INTERNATIONAL STANDARD

ISO 13702

First edition
1999-03-15

Petroleum and natural gas industries — Control and mitigation of fires and explosions on offshore production installations — Requirements and guidelines

Industries du pétrole et du gaz naturel — Contrôle et atténuation des feux et des explosions dans les installations en mer — Exigences et lignes directrices

Reference number
ISO 13702:1999(E)

Contents

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Printed in Switzerland

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 13702 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, Subcommittee SC 6, *Processing equipment and systems*.

Annexes A, B and C of this International Standard are for information only.

Introduction

The successful development of the arrangements required to promote safety and environmental protection during the recovery of hydrocarbon resources, requires a structured approach to the identification and management of health, safety and environmental hazards applied during the design, construction, operation, inspection, maintenance and decommissioning of a facility.

This International Standard has been prepared primarily to assist in the development of new installations and as such it may not be appropriate to apply some of the requirements to existing installations. Retrospective application of this International Standard should only be undertaken where it is reasonably practicable to do so. During the planning for a major change to an installation there may be more opportunity to implement the requirements and a careful review of this International Standard should be undertaken to determine those sections which can be utilised in the change.

The technical content of this International Standard is arranged as follows:

— **Objectives** - lists the goals to be achieved by the control and mitigation measures being described.

— **Functional requirements** - represent the minimum criteria which shall be satisfied to meet the stated objectives. The functional requirements are performance-orientated measures and, as such, should be applicable to the variety of offshore installations utilized for the development of hydrocarbon resources throughout the world.

— **Guidelines** (annex B) - describe recognized practices which should be considered in conjunction with statutory requirements, industry standards and individual operator philosophy, to determine that the measures necessary are implemented for the control and mitigation of fires and explosions. The guidelines are limited to principal elements and are intended to provide specific guidance which, due to the wide variety of offshore operating environments, may in some circumstances not be applicable.

— **Bibliography** - lists documents to which informative reference is made in this International Standard.

Petroleum and natural gas industries — Control and mitigation of fires and explosions on offshore production installations — Requirements and guidelines

1 Scope

This International Standard describes the objectives, functional requirements and guidelines for the control and mitigation of fires and explosions on offshore installations used for the development of hydrocarbon resources.

This International Standard is applicable to:

— fixed offshore structures;

— floating production, storage and off-take systems;

for the petroleum and natural gas industries.

Mobile offshore units as defined in this International Standard and subsea installations are excluded, although many of the principles contained in this International Standard may be used as guidance.

This International Standard is based on an approach where the selection of control and mitigation measures for fires and explosions is determined by an evaluation of hazards on the offshore installation. The methodologies employed in this assessment and the resultant recommendations will differ depending on the complexity of the production process and facilities, type of facility (i.e. open or enclosed), manning levels, and the environmental conditions associated with the area of operation.

Users of this International Standard should note that while observing its requirements, they should, at the same time, ensure compliance with such statutory requirements, rules and regulations as may be applicable to the individual offshore installation concerned.

2 Terms, definitions and abbreviated terms

2.1 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

2.1.1
abandonment
act of personnel onboard leaving an installation in an emergency

2.1.2
accommodation
place where personnel onboard sleep and spend their off-duty time

NOTE It may include dining rooms, recreation rooms, lavatories, cabins, offices, sickbay, living quarters, galley, pantries and similar permanently enclosed spaces.

2.1.3
active fire protection
AFP
equipment, systems and methods which, following initiation, may be used to control, mitigate and extinguish fires

2.1.4
area classification
division of an installation into hazardous areas and nonhazardous areas and the sub-division of hazardous areas into zones

NOTE This classification is based on the materials which may be present and the probability of a flammable atmosphere developing. Area classification is primarily used in the selection of electrical equipment to minimize the likelihood of ignition if a release occurs.

2.1.5
cellulosic fire
CF
fire involving combustible material such as wood, paper, furniture, etc.

2.1.6
class of fire
type of fire
classification used to facilitate the selection of extinguishers

2.1.7
control
<of hazards> limiting the extent and/or duration of a hazardous event to prevent escalation

2.1.8
control station
CS
place on the installation from which personnel can monitor the status of the installation, initiate appropriate shutdown actions and undertake any emergency communication

2.1.9
deluge system
system to apply fire-water through an array of open spray nozzles by operation of a valve on the inlet to the system

2.1.10
embarkation area
place from which personnel leave the installation during evacuation

EXAMPLES A helideck and associated waiting area or a lifeboat/liferaft boarding area.

