be met by each of the four systems during the endurance period are:

5.1.1 Life support

Analysis of the major incident scenarios shall determine whether and at what point normal life support related services (e.g. normal power, HVAC, etc.) will be impaired or lost. This shall be taken into account when evaluating life support endurance.

The life support acceptance criteria relate to potentially hazardous conditions for persons unprotected by special equipment or clothing. Where personnel do have such protection, the life support acceptance criteria may be redefined to reflect corresponding human limitations under the relevant restrictions (such as absolute limits for use of equipment). Any such redefinition of acceptance criteria shall be clearly substantiated.

The main threats to life support are likely to come from the incident consequences listed in (5.1.1.1) to (5.1.1.6).

5.1.1.1 Generation of smoke

The toxic products of combustion produced during a fire depend on the chemical nature of the material burning, supply of oxygen and heat. Products of combustion will also depend on the physical form of the burning material. The major toxic gas produced in any hydrocarbon fire is likely to be carbon monoxide but other gases, vapour and smoke may contribute to overall toxicity (e.g. hydrogen cyanide) and irritation (e.g. hydrogen chloride and acrolein).

Polymeric materials are the main sources of products of combustion gases other than carbon monoxide. (Appendix 1) lists the thermal decomposition products from various polymeric materials.

A computer program for smoke ingress analysis (into enclosed spaces) can be made available by SIPM.

<u>Carbon monoxide</u>

Exposure to carbon monoxide is normally assessed by measuring the percentage saturation of carboxyhaemoglobin in the blood. A blood carboxyhaemoglobin level of not more than 15% resulting from breathing carbon monoxide in air is the acceptance criterion for the endurance period. This is the level just below that which may impair the ability of persons to take rational action. WHO Criteria Document 13 (9, Bibliography Ref. 2) indicates that individuals may encounter abnormal visual response and headaches in the 16 to 20% carboxyhaemoglobin range.

Carboxyhaemoglobin levels of 60% or greater are normally fatal.

To evaluate levels of carboxyhaemoglobin over time, various factors should be taken into account. The principal factors are carbon monoxide concentration and time (the effects of carbon monoxide are cumulative over time).

As a general guide, a carboxyhaemoglobin level of 15% results from an exposure of 13,000 ppm minutes (e.g. an exposure of 1000 ppm for 13 minutes).

Equations describing the relationship between environmental carbon monoxide exposure and bodily uptake are included in (Appendix 2).

<u>Other products of combustion</u>

Where other products of combustion represent a greater risk than carbon monoxide, the acceptance criterion is that the short term exposure limit (STEL) stated in HSE EH40 for that product of combustion should not be exceeded during the endurance period.

<u>Visibility in Smoke</u>

Visibility in smoke may be a limiting factor. Remedial measures shall be provided where this may be a problem, e.g. path finding aids.

NOTE: The STEL of a component is the concentration to which workers may be exposed for a short period of time (about 15 minutes) without suffering from irritation, chronic or irreversible tissue damage, or narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduce work efficiency.

STELs are usually very much lower than IDHL concentrations, which represent the concentration to which workers may be exposed for 30 minutes without experiencing definite escape-impairing effects (e.g. severe eye irritation) or irreversible health effects.

STELs are published by the American Conference of Govermental Industrial Hygienist. IDHLs are published by the US National Institution of Occupational Safety and Health.

5.1.1.2 Generation of toxic and flammable gases

In addition to those that occur through thermal decomposition, gases associated with the production processes may be released into the atmosphere and find their way to the TR. These may be toxic and/or flammable. Hydrogen sulphide is the most likely toxic gas to be released. The acceptance criterion is that the STEL for hydrogen sulphide of 15 ppm should not be exceeded.

The acceptance criteria for other toxic gases should be such that their respective STELs are not exceeded for the endurance period.

The acceptance criteria for those gases or vapours that may be released and are flammable at concentrations below the level at which they become asphyxiant or toxic (e.g. methane, propane, ethane) is a concentration equal to or less than 60% of the LFL.

5.1.1.3 Generation of toxic fumes

Toxic fumes may be generated as a result of the effect of high temperatures on construction materials in the vicinity of or in contact with external bulkheads, decks and structure. In such cases pyrolysis is more likely to occur in which encapsulated layers of construction elements which are not exposed to air decompose thermally. In the absence of oxygen, gases other than carbon monoxide will present the greatest risk. These are listed in (Appendix 1).

Suitable methodologies and base data are not presently available to quantitatively predict toxic levels resulting from the thermal decomposition of construction materials. A qualitative assessment should therefore be made to limit as far as practical the generation of toxic fumes. This is particularly relevant to enclosed TRs.

5.1.1.4 Oxygen deficiency and carbon dioxide accumulation (enclosed TRs)

When air is not renewed (i.e. within an enclosed TR with lost ventilation), breathing will decrease the concentration of oxygen and increase and the concentration of carbon dioxide.

Muscular coordination disturbance occurs at an oxygen level below 17% v/v. The acceptance criterion is therefore a minimum internal oxygen level of 17% v/v.

At a carbon dioxide level of 20,000 ppm (2%), respiration increases. This is not harmful in itself, but will increase the effects of other toxins that may be present. The acceptance criterion for carbon dioxide accumulation is therefore a maximum carbon dioxide level of 20,000 ppm (2%).

(Appendix 3) shows how to determine the required breathable air volumes. These are determined by carbon dioxide accumulation and not oxygen deficiency.