2.1.11
emergency depressurization
EDP
controlled disposal of pressurized fluids to a flare or vent system when required to avoid or minimize a hazardous situation

2.1.12
emergency response
action taken by personnel on or off the installation to control or mitigate a hazardous event or initiate and execute abandonment

2.1.13
emergency response team
group of personnel who have designated duties in an emergency

2.1.14
emergency shutdown
ESD
control actions undertaken to shut down equipment or processes in response to a hazardous situation

2.1.15
emergency station
place where emergency response personnel go to undertake their emergency duties

2.1.16
escalation
spread of impact from fires, explosions, toxic gas releases to equipment or other areas thereby causing an increase in the consequences of a hazardous event

2.1.17
escape
act of personnel moving away from a hazardous event to a place where its effects are reduced or removed

2.1.18
escape route
route from an area of an installation leading to a muster area, temporary refuge (TR), embarkation area or means of escape to the sea

2.1.19
essential safety system
any system which has a major role in the control and mitigation of fires and explosions and in any subsequent EER activities

2.1.20
evacuation
the planned method of leaving the installation in an emergency

2.1.21
evacuation, escape and rescue
EER
general term used to describe the range of possible actions including escape, muster, refuge, evacuation, escape to the sea and rescue/recovery

2.1.22
evacuation, escape and rescue strategy
EERS
results of the process that uses information from an evaluation of events which may require EER to determine the measures required and the role of these measures

2.1.23
evacuation route
escape route which leads from the temporary refuge (TR) to the place(s) used for primary or secondary evacuation from the installation

2.1.24 explosion

2.1.24.1
chemical explosion
violent combustion of a flammable gas or mist which generates pressure effects due to confinement of the combustion-induced flow and/or the acceleration of the flame front by obstacles in the flame path

2.1.24.2
physical explosion
explosion arising from the sudden release of stored energy such as from failure of a pressure vessel, or high voltage electrical discharge to earth

2.1.25
fire and explosion strategy
FES
results of the process that uses information from the fire and explosion evaluation to determine the measures required to manage these hazardous events and the role of these measures

2.1.26
flammable atmosphere
mixture of flammable gas or vapour in air which will burn when ignited

2.1.27
functional requirements
minimum criteria which must be satisfied to meet the stated health, safety and environmental objectives

2.1.28
grade of release
<area classification> measure of the likely frequency and duration of a release

NOTE It is independent of the rate of release, the quantity of material released, the degree of ventilation and the characteristics of the fluid.

2.1.29
hazard
potential for human injury, damage to the environment, damage to property, or a combination of these

2.1.30
hazard assessment
process whereby the results of an analysis of a hazard or hazardous event are considered against either judgement, standards or criteria which have been developed as a basis for decision-making

2.1.31
hazardous area
three-dimensional space in which a flammable atmosphere may be expected to be present at such frequencies as to require special precautions for the control of potential ignition sources

2.1.32
hazardous event
incident which occurs when a hazard is realized

EXAMPLES Release of gas, fire, loss of buoyancy.

2.1.33
ignition sources
any source with sufficient energy to initiate combustion

2.1.34
integrated installation
offshore installation which contains, on the same structure, accommodation and utilities in addition to process and/or wellhead facilities

2.1.35
jet fire
JF
ignited release of pressurized, flammable fluids

2.1.36
life jacket
device worn by personnel which has sufficient buoyancy and stability to turn the body of an unconscious person and keep the person's mouth clear of the water

2.1.37
mitigation
<of hazardous event> reduction of the effects of a hazardous event

2.1.38
manned installation
installation on which people are routinely accommodated

2.1.39
mobile offshore unit
mobile platform, including drilling ships, equipped for drilling for subsea hydrocarbon deposits, and mobile platform for purposes other than production and storage of hydrocarbon deposits

2.1.40
muster area
designated area where personnel report when required to do so

2.1.41
operator
individual, partnership, firm or corporation having control or management of operations on the leased area or a portion thereof

NOTE The operator may be a lessee, designated agent of the lessee(s), or holder of operating rights under an approved operating agreement.

2.1.42
passive fire protection
PFP
coating or cladding arrangement or free-standing system which, in the event of fire, will provide thermal protection to restrict the rate at which heat is transmitted to the object or area being protected

2.1.43
pool fire
combustion of flammable or combustible liquid spilled and retained on a surface

2.1.44
prevention
<of hazardous event> reduction of the likelihood of a hazardous event

2.1.45
primary method
<for evacuation> preferred method of leaving the installation in an emergency

2.1.46
rescue
process by which those who have entered the sea directly or in TEMPSC/liferafts are retrieved to a place where medical assistance is available

2.1.47
risk
combination of the chance that a specified undesired event will occur and the severity of the consequences of that event

2.1.48
running liquid fire
fire involving a flammable liquid flowing over a surface

2.1.49
secondary method
<for evacuation> method of leaving the installation which can be carried out in a fully controlled manner under the direction of the person in charge, independent of external support

2.1.50
source of release
point from which flammable gas, liquid or a combination of both can be released into the atmosphere