5.1.1.5 Mixed exposure

The majority of STELs listed in HSE EH40 are for single compounds or for substances containing a common entity. In certain circumstances personnel may be subjected to a mixture of compounds, from the processes described in (5.1.1.1) to (5.1.1.4). Mixed exposures may be additive and require careful assessment for their health effects. Medical advice should be sought for mixed exposure.

5.1.1.6 Heat stress

The estimation and evaluation of heat stress shall be in accordance with ISO 7933, the main objectives of which are:

- the evaluation of the thermal stress in conditions likely to lead to excessive core temperature increase or water loss;
- the determination of the modifications to reduce or exclude these effects; and
- the determination of the maximum allowable exposure times required to limit physiological strain to an acceptable value.

With respect to the third objective, ISO 7933 gives, as a function of the mean characteristics of the exposed subjects (acclimatised or non-acclimatised) and the adopted criteria (warning or danger), maximum values for a number of different criteria relating to thermal stress and strain. These are:

- skin wettedness;
- sweat rate;
- heat storage; and
- loss of water and electrolytes.

The acceptance criterion is that the maximum warning values for non-acclimatised persons shall not be exceeded for each of the above criteria during the endurance period.

5.1.1.7 Use of respiratory protective equipment (RPE)

In certain circumstances (e.g. in open spaces), the use of RPE may be considered as a protection measure for personnel at the TR, and while using escape and evacuation routes.

The use of RPE requires careful consideration to ensure that the primary objective (2.1) is achieved. In particular, consideration should be given to the possible effects on the command structure (organisation, communications), the provision of sufficient air supply for the duration required, and the difficulty of putting RPE on injured persons.

Enclosed TRs should be designed such that RPE is not necessary while personnel are within the TR.

NOTE: RPE is a general term covering both breathing apparatus (which is independent of the local atmosphere) and respirators (e.g. smoke hoods and filters which are dependent on the local atmosphere). Smoke hoods of the simple filter type are unlikely to provide sufficient respiratory protection for major incidents on large and complex installations.

5.1.2 Structural support

The TR structural acceptance criterion is the maintenance of the integrity of the supporting structure, defined in (4.2), such that the TR as a whole remains in a stable, usable and accessible condition for the endurance period.

The failure of any structural component or adjacent structure should not lead to loss of integrity as defined by the acceptance criteria for life and command support. An example of such failure would be a breach in the external boundary of an enclosed TR caused by an explosion leading to an internal carbon monoxide level which results in failure of the acceptance criteria set for smoke ingress.

Where an adjacent mobile unit or floating vessel provides the TR for a fixed installation, the unit or vessel shall be able to remain on station and accessible for the endurance period.

5.1.3 Command support

5.1.3.1 Essential command support functions

The acceptance criterion for command support is the availability, for the endurance period, of the following essential command support functions (4.3). These functions are not specific to any scenario and are:

- the ability to communicate with all personnel at muster stations and embarkation areas;
- the ability to request outside assistance;
- the ability to initiate general alarm conditions;
- two-way voice communications with a secondary TR, for the endurance period of the secondary TR;
- the ability to monitor fire, smoke and those toxic and flammable gases which may occur,

and to monitor their propagation:

  - in the TR;
  - on evacuation routes;
  - at embarkation areas; and
  - in modules and areas adjacent to the TR, evacuation routes and embarkation areas;

- the ability to visually determine the physical condition of:

  - evacuation routes leading to embarkation areas; and
  - embarkation areas;

- for manned installations, the provision of emergency power and emergency lighting.

5.1.3.2 Additional command support functions (installation specific)

It may be necessary to provide additional command support functions to ensure that risk of loss of integrity, including those relating to life and structural support, is acceptable. These will generally be related to the containment of an incident. Loss or impairment of the additional command support functions would not directly constitute loss of integrity, but the consequences of their not being available may lead to loss of integrity through escalation. These functions will be dependent on the installation and the incident scenario. Additional command support functions may include the following:

- person-to-person installation communications;
- communication with land base;
- communication with pipeline-connected installations;
- communication with gangway-connected installations;
- the ability to monitor fire in the major process areas, e.g. wellheads, gas compression, etc.
- the ability to determine the physical condition of the helideck and to detect fire, smoke and gas in its immediate vicinity;
- the ability to monitor and close TR boundary HVAC fire dampers, where fitted;
- the ability to initiate SPS/TPS;
- the ability to close pipeline ESD valves (where not integral with the SPS/TPS);
- the ability to operate BOPs;
- the ability to activate process blowdown;
- the ability to monitor the running of the fire water pumps.

The above additional command support functions should be available on a manned installation.

5.1.3.3 Secondary TRs

The acceptance criterion is the availability for the secondary TR endurance period of the following:

- two-way voice communications with the main TR; and
- the ability to monitor fire, smoke and those gases which may occur on the designated evacuation route and visually determine the physical condition of the designated evacuation route.

Emergency power and lighting and any facility or system which is necessary to maintain integrity of the secondary TR for life and structural support shall be provided.

5.1.4 Escape and evacuation

The conditions of integrity for escape and evacuation shall be maintained for their respective endurance periods:

- on at least one escape route to the TR(s);
- on at least one evacuation route from the TR(s) to the point of embarkation of the primary and, as applicable, the secondary means of evacuation; and
- at sufficient embarkation areas, providing accessible survival craft (when provided) with an aggregate capacity equal to or greater than the POB.

5.1.4.1 Fire

Escape and evacuation routes and points of embarkation shall be arranged so that personnel will not be directly affected by flame. They should be designed to remain passable by position rather than special protection.