2.1.51
survival suit
protective suit made of waterproof materials which reduces the body heat-loss of a person wearing it in cold water

2.1.52
temporary refuge
TR
place provided where personnel can take refuge for a predetermined period whilst investigations, emergency response and evacuation preplanning are undertaken

2.1.53
tertiary method
<for escape to the sea> method of leaving the instsllation which relies considerably on the individual's own action

2.1.54
totally enclosed motor-propelled survival craft
TEMPSC
craft capable of sustaining the lives of persons in distress from the time of abandoning the installation

2.1.55
zone
<area classification> distance in any direction from the source of release to the point where the flammable atmosphere has been diluted by air to a sufficiently low level

NOTE Different zone ratings are possible depending on the frequency that flammable mixtures are expected to be present.

2.2 Abbreviated terms

AB	Accommodation Block
AFP	Active Fire Protection
API	American Petroleum Institute
BA	Breathing Apparatus
BOP	Blowout Preventer
CCR	Central Control Room
CF	Cellulosic Fire
CS	Control Station
EDP	Emergency Depressurization
EER	Evacuation, Escape and Rescue
EERS	EER Strategy
ESD	Emergency Shutdown
FES	Fire and Explosion Strategy
SDV	Shutdown valve
F&G	Fire and Gas System
HC	Hydrocarbon
HVAC	Heating, Ventilation and Air Conditioning
OCS	Outer Continental Shelf
IEC	International Electrotechnical Commission
IMO	International Maritime Organization
JF	Jet Fire
PA	Process Area
PFP	Passive Fire Protection
PLC	Programmable Logic Controllers
SSIV	Sub-Sea Isolation Valve
SSSV	Sub-Surface Safety Valve
TEMPSC	Totally Enclosed Motor-Propelled Survival Craft
TR	Temporary Refuge
UPS	Uninterruptable Power Supply
UKOOA	United Kingdom Offshore Operators Association
UA	Utility Area
WH	Wellhead Area

3 Objectives

The principal objectives of this International Standard are, in order of priority:

— safety of personnel;

— protection of the environment;

— protection of assets;

— minimization of financial consequences of fires and explosions.

4 Fire and explosion evaluation and risk management

All companies associated with the offfshore recovery of hydrocarbons shall have, or conduct their activities in accordance with, an effective management system which addresses environmental issues such as described in ISO 14001 or similar[1)], and additionally addresses issues relating to health and safety. One key element of such management systems shall be a process of evaluation and risk management. The starting point for evaluation and risk management is the systematic identification of the hazards and effects which may arise from offshore recovery locations and activities and from the materials which are used or encountered in them. The identification process should be applied to all stages in the life cycle of an installation and to all types of hazards encountered as a consequence of the development of hydrocarbon resources.

The results of the identification process should be used both to evaluate the consequences of hazardous events and to determine appropriate risk reduction. The process of selecting risk-reduction measures will predominantly entail the use of sound engineering judgement, but this may need to be supplemented by a recognition of the particular circumstances which may require deviation from past practices and previously applied codes and standards. In certain circumstances, risk assessment may be able to provide useful input to the decision-making process, providing that the operator has established criteria for this purpose. Risk-reduction measures should include those to prevent incidents (i.e. reduction of the probability of occurrence), to control incidents (i.e. limiting the extent and duration of a hazardous event) and to mitigate the effects (i.e. reduction of the consequences). Preventative measures, such as using inherently safer designs and ensuring asset integrity, should be emphasized wherever practicable. Emergency response measures to recover from incidents should be provided based on the evaluation and should be developed taking into account possible failures of the control and mitigation measures. Based on the results of the evaluation, detailed health, safety and environmental objectives and functional requirements should be set at appropriate levels.

The above is general and applies to all hazards and potentially hazardous events. In the context of fires and explosions, the evaluation of these events may be part of an overall installation evaluation or may be treated as a separate process which provides information to the overall evaluation.

The results of the evaluation process and the decisions taken with respect to the need for, and role of, any risk reduction measures should be recorded so that they are available for those who operate the installation and for those involved in any subsequent change to the installation. For convenience in the remainder of this International Standard, the term 'strategy' has been adopted for this record. Two such strategies are introduced, namely a Fire and Explosion Strategy (FES) and an Evacuation, Escape and Rescue Strategy (EERS). These strategies do not have to be separately documented and the relevant information may be included with other health, safety and environmental information as part of the management of all hazardous events on an installation. The EERS may, for example be included in an overall installation Emergency Response Strategy. For many existing installations, the FES and EERS may be contained in previous risk assessments, or may be restricted to a simple statement of the standards and/or procedures, which are applied to deal with fire and explosion and escape and evacuation aspects of the installation.

The strategies should be updated whenever there is a change to the installation which may affect the management of the fire and explosion hazardous events.

The level of detail in a strategy will vary depending on the scale of the installation and the stage in the installation life cycle when the risk management process is undertaken. For example:

— complex installations, e.g. a large production platform incorporating complex facilities, drilling modules and large accommodation modules, are likely to require detailed studies to address the fire and explosion hazardous events. Typical examples of some of the issues that may need to be addressed for such installations are given in annex C;

— for simpler installations, e.g. a wellhead platform or other small platforms with limited process facilities, it may be possible to rely on application of recognized codes and standards as a suitable base which reflects industry experience for this type of facility;

1) For example, operators should have an effective management system. Contractors should have either their own management system or conduct their activities consistently with the operators management system.

— for installations which are a repeat of earlier designs, evaluations undertaken for the original design may be deemed sufficient to determine the measures needed to manage the fire and explosion hazardous events, but new knowledge and technology should be considered;

— for installations in the early design phases, the evaluations will necessarily be less detailed than those undertaken during later design phases.

The strategies should describe the role and any functional requirements for each of the systems required to manage possible hazardous events on the installation. In developing functional requirements, the following should be considered:

a) the functional parameters of the particular system. This should be a statement of the purpose and essential duties that the system is expected to perform;

b) the integrity, reliability and availability of the system;

c) the survivability of the system under the emergency conditions which may be present when it is required to operate;

d) the dependency on other systems which may not be available in an emergency.

The identified essential elements should form the basis for the specification for each of the systems to be provided, and should be verified for the life of the installation in order to ensure that the strategies remain valid and to identify the need for any remedial action.

In developing the strategies, there are a wide range of issues which should be considered to ensure that the measures selected are capable of performing their function when required to do so. For the FES, these issues include:

— the nature of the fires and explosions which may occur (see annex A);

— the risks of fires and explosions;

— the marine environment;

— the nature of the fluids to be handled;

— the anticipated ambient conditions;

— the temperature and pressure of fluids to be handled;

— the quantities of flammable materials to be processed and stored;

— the amount, complexity and layout of equipment on the installation;

— the location of the installation with respect to external assistance/support;

— the EERS;

— the production and manning philosophy;

— human factors.

For the EERS, issues to be considered include:

— normal means of access to the installation;

— means available for evacuation, escape and rescue and their likely availability in the identified accident scenarios;

— fire and explosion scenarios which might lead to the need for escape or evacuation (including the effects of smoke and radiant heat);

- number and distribution of personnel;
- emergency command and communication;
- emergency monitoring and control;
- layout of the installation and arrangement of equipment;
- environment in which the installation is located;
- level of assistance available from external sources;
- any regulations and guidance which are applicable to the installation;
- human factors.

The following clauses of this International Standard identify requirements and provide guidance on a range of measures which may have a role in either the control and mitigation of the potential fire and explosion hazardous events on an installation or in the EER activities which may be required as a result of a fire or explosion.

5 Installation layout

5.1 Objectives

- To minimize the possibility of hazardous accumulations of both liquids and gaseous hydrocarbon, and to provide for the rapid removal of any accumulations which do occur;
- To minimize the probability of ignition;
- To minimize the spread of flammable liquids and gases which may result in a hazardous event;
- To separate areas required to be nonhazardous from those designated as being hazardous;
- To minimize the consequences of fire and explosions;
- To provide for adequate arrangements for escape and evacuation;
- To facilitate effective emergency response.

5.2 Functional requirements

The layout of an installation may have a major effect on the consequences of fires and explosions and on the arrangements required for EER. Consequently, for a new installation or the modification of an existing installation the impact of layout options on the FES and EERS shall be fully evaluated as a basis for the selection of the design which, so far as is reasonably practicable, minimizes the risks of fire and explosion.

In developing the layout of the installation, consideration shall be given to maximizing so far as is reasonable the separation by distance of the temporary refuge (TR), accommodation and evacuation, escape and rescue (EER) facilities from areas containing equipment handling hydrocarbons.

Either separation by distance or the use of barriers can prevent the escalation of fire to another area. Where such barriers are required to avoid escalation, they shall be adequate to resist fire and, as far as is reasonable the effects of explosions. The provision of such barriers will influence ventilation, access/escape routes, ESD/EDP system design, explosion resistance and firewater demands. The interdependency of safety systems shall be considered during the design of the installation. Any penetration of a barrier provided to prevent escalation of a fire or explosion shall not jeopardize the integrity of the barrier.

Essential safety systems (such as control stations, temporary refuge, muster areas, fire pumps) shall be located where they are least likely to be affected by fires and explosions. In some situations such systems will need to be designed to withstand fire and explosions, at least until people on board have been safely evacuated or the situation has been brought under control.