The structural integrity of escape and evacuation routes and points of embarkation should not be considered in isolation. Due regard should be given to the structural elements that support them.

Fire protection should be considered to maintain the structural integrity of open walkways and open decks which form escape and evacuation routes. Although these routes may not be passable whilst exposed to flames or radiation levels, fire protection may maintain their structural integrity for use after flames or radiation levels have subsided.

5.1.4.2 Thermal radiation (human exposure)

The Management Guide to Thermal Stress issued by the Shell Safety and Health Committee (SHC) gives guidance for the control of exposure to thermal radiation. This shall be used in determining whether escape and evacuation routes and survival craft embarkation areas can be used if exposed to the predicted radiation intensities. The information includes an indication of the period of time after which pain would be experienced on bare skin and areas of skin protected by clothing or intermittently exposed for different radiation intensities. The acceptance criterion for human exposure to thermal radiation is that the maximum time after which pain would be experienced shall not be exceeded for the relevant protection condition and predicted radiation intensity.

(Appendix 4) gives guidance on the mitigation of the effects of thermal radiation.

5.1.4.3 Explosion

Escape and evacuation routes and survival craft embarkation areas shall be considered to be acceptable if it can be demonstrated that they remain passable, and free of obstructive debris, when the effects of potential explosions are evaluated. Similarly, it shall be demonstrated that any explosion shall not in any way adversely affect the operation of the primary and, as applicable, secondary means to evacuate the POB.

The effects of potential explosions on the structural elements that support escape and evacuation routes and points of embarkation shall also be evaluated.

Panels in bulkheads and decks which are designed to vent explosion overpressures should not obstruct escape and evacuation routes and points of embarkation as a result of an explosion.

5.1.4.4 Air quality

The life support conditions defined in (5.1.1) also apply to escape and evacuation routes and points of embarkation.

5.2 ENDURANCE PERIOD

The endurance period of the TR is the period for which the relevant conditions of integrity shall be maintained.

The endurance period of the TR shall be based on one of two criteria, whichever is the shorter:

- maximum major incident duration; or
- time required to complete evacuation.

The endurance period shall begin from the time of "call to muster" (accounting for delays in calling). The effect on the TR of an incident will not necessarily be present at the beginning of the endurance period.

5.2.1 Maximum major incident duration

Under this criterion, the TR shall be designed to maintain its integrity until the immediate threat has been relieved or has subsided. The integrity of the TR is no longer threatened when life support and conditions external to the TR which are not harmful to personnel are re-established.

A potential threat to the TR is an ignited hydrocarbon release. Under this scenario consideration shall be given to the inventory of hydrocarbons available to feed or sustain an event and to the reliability of shutdown systems and emergency depressurisation facilities.

The adoption of this method for calculating TR endurance does not avoid the requirement to provide a means of evacuation from the installation.

5.2.2 Time required to complete evacuation

Under this criterion, those incidents which require personnel to take refuge in the TR, and where the potential exists for a loss of integrity which would necessitate installation evacuation, are considered.

5.2.2.1 Minimum endurance time

Minimum Endurance Time = $D_1 + D_2 + D_3 + D_4$

Where:

D_1 - Time to respond to an alarm

The time required to inform all personnel on the installation that a major incident has occurred and the response that is necessary. Personnel shall then act in accordance with the relevant emergency procedures.

D_2 - Time to travel to the TR

The time required for all personnel to travel from their place of work or rest to the TR. This time includes an allowance for personnel to respond to instructions.

D_3 - Time to muster and reach decision

The time required for all personnel on the installation to be accounted for. During this time the OIM must be capable of assessing the situation and deciding upon the safest course of action.

D_4 - Time to evacuate

The time required for evacuation of personnel from the installation by the most expeditious manner. This will include the donning of protective clothing and equipment.

5.2.2.2 Factored endurance times

The method in (5.2.2.1) establishes the minimum times to evacuate the installation and assumes that there are no external factors which will affect evacuation time, i.e. that all escape routes are open, there are no casualties, and information on the incident is readily available.

Response, escape, mustering and evacuation times may be affected by the result of different incident scenarios and a factored time is required. The time elements D_1 to D_4 will be affected as follows:

D_1 - The initial incident may affect the alarm system or destroy or otherwise affect communications in different areas of the installation. Other factors which may also influence this time can include the need to shut down or make safe sensitive operations, (e.g. well control, pipeline shut-in) prior to mustering. Noise may prevent audible communications. Also, personnel may not initially react.

D_2 - Damage to escape routes may cause personnel to resort to alternative routes. The effect of such damage may result in increased travel time to muster points. Other factors which may influence this time include the need to put on protective equipment (e.g. smoke hoods, breathing apparatus), the adverse affect of poor environmental conditions (e.g. bad weather, radiant heat), minor injuries etc.

D_3 - Information about the incident and its immediate effect on the installation and TR integrity may be difficult to assess. The presence of casualties, fatalities or men overboard may affect the mustering process, making reconciliation of POB a more difficult task. The provision of a secondary TR may add to this complication.

D_4 - The time to evacuate may be affected by damage to evacuation routes or evacuation equipment. Personnel may need to be directed to alternative means of evacuation. Other factors which may influence this time include the need to evacuate casualties, change in weather conditions, etc.