The installation layout may result in equipment being at risk from impact of dropped objects or collisions. The need to protect critical items of process equipment, especially where failure could result in a major loss of inventory, shall be considered to determine whether impact protection is required.

6 Emergency shutdown systems and blowdown

6.1 Objective

- To initiate appropriate shutdown, isolation and blowdown actions to prevent escalation of abnormal conditions into a major hazardous event and to limit the extent and duration of any such events which do occur.

6.2 Functional requirements

An emergency shutdown (ESD) system shall be provided, in accordance with the requirements of the FES, in order to:

— isolate the installation from the major hydrocarbon inventories within pipelines and reservoirs which, if released on failure, would pose an intolerable risk to personnel, environment and the equipment;

— where appropriate, sectionalize topside inventory to limit the quantity of material released on loss of containment;

— control potential ignition sources such as fired units, engines and non-essential electrical equipment;

— control subsurface safety valve(s);

— where appropriate, depressurize hydrocarbon inventory and vent it to a safe place.

An ESD system shall be designed such that it is capable of fulfilling its function under the conditions which may be experienced when the system is required to operate.

An ESD system shall provide adequate information at a control station so that personnel involved in managing an emergency have the information they need. The information presented to the operator and the controls provided shall be such that the operator can effectively execute the required actions in an emergency.

If plant is in operation, the essential shutdown functions shall be available during maintenance activities which affect the operation of the ESD system.

Emergency depressurization (EDP) systems shall be considered for pressurized hydrocarbon systems to dispose of the gaseous inventory under emergency conditions in order to reduce the duration of an event, the quantity of material released or the likelihood of a pressure vessel failure in a fire.

The design of an ESD system may be for manual or automatic initiation or both. When manual initiation is required, the systems shall be simple to operate and shall not require operators to make complex or non-routine decisions.

Once initiated, all control actions required by the ESD system shall occur automatically.

Manual stations for initiation of ESD shall be located in strategic positions, be readily accessible, well marked and protected against unintentional activation.

The ESD system shall contain facilities for testing of both input/output devices and internal functions.

7 Control of ignition

7.1 Objective

- To minimize the likelihood of ignition of flammable liquids and gases following a loss of containment.

7.2 Functional requirements

Arrangements to minimize the likelihood of ignition shall be provided in accordance with the requirements of the FES. This should include minimization of the number of potential ignition sources as far as reasonably practicable.

Ignition of flammable liquid and gas leaks shall be minimized by identifying those areas where such leaks are likely to occur and by providing in these areas equipment which is designed to reduce the likelihood of ignition of flammable liquids and gases.

The installation shall be classified into hazardous and nonhazardous areas in accordance with a recognized standard or code.

The need for the ESD system to incorporate isolation of electrical equipment which is not suitable for use in hazardous areas during major gas emergencies shall be considered in the design of the ESD system.

Procedures to control the use of temporary equipment which may present ignition sources shall be established.

Direct-fired equipment shall be located or protected to prevent ignition following loss of containment.

8 Control of spills

8.1 Objective

- To provide measures for containment and proper disposal of flammable liquid spills.

8.2 Functional requirements

Arrangements for control of spills shall be provided in accordance with the requirements of the FES.

Measures shall be provided for dealing with spills in all areas which have a source of liquid hydrocarbons so as to minimize the risk of fires and to avoid damage to the environment.

Hazardous and nonhazardous open drains shall be physically separate.

Hazardous closed drains shall be separate from all open drainage systems.

The design of the drainage system shall limit the maximum spread of a spill and attempt to minimize any escalation arising from the spill.

9 Emergency power systems

9.1 Objective

- To provide a reliable source of emergency power.

9.2 Functional requirements

Emergency power shall be provided in accordance with the requirements of the FES.

Systems requiring electrical power to fulfil their functions and to allow the installation to be safely shut down and evacuated shall have a secure power supply of sufficient capacity and duration for a period sufficient for effective management of the installation while main power generation is unavailable.

Facilities shall be provided to allow maintenance of the emergency power system without significantly reducing the functionality of the system.

The location and design of the emergency power systems shall ensure that they will be able to perform their function under the conditions which may be experienced when called upon to operate.

Consideration shall be given to the facilities required to maintain control of drilling activities. The consequences of loss of mains power during drilling activities shall be evaluated to ensure that the emergency power systems, where necessary to allow essential equipment to remain available, are suitable for use during an emergency.

10 Fire and gas systems

10.1 Objectives

- To provide continuous automatic monitoring functions to alert personnel of the presence of a hazardous fire or gas condition.
- To allow control actions to be initiated manually or automatically in order to minimize the likelihood of escalation.

10.2 Functional requirements

A Fire and Gas (F&G) system shall be provided in accordance with the requirements of the FES.

The FES shall describe the basis for determining the location, number and types of detectors. This requires a process of identifying and assessing the possible F&G hazardous events in each area and evaluating the requirements to reliably detect these events.

The F&G detection devices shall be selected taking into account their response characteristics and the conditions which may be experienced when detection is required.

Fire detectors shall be selected to be suitable for detection of the types of fires that may occur in the area.

All F&G field devices shall be suitable for the area in which they will be located and shall be approved for use by a recognized authority.

When necessary to prevent ignition of a gas release in nonhazardous areas, the air intakes to these areas, or the areas themselves, shall be fitted with gas detection if gas can realistically reach these areas in an emergency. Reliance on gas detection within a nonhazardous area to prevent ignition of gas needs careful consideration to ensure that sufficient time will be available after initial detection to complete the necessary shutdown actions.

The F&G system shall have facilities to allow testing of field devices, the system internal functions and executive outputs.

Devices to initiate F&G alarm and, where provided, control actions shall be available in a control station.

Alarm conditions requiring muster of personnel shall be identified by acoustic signals, supplemented by visual signals in high noise areas where high noise levels will persist after ESD.

Temporary removal or isolation of the F&G system, or part of the system, is acceptable providing that adequate alternative arrangements are provided.

The F&G information required at the TR and control stations shall be considered during the design of the system. The F&G control system shall be designed, located or protected so that it will be available in those emergencies where fire and gas detection is required.

11 Active fire protection

11.1 Objectives

- To control fires and limit escalation;
- To reduce the effects of a fire to allow personnel to undertake emergency response activities or to evacuate;
- To extinguish the fire where it is considered safe to do so;
- To limit damage to structures and equipment.

11.2 Functional requirements

Active Fire Protection (AFP) systems shall be provided in accordance with the requirements of the FES.

AFP systems shall be designed, installed and maintained in accordance with recognized standards which shall be relevant to the particular application.

If considered essential, AFP systems shall be located or protected so that they will be able to withstand the expected fire or explosion loading.

The discharge effects from an AFP system shall be considered in selection of the system for particular areas (for example, the effects of water on electrical equipment).

The capacity and discharge density (or application rate) of AFP systems and equipment shall be determined either by engineering evaluation or through use of a relevant recognized standard.

AFP systems and equipment shall be suitable for the intended duty and environment. Major components shall be of a type approved by a recognized testing authority. The conditions of approval shall be relevant to the intended operating environment.

All AFP systems and equipment shall be marked with easily understood operating instructions.

The response time for activation and reaching an operational state for all AFP systems shall not affect the ability of the system to fulfil its intended function.

For automatically initiated systems, a manual release station shall be provided and conveniently located outside the protected area.

The information required at the control station shall be considered in the design of the AFP system.

AFP systems shall be returned to service following use. Where systems cannot be immediately returned to service alternative actions to minimize the fire risks shall be considered and implemented where appropriate, before resumption of operations in the affected area.

NOTE The most effective way to limit escalation and damage is to detect and control fires at an early stage. In practice, fire control cannot be achieved until the source of fuel and ignition is isolated.

For some fire events, it may not be practical or necessary to provide AFP systems to extinguish the fire. In addition, extinguishment may create a greater hazard due to an increased potential for an explosion should gas from a release subsequently re-ignite.

12 Passive fire protection

12.1 Objectives

- To prevent escalation of the fire due to progressive releases of inventory, by separating the different fire risk areas;

- To protect essential safety systems;
- To protect critical components, such as separators, risers and topside ESD valves;
- To minimize damage to the installation by protecting the critical structural members, and in particular those members essential to the support of the TR(s), the evacuation routes to and from the TR(s) and other critical equipment;
- To encourage controlled collapse of tall structures to minimize the likelihood of collapse of structures and equipment onto TR/evacuation facilities;
- To protect personnel in the TR(s), until safe evacuation can take place;
- To protect any section of the escape routes to the TR(s) for a predetermined time to allow for safe escape from the area and allow for emergency response activities;
- To protect any sections of the evacuation routes from the TR(s) to the locations used for installation evacuation.

12.2 Functional requirements

Passive Fire Protection (PFP) shall be provided in accordance with the requirements of the FES.

PFP of essential systems and equipment or enclosures containing such systems and equipment shall be provided where failure in a fire is intolerable.

Where PFP is required to provide protection following an explosion, it shall be designed and installed such that deformation of the substrate caused by an explosion will not affect its performance.

Selection of the PFP systems shall take into account the duration of protection required, type of fire which may be experienced and the limiting temperature for the structure/equipment to be protected.

13 Explosion mitigation and protection systems

13.1 Objective

- To reduce to an acceptable level the probability of an explosion leading to unacceptable consequences.