Factors affecting one stage of the escape and evacuation system do not necessarily affect all stages. However, it is stressed that failures in the evacuation means can have a "knock-on" effect, subsequently delaying decisions or affecting other parts of the system. Delays will also substantially increase the stress levels of affected personnel, making rational decisions more difficult (6.3). The factors affecting the elements D_1 to D_4 will vary according to the complexity of the installation, it may be necessary to consider the effects and responses for each platform incident scenario, and for each of the time elements.

A contingency shall be added to reflect the level of qualitative assessment in the above process. A minimum of ten minutes should be added to the total required time. Experience from realistic drills on comparable existing installations shall be taken into account for new installations.

When calculated on the basis of the time required to complete evacuation, the TR endurance period will be longest factored endurance time of the scenarios considered.

The time available before impairment should be equal to or greater than the TR endurance period. Where this is not the case, steps will be required to review the consequences of the incident scenarios and/or to review the escape and evacuation process.

The time estimates shall be developed by competent Operations staff, and take account of specific practices and procedures. On existing installations, the elements of the access and evacuation process shall be validated by evacuation exercises, making allowance for realistic incident conditions.

A form for calculation of evacuation times is included in (Appendix 5). It should be used for the determination of minimum and factored endurance times.

5.2.2.3 Secondary TRs

The endurance period should take account of the incident scenarios from which the requirement of a secondary TR was determined. The secondary TR endurance period should allow sufficient time as described under (5.2.2.1) and (5.2.2.2) to:

- escape to the secondary TR;
- muster at the secondary TR;
- communicate with the primary TR; and

- if appropriate, evacuate using the dedicated means of evacuation.

5.2.2.4 Escape routes to the TR

Escape routes to the TR shall be required to maintain the conditions of integrity detailed herein only for the time that they may be used. They will, therefore, have different endurance periods to that of the TR, and the evacuation routes from the TR to the points of embarkation.

The endurance period required for escape routes to the TR shall be that necessary to complete a full muster in the TR from all installation locations. It should include a contingency and take account of the following:

- the incident may occur at night or during a time when personnel are involved in complex operations or activities;
- more than one route may have to be tried;
- the movement of personnel may be hampered by injury or the consequences of the incident (e.g. smoke);
- the need to undertake a single search and rescue operation on the installation.

Escape route endurance periods should be determined using the principles described in (5.2.2.1).

5.2.2.5 Evacuation routes from the TR

The endurance period for evacuation routes and points of embarkation shall be the time during which they may be required to be in use.

The start of the evacuation routes endurance period should correspond to $(D_1+D_2+D_3)_{unfactored}$, and the end to $(D_1+D_2+D_3+D_4)_{factored}$. The difference between these 2 values gives a result which is not the same as $(D_4)_{factored}$.

6. DESIGN PROCESS/TOOLS

6.1 SAFETY MANAGEMENT SYSTEM (SMS) AND SAFETY CASES

The safety case can be defined as the output of a programme of formal safety assessment conducted to assure that the risks of operating an installation are as low as reasonably practicable.

EP 92-0100 provides guidance on the preparation and content of safety cases.

A safety case has the following main elements:

- a description of the installation and how it is equipped for safety and emergency management;
- a description of the application of the safety management system and a demonstration that it is "alive";
- a demonstration that the hazards and risks associated with the installation have been identified, assessed and are under control and that the necessary arrangements are in place to deal with the consequences of loss of control should the need arise;
- a demonstration that safety management and risk minimisation objectives have been met;
- a demonstration that there is an improvement plan in place to eliminate the gap between the intention of safety management and its achievement.

6.2 HAZARD MANAGEMENT PROCESS (HMP)

HMP provides a structure for analysing the inherent hazards of any operation or installation. Four steps shall be taken to manage a hazard. These are:

- systematic identification of hazards;
- assessment of the significance of hazards;
- implementation of suitable hazard controls; and
- planning for recovery in the event of a loss control.

These four steps are described in EP 92-0100.

The methods presently available from SIPM include the following.

6.2.1 Fire protection

The analysis of fire protection should be carried out in accordance with the FIREPRAN methodology (see EP 55000-19) or equivalent. The purpose of FIREPRAN is to stimulate structured but wide-ranging discussion to establish whether protection is adequate, and, if not, to develop practical remedial measures. FIREPRAN comprises six blocks which constitute a complete fire protection framework. These blocks are:

- establish philosophy;
- identify hazards;
- analyse fire risks;
- reduce fire risks;
- re-analyse fire risks; and
- feedback.

6.2.2 Platform layout methodology

The platform layout methodology documented in EP 90-2500 should be used to assist in the determination of the location of the TR and its special relationship with other installation functions and equipment. The objective of the methodology is to provide an auditable framework within which the essential processes in the development of an offshore platform topsides layout can be structured. Safety considerations are paramount in the methodology. Whilst the methodology has been derived for new installations, the basic concepts also apply to the assessment of existing ones.

6.2.3 Other tools

- escape, evacuation and rescue analysis;

- explosion protection review;
- emergency systems survivability analysis;
- smoke ingress analysis;
- structural consequence analysis;
- offshore pipeline sub-sea isolation systems analysis.

6.2.4 QRA

QRA is a powerful decision making tool which can assist in the evaluation of means to assess safety problems. QRA can be defined as the formal and systematic approach of estimating the likelihood and consequences to people, environment and resources, of accidents developing from hazardous events. The technique provides a structured approach to assessing the potential for accidents and expressing this potential numerically.

QRA shall be carried out in accordance with EP 55000-18 which includes sections on:

- risk quantification;
- presentation of results;
- yardsticks to assess risk to people, including guidance for decision making;
- the use of QRA results;
- performance of quantitative risk assessment; and
- methods and data.