13.2 Functional requirements

Measures to prevent, control and mitigate explosions shall be provided in accordance with the requirements of the FES. These measures should fulfil at least one of the following requirements:

- Reduce the probability of an explosion occurring.
- Control an explosion by mitigation techniques that reduce explosion loads to acceptable levels.
- Mitigate the consequences of an explosion and reduce the likelihood of escalation as a result of explosion loads.

As input to the FES, an evaluation of explosion loads and the associated probabilities of exceeding those loads shall be performed. Similarly, it is recommended to evaluate the probabilities of critical structures and equipment responding in an unacceptable manner to these explosion loads (e.g. by leading to escalation).

In particular, the evaluation used to develop the FES shall consider all areas where the potential for a gas or vapour-cloud explosion exists. The evaluation shall identify those systems required to maintain the integrity of the structure and the major equipment or piping systems. In particular, the possible benefits of using water deluge for explosion control shall be evaluated. The evaluation shall also identify the potential for escalation resulting from damage caused by blast overpressures which would impair the operation of the essential safety systems, and the effect of any fire which may occur after an explosion.

Functional requirements for passive explosion protection systems, when required by the FES, shall be expressed as pressure/loadings time histories, which are generated either from experimental/test data or from suitable computer models. The response calculations shall be accounted for in the dynamic analysis or other acceptable analysis methodology.

Where explosion mitigation measures are provided, they shall be designed to limit blast overpressures and/or to have adequate strength.

14 Evacuation, escape and rescue

14.1 Objectives

- To maintain the safety of all personnel when they move to another location to avoid the effects of a hazardous event;
- To provide a refuge on the installation for as long as required for a controlled evacuation of the installation;
- To facilitate rescue of injured personnel;
- To ensure safe abandonment of the installation.

14.2 Functional requirements

EER arrangements shall be provided in accordance with the requirements of the EERS.

The EERS shall be based on an EER assessment which considers the wide range of events which may arise and contain a viable approach for all these events.

The EERS shall also address issues such as organization, procedures, information, training and emergency response which are necessary to achieve a successful EER process.

Escape routes shall be provided to enable all personnel to leave an area when they are directly affected by an incident.

A command structure shall be established that will, so far as is reasonably practicable, remain effective throughout all stages of an emergency.

A place shall be provided where personnel can muster while investigations, emergency response and evacuation pre-planning are undertaken.

Communication systems shall be provided to allow personnel on the installation to effectively execute their emergency duties.

Arrangements shall be provided on the installation so that personnel can evacuate in an emergency and, if necessary, escape to the sea.

Arrangements for rescue and recovery of personnel who abandon the installation shall be selected to provide a good prospect of being able to safely transfer them to a place of safety.

15 Inspection, testing and maintenance

15.1 Objective

- To inspect, test and maintain systems and equipment covered by this International Standard to ensure that they are fit for purpose.

15.2 Functional requirements

As part of an overall HS&E management system, each operator shall establish effective operations, inspection, testing and maintenance procedures to ensure the functional requirements of the equipment and systems provided are maintained. This shall be achieved by implementation of suitable maintenance, inspection and testing schemes, taking due account of the safety of personnel, protection of the environment and compliance with any local regulatory requirements.

In order to provide effective procedures, it will be necessary for the following to be carried out.

a) Systems shall be subjected to appropriate testing prior to first use to confirm that they will meet the appropriate functional requirements.

b) A written scheme shall be prepared, detailing the inspection, testing and maintenance routines and frequencies to be followed.

c) All systems shall be thoroughly inspected, following established procedures. This will determine if remedial measures are needed so that the item inspected will function satisfactorily.

d) Adequate records of the results of the inspection, testing and maintenance shall be kept and shall be periodically reviewed to confirm that the written scheme is appropriate and is being adequately implemented.

e) The maintenance procedures shall include for regular visual inspection.

f) Appropriate operational tests shall be conducted.

g) The latest inspection/test report shall be available on the installation.

h) Use, impairment and restoration of equipment or systems shall be recorded and reported as appropriate.

i) Any identified failures or impairments shall be promptly corrected. Where equipment cannot be promptly returned to service, contingency plans shall be implemented.

Annex A
(informative)

Typical fire and explosion hazardous events

A.1 General

Whilst good techniques exist to calculate the loadings and responses to some of the hazardous events which may occur, others are still the subject of research. Users of this International Standard who need this information should consult references such as those issued by the SCI (Steel Construction Institute), SINTEF (Foundation for Scientific and Industrial Research, Norway), CMR (Christian Michelsen Research) and TNO (Netherlands Organization for Applied Scientific Research) for further details. Some of the key features of fires and explosions are given below.