6.3 HUMAN FACTORS

6.3.1 Behaviour under stress

The physical and psychological demands on personnel during a major incident may lead to very high stress levels and a consequential reduction in performance. The design of the TR and its associated means of escape and evacuation shall limit physical and psychological demands on personnel, whilst acknowledging the inevitability of residual high levels of stress.

For those individuals not involved in the management of the incident, uncertainty arising from a lack of information is likely to be the most significant psychological factor.

Under very high stress levels the ability to assimilate information diminishes and highly reinforced or learned behaviour comes to the fore. In such circumstances problems are more likely to occur if personnel are required to do something that is unfamiliar, e.g. using unfamiliar routes, operating equipment that is not normally used and taking in unfamiliar signs. What the designer considers to be an adequate response to a particular scenario, may not in reality be perceived as such by the personnel concerned. The design of the TR and its associated escape and evacuation systems should, as far as is practical, be based on what is normal and familiar in the daily routine.

6.3.2 Complex decision-making

To minimise human error, consideration should be given to:

- automating as many suitable functions as possible. Not all functions are suitable for automation, e.g. knowledge-based decision-making tasks; and
- optimising the provision of information to assist in those decisions that are not automated.

Assessment of the performance of the TR and its associated means of escape and evacuation should consider the possibility and implications of decision errors.

7. FACILITIES

7.1 FACILITY PROVISION

This section provides guidance on equipment and facilities that may be specified in the selected TR system. For enclosed TR systems, general materials and systems shall be in accordance with DEP 37.17.10.10-Gen.

7.2 EQUIPMENT FOR SURVIVAL, EMERGENCY RESPONSE AND MEDICAL

7.2.1 Personal equipment (survival pack)

Every person on board an installation should be provided with a personal survival pack comprising:

- a waterproof electric torch or flashlight with a capacity of at least 3 hours, with a simple means of attachment to waist belt;
- one pair of heat resistant gloves;
- one life jacket;

and, where applicable,

- respiratory protection sufficient to enable safe evacuation;
- one immersion type survival suit.

The above should be in addition to communal stores of equipment held at key locations on the installation (e.g. at survival craft stations).

Personal survival packs shall be located in accordance with the installation mustering philosophy and procedures.

Additional personal survival packs should be located at secondary TR locations, areas such as control rooms or other normally manned locations remote from the TR, and personal descent systems where provided.

7.2.2 General equipment

The provision, number and location of general survival and emergency response, medical and welfare equipment should be separately determined taking account of TR configuration and endurance, likely hazards and the equipment provided to fulfil dual operational functions.

The following lists key equipment which should be made available to personnel at the TR and any secondary TR.

7.2.2.1 Survival equipment

- Safety lamps and self-contained charging units;
- Portable gas detectors; capable of detecting, testing and measuring quantitatively concentrations in air of hydrocarbons, carbon monoxide, hydrogen-sulphide, and oxygen.

7.2.2.2 Medical equipment

- First-aid medical kits (Appendix 6) plus additional dressings and burns packs;
- Stretcher(s);
- Portable automatic oxygen resuscitator(s);
- Packs of eye wash; and
- Bottles of drinking water.

7.3 SIGNS

7.3.1 Signs

Signs shall be provided in accordance with DEP 37.17.10.10-Gen.

Signs directing personnel to the TR shall be different from those leading from the TR to embarkation areas. The differences shall be readily and instantly distinguishable. Similarly, signs that direct personnel out of the TR only in the event of a fire or similar incident within the TR shall clearly indicate this and be distinguishable from all other escape signs.

7.3.2 Safety information

Diagrams showing the basic room/module layouts, evacuation routes, emergency escape equipment and locations/details of fire control arrangements shall be located in strategic areas around the installation, e.g. at muster areas, main stair landings, close to fire fighting areas and at emergency exits/entrances as applicable. They shall be clearly visible and, if necessary, illuminated.

7.4 ENTRANCES AND EXITS (ENCLOSED TRS)

This section applies to enclosed TRs only.

The protection, location and type of TR entrances and exits are critical factors in the fulfilment of certain TR objectives and can improve safety by:

- improving the flow and movement of personnel; and
- mitigating the consequences of certain incidents, particularly smoke and gas ingress.

7.4.1 Protection

Entrances and exits to the TR shall be protected against the ingress of smoke and gas and against blast and radiant heat. Positioning of the entrances and exits in locations naturally protected shall provide primary protection. Only where it is unavoidable should shielding be used to protect entrances and exits from blast and radiant heat.

7.4.2 Location

TR entrances and exits should be located where they are least likely to be affected by blast and impingement of smoke, gas, heat and flame.

The location of entrances and exits should consider the duration for which they may be required and predicted incident scenarios.

The location of entrances and exits should promote a single directional flow of personnel during an incident, where possible avoiding crossflow and counterflow. This applies equally for:

- escape to the TR;
- movement within the TR; and
- evacuation from the TR.

Entrances and exits should be located so that escape and evacuation routes leading to and from them can be as logical, straightforward and direct as possible. The number and size of entrances and exits should be commensurate with the number of personnel which may use them at any one time.

There shall be a minimum of two entrances and two exits which are separate and offer a distinct alternative to one another. A door may act as both an entrance and an exit.

Entrances and exits are potentially weak points in the exterior fabric of a TR, particularly with regard to smoke and gas ingress. The number of entrances and exits should therefore be restricted to only those needed to comply with the foregoing. Where a TR has another operational function (e.g. accommodation) there will probably be a number of additional external doors for operational reasons or for escape from internal fire or other similar incident. The design should limit the number of external doors to the minimum practicable.

7.4.3 Type of doors

All TR external doors should resist smoke and gas penetration. These doors would typically have a continuous seal on one of the closing surfaces. Manufacturers' specifications with respect to resistance to gas penetration vary. The selection of gas resistant doors should therefore be based on the performance requirements.

Doors which are regularly used on a day to day basis should be designed to minimise the wear on door seals. The analysis of smoke and gas ingress shall take account of loss of sealing performance due to wear of door seals. Where it is not practical to fit gas tight doors or where the wear of door seals may be significant (e.g. main working access, arrival/departure, galley, etc.) secondary emergency airlocks which incorporate gas tight doors which are only closed in the event of an incident should be considered.

TR doors which serve escape and evacuation routes shall be designed to be usable for the endurance period. The design shall account for the effect of potential explosions and fire on the operation of the door.

All doors should be clearly marked to indicate the circumstances under which they are to be used.

7.4.4 Airlocks

Where there is a likelihood of smoke and gas impingement there should be at least one, but preferably a number of, airlocks or intervening spaces between the external environment and TR muster and control points.

A crucial factor in the mitigation of smoke and gas ingress will be the procedural use of entrances and exits during an incident, in particular the use of entrances during the initial mustering phase. The uncontrolled use of doors could result in there effectively being no barrier to smoke and gas ingress, completely negating what may otherwise have been a satisfactory design.

The design of entrances, exits and airlocks shall take account of the requirements of stretcher access. In particular, airlocks should be sized to ensure that only one door requires to be open at any one time.

7.5 EMERGENCY POWER AND LIGHTING

7.5.1 General

This section applies primarily to manned installations. The requirements for emergency power and lighting on unmanned installations should be derived from the expected visitation frequency and operational practices.

The provision of emergency power and lighting should be in accordance with DEP 33.64.10.10-Gen.

7.5.2 Emergency power requirement

Emergency power may be required to supply the following consumers during an incident:

- communications;
- monitoring and control; and
- emergency lighting.

Other supplies within the TR may be maintained depending upon the level of power available during a particular incident.

The duration of emergency power shall be determined in each instance. The minimum duration shall be greater than the required TR endurance. This allows for incidents where normal power is lost and the effects which could lead to evacuation do not arise or threaten the TR until a significant period of time has elapsed. In such circumstance the option to remain onboard should be available. If the duration of the emergency power system is less than the required TR endurance period, this requirement will not be met and loss of emergency power would become the determining factor in deciding to abandon the installation, perhaps prematurely. The duration of the emergency power system should include sufficient contingency to ensure that premature abandonment does not occur.

A notice should be provided at the TR to indicate the design duration of all emergency power sources required for the TR functions.

The foregoing does not supersede, or exempt compliance from, the requirements for the supply of emergency power to various items of electrical equipment defined in relevant legislation and regulations.

7.5.3 Emergency lighting

7.5.3.1 General

Emergency lighting systems shall be provided in the following areas, for the endurance period:

- at the TR;
- on escape routes to the TR;
- on evacuation routes from the TR;
- at survival craft embarkation areas;
- at personal descent systems if provided;
- on the helideck if applicable; and
- at boat landings where used for evacuation.

Emergency lighting provided on all offshore installations shall be designed to provide an adequate level of lighting in the event of main power failure. This is typically in the form of fluorescent luminaires with integral battery and inverter/charger power supply. The lamps automatically switch to battery supply and continue to operate for 45 to 90 minutes following loss of mains supply. The effectiveness of emergency lighting depends on correct maintenance of batteries.

7.5.3.2 Lighting at the TR

The duration for which lighting is required at the TR may exceed the length of time that can be guaranteed from the standard emergency luminaires described above, in which case some form of additional power may be required.

7.5.3.3 Lighting of escape routes to the TR

All escape routes on the installation should be provided with emergency lighting of the battery backed fluorescent type. Where smoke may obstruct vision when the escape route is to be used, some form of illuminated low level route indication should be provided.

7.5.3.4 Lighting of evacuation routes from the TR

Lighting of the evacuation routes from the TR shall be available when the platform is evacuated. The standard emergency luminaires may have discharged before this time. This type of lighting may therefore be unsuitable for lighting evacuation routes from the TR. Where smoke may obstruct vision when the evacuation route is to be used, some form of illuminated low level route indication should be provided. High intensity LED based lighting is particularly effective in highlighting handrails and tops and bottoms of stairs.

Depending upon the numbers of luminaires provided for the evacuation routes, provision of a constant power supply for these luminaires from within the TR may place an unnecessary burden on the emergency power supply within the TR. The power supply to the evacuation route lighting should therefore be provided from within the TR such that it can be manually switched on at the time that it is actually required.

Luminaires should be of the internal battery backed type as this will allow light to be provided for some time in the event that the power cabling is damaged. Cabling for the evacuation route lighting circuits should be well protected and able to resist fire damage. To prevent the internal batteries being discharged unnecessarily, a control wire used to inhibit the changeover to the internal battery may be incorporated into the cable.

7.5.3.5 Lighting of survival craft embarkation areas

Emergency lighting of the survival craft embarkation areas should only be required for a short period of time. A relatively high lighting level will be required and can be conveniently provided by a battery system located in the vicinity of the embarkation area. Local switching (i.e. at embarkation areas) and manual switching from the TR should be provided. Any manual light switches shall be self illuminating. Consideration should also be given to providing switching by means of radio signals as a means of ensuring high integrity without dependence on external cabling.

7.6 COMMUNICATIONS

The provision of communication facilities should be in accordance with DEP 32.71.00.12-Gen. Communication equipment should be able to continue functioning at the temperature expected during fire conditions.

7.7 HVAC (ENCLOSED TRS)

The section applies to enclosed TRs only.

The HVAC system, if provided, should be in accordance with DEP 37.17.10.10-Gen.

When the HVAC system is in operation it should maintain life support conditions (5.1.1) and provide protection through the:

- maintenance of a supply of breathable air;
- prevention of heat build-up;
- prevention of smoke and gas ingress through positive pressurisation of the TR; and
- maintenance of visibility (in smoke).

The design should maximise the duration of the HVAC system operation during an incident. To this end, a detailed assessment should be made to establish suitable locations for the HVAC inlets. The HVAC system shall shutdown automatically and the TR shall be isolated in the event of smoke or gas detection at the air inlets. Provisions should be made to manually shutdown and restart the HVAC system from the TR itself.

7.8 MATERIALS FOR FIRE PROTECTION

The selection and specification of materials used in the construction of the TR shall be consistent with their function. In particular, all practical measures shall be taken to ensure that they do not lead or contribute to loss of integrity as defined by the acceptance criteria.

Direct fire or radiant heat impingement on the TR may result in temperatures within or on its external boundaries which are high enough to cause thermal decomposition, releasing toxic fumes. The level of toxic fumes generated in this way should be reduced to acceptable levels through temperature limitation and material selection.

8. REFERENCES

In this DEP, reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Telecommunications for offshore platforms	DEP 32.71.00.12-Gen.
Electrical engineering guidelines	DEP 33.64.10.10-Gen.
Design of offshore living quarters	DEP 37.17.10.10-Gen
Quantitative Risk Assessment	EP 55000-18
"FIRE-PRAN" Fire protection analysis	EP 55000-19
Emergency response	EP 55000-39
Layout Considerations for Offshore Topsides Facilities, Volume 1 The Method	EP 90-2500
User's Guide to the Structure of SMS and Safety Cases	EP 92-0100
Management Guide to Thermal Stress, December 1991 (Shell Safety and Health Committee)	

BRITISH STANDARDS

HSE Guidance Note: 'Occupational Exposure Limits'	HSE EH40

Issued by:
Health and Safety Executive
Ferguson House
15 Marylebone Road
London NW1 5JD
United Kingdom.

INTERNATIONAL STANDARDS

Hot Environments - Analytical Determination, and Interpretation of Thermal Stress Using Calculation of Required Sweat Rate

Issued by:
International Organisation for Standardisation
1 Rue de Varembé
CH-1211 Geneva 20
Switzerland.

9. BIBLIOGRAPHY

NOTE: The documents listed in this Bibliography are for information only and do not form an integral part of this DEP.

Ref. 1. Report of the Task Group on Reference Man, Pub 23, International Commission on Radiological Protection (ICRP)

Ref. 2. WHO Criteria Document 13, World Health Organisation

Ref. 3. Coburn et al. (1965), Considerations of the physiological variables that determine the blood carboxyhaemoglobin in man. Journal of Clinical Investigations 44 1899-1910

APPENDICES

APPENDIX 1 THERMAL DECOMPOSITION OF POLYMERIC MATERIALS

The table shows the variety of decomposition products from various polymeric materials undergoing pyrolysis (thermal decomposition in the absence of oxidising agents) and oxidative decomposition.

ELEMENTAL COMPOSITION	EXAMPLES	PYROLYSIS	OXIDATIVE DECOMPOSITION
CH	Polyethylene Polypropylene Oil	Hydrocarbons	CO, hydrocarbons aldehydes
CHO	Wood Polyesters	CO, Hydrocarbons aldehydes	As for pyrolysis
CHN	Polyacryolnitrile Nylon	CO, Hydrocarbons	Hydrocarbons amines, cyanides
CHNO	Polyurethanes Polyisocyanurates	CO, Hydrocarbons cyanides aldehydes	As for pyrolysis
CHCl	PVC	Hydrocarbons hydrogen chloride	CO, Hydrocarbons hydrogen fluoride
CHF	PTFE	Hydrocarbons hydrogen fluoride	CO, hyrocarbons hydrogen fluoride
CHS	Vulcanised rubbers Wools	Hydrocarbons hydrogen sulphide	CO, Hydrocarbons hydrogen sulphide sulphur dioxide
P&Sb	Various polymers	Phosphorus and antimony compounds	

APPENDIX 2 BODILY UPTAKE OF CO

The exposure data contained in this appendix result from programming the equation introduced by Coburn that relates environmental carbon monoxide (CO) exposure to bodily uptake. The Coburn equation (9, Bibliography, Ref. 3) has been rearranged for programming as follows:

$$\text{CO in air (ppm)} = \frac{1316\left[(AC - V_{CO}B) + a(V_{CO}B - AD)\right]}{1 - a}$$

where

$$A = \frac{P_c - O_2}{M\left[O_2Hb\right]}$$

$$B = \frac{1}{D_L} + \frac{P_L}{V_A}$$

C = $[COHb]_t$ = carboxyhaemoglobin (COHb) concentration (ml CO/ml blood) at time t

D = $[COHb]_o$ = "background" COHb (ml CO/ml blood) at time = O

V_{CO} = rate of endogenous CO production (ml/min)

$$a = e^{-\left[\frac{A}{V_b B}\right]t}$$

V_b = blood volume

$P_c - O_2$ = PO_2 in capillaries (mm Hg)

$[O_2Hb]$ = oxyhaemoglobin concentration (ml/ml blood)

M = CO/O_2 affinity for Hb

D_L = diffusion rate of CO through lungs (ml/min/mm Hg)

P_L = dry barometric pressure in lungs (mm Hg)

V_A = ventilation rate (ml/min)

<u>Assumptions (Constants)</u>

The model takes account of an initial COHb level due either to the metabolism in non-smokers or that found in smokers.

D (non-smokers) = 0.001 (0.5% equal to 2.172 ppm)

D (smokers) = 0.01 (5.0% equal to 26.469 ppm)

V_{co} = 0.007 ml/min

V_b = 6085 ml

$P_c - O_2$ = 72 mm Hg

$[O_2Hb]$ = 0.161 ml/ml blood

M = 218

P_L = 713 mm Hg

<u>Assumptions (Variables)</u>

<u>All "work" rates</u>

D_L = 72.4 ml/min/mm Hg

V_A = 16430 ml/min

APPENDIX 3 OXYGEN DEPLETION AND CARBON DIOXIDE ACCUMULATION

Where the TR is an enclosure and analysis of incident scenarios indicates that significant smoke and gas impingement may occur, a probable protection measure will be to seal the TR. Under such circumstances it will be necessary to ensure that from the instant when a breathable external air supply is lost, an adequate internal air supply is available for the remainder of the endurance period.

Oxygen consumption and carbon dioxide production are linked to energy expenditure. ICRP (9, Bibliography, Ref. 1) gives the following figures.

For a daily energy expenditure of 3000 Kcal, 620 litres of oxygen are consumed and 510 litres of carbon dioxide produced (at STP - 0 °C/760 mm Hg).

Assuming an air temperature of 20 °C, this equates to 665 litres of oxygen and 547 litres of carbon dioxide. Taking an initial oxygen content of 21% and a lower acceptable limit of 17% then each cubic metre of air contains 40 litres of usable oxygen; therefore every person requires 16.6 cubic metres of air per day or 0.69 cubic metres per hour. As carbon dioxide is given out at a rate dependent on oxygen consumption, the carbon dioxide level in an atmosphere reaching the 17% limit for oxygen would be 3.5%. This is above the acceptance criteria for carbon dioxide accumulation set in (5.1.1.5). To ensure that the limit of 2% carbon dioxide is not exceeded the requirement would be 1.2 cubic metres of air per person per hour.

The minimum air space required is therefore 1.2 cubic metres per person per hour of TR endurance.

Other factors which could affect oxygen and carbon dioxide levels, e.g. combustion, have not been taken into account in the establishment of the above.

APPENDIX 4 THERMAL RADIATION (MITIGATION)

The attenuation and mitigation of thermal radiation can be achieved by screening with solid barriers, wire mesh, water spray or the provision of personal protective safety equipment.

<u>Solid Barriers</u>

Thermal radiation travels in line of sight, and when a solid barrier is interposed between radiating source and receptor the latter is shielded from the heat flux. The evaluation of the thermal radiation level shall take account of intervening structures, bulkheads etc. The progressive effects of fire shall also be taken into account when determining lines of sight.

<u>Wire Mesh</u>

The screening effect of wire mesh corresponds approximately to an enclosed screen area,

i.e. if the screen area is 40 percent, radiation screened out is 40 percent.

An important variable is the dullness/blackness of the mesh. Bright metal will result in additional proportions of the incident radiation being reflected through the mesh.

APPENDIX 5 EVACUATE TIME CRITERIA

	TIME ELEMENT		INSTALLATION SPECIFIC FACTORS	MINIMUM TIME ESTIMATE (MINUTES)	FACTORED TIME ESTIMATE (MINUTES)
D_1	Initiate alarm		Alarm and Public Address		
D_2	Escape to TR		Length of escape routes Alternative TR locations		
D_3	Muster	a	Account for personnel onboard		
	Assessment and Evaluation	b	Availability of, and collation of information		
	Communications	c	Internal and external		
	Executive action	d	Automatic systems - ESD, BOP		
	Decision making	e	Quantity and quality of information		
D_4	Evacuation		Personnel don survival equipment Travel to point of embarkation Embark and evacuate		
			TOTAL		

NOTE: The timing of the elements are not necessarily cumulative.

APPENDIX 6 FIRST AID MEDICAL KITS

A typical first-aid medical kit includes the following items:

8	bandages, triangular BPC, approx. 90 cm side x 127 cm base;
2 packets	cotton wool, absorbent 100g;
4	dressings - standard No. 13 BPC;
2	dressings - standard No. 14 BPC;
1	dressing - standard No. 15 BPC;
1 roll	absorbent ribbon gauze BPC, 2.5 cm x 5 m;
1	resuscitator (mouth to mouth) short oral airway with non-return valve, Brook Airway type (medical airway). The airway shall have a close-fitting mouthpiece and a tube to fit into patient's mouth and induce a clear passage for air. It shall be easy to use;
6	rustless 5 cm safety pins;
1 pair	rustless scissors (7 inch - 18 cm);
1 set	arm splints (inflatable); and
1 set	leg splints (inflatable).

A waterproof bag, or case, of sufficient size to contain all of the items listed above should be provided. This should be emerald green and marked FIRST AID in bold white letters.

Such first-aid medical kits are intended for general use and their use is not confined to Medical Officers.