A.2 Fire events

A pool fire is the turbulent diffusion fire burning above a horizontal pool of vaporizing hydrocarbon fuel under conditions where the fuel has zero or very low initial momentum. There is a degree of feedback between the fire and the fuel which controls the rate of evaporation and hence the size of the fire and other characteristics such as flame height and smoke production rates. A pool fire is not necessarily static and may spread or contract depending on the supply of fuel. Depletion of fuel can occur due to drainage or overflow to other areas, perhaps giving rise to running liquid fires. The fire has inertia in that it takes time to develop and cannot be eliminated quickly by isolating the fuel supply.

Running liquid fires are broadly similar to pool fires in that they rely on thermal feedback from the flame for their fuel vapour supply, but the liquid fuel is in motion and can be on surfaces of any orientation.

A jet fire in the open is a turbulent diffusion flame resulting from the combustion of a fuel continuously released with some significant momentum in a particular direction. In jet fires there is the absence of any direct feedback from the fire to the source. For fires in the open, this suggests that jet fire hazards can be treated more deterministically than pool fires, as the mass flowrate and the behaviour with time is determined to a large degree by the leak characteristics. Unlike pool fires, jet fires have minimal inertia and reach their full intensity almost instantaneously. In principle they can be turned off very quickly and thus isolation and minimization of inventory are important techniques to reduce the potential impact of jet fires.

A cellulosic fire is a fire involving materials such as rags, paper and wood. In addition, many surface linings used on walls, floors and ceilings give the same type of fire. The fire grows by heat transfer and flame spread. When the fire has developed, all three modes of heat transfer (convection, conduction and radiation) contribute to fire growth until there is no more flammable material. Compared to hydrocarbon fires, the development of cellulosic fires is slower and they do not usually reach such high temperatures.

The behaviour of all fires is changed by reduction in the ventilation from that available in the open. In the absence of all ventilation fires cannot continue to burn, but there are likely to be relatively few situations on offshore installations where this is possible. At intermediate levels of ventilation, knowledge of the effect on fire characteristics is limited but it appears that the extent of flaming, and hence the amount of equipment engulfed in the fire, can be significantly higher than for fires in the open. The concentration of carbon monoxide in smoke increases as the ventilation is restricted. Assessment of fire hazards should ensure that methods of prediction of fire size and heat transfer rates are validated and are relevant to the particular application.

A.3 Explosion events

An explosion is a sudden and violent release of energy, with a typical duration of the order of 1 s to 2 s. Any measures intended to control or mitigate an explosion must take this behaviour into account.

The violence of an explosion depends on the rate at which energy is released. In offshore design, two types of energy are considered, namely physical energy and chemical energy.

Physical energy may be represented as pressure energy in gases, strain energy in metals and electrical energy. A typical example on offshore installations may be failure of a fitting on high-pressure gas systems. Physical energy when released may cause blast effects but will primarily create projectiles, which may cause escalation if these cause damage to hydrocarbon-containing equipment.

Chemical energy is released following a chemical reaction, an example of which is the combustion of a premixed fuel/air cloud, creating the pressure build-up that might characterize an explosion. Chemical energy will create overpressure/impulse, drag forces and eventually projectiles from objects due to the overpressure and/or the drag forces. All these effects have to be considered in developing the FES.

Explosion overpressure will generally increase with increased confinement and/or congestion of the affected area.

The overpressure, drag forces and projectiles are capable of causing injury to personnel as well as causing structural failure and damage to plant and equipment unless appropriate action is taken.

A.4 Potential ignition sources

A.4.1 General

Ignition occurs when sufficient heat is present to cause combustion. Factors influencing resultant combustion from a given ignition source are temperature, exposure time and energy. Ignition sources that may be present in offshore installations are discussed in A.3.2 to A.3.9.

A.4.2 Chemical reactions

Chemical reactions may produce heat. This heat can ignite the substances reacting, products of the chemical reaction or nearby materials. An example of a chemical reaction that might occur on an offshore installation is auto-ignition of oil-soaked lagging on hot pipework.

Offshore facilities where hydrogen sulfide is present may develop pyrophoric iron sulfide as a product of corrosion of steel in the absence of oxygen. This is a highly reduced form of iron sulfide, which will convert to a more stable form on exposure to air with the release of heat which may cause the material to glow and ignite any hydrocarbon (HC) which may be present.

A.4.3 Electric sparks and arcs

An electric spark is a discharge of electric current across a gap between two charged objects. Although static electricity and lightning are forms of electric sparks, they are listed as separate ignition sources to emphasize their importance. Electric sparks from many of the electrical supplies on an offshore installation may contain sufficient energy to ignite a flammable mixture. An electric arc occurs when an electric circuit carrying current is interrupted, either intentionally as by a switch or accidentally as when a contact or terminal becomes loosened or a current-carrying conductor is broken. Sources of electric sparks and arcs can be the following:

— electric motors and generators;

— switches, relays and other arcing components of electric circuits under normal operating conditions;

— electric wiring and equipment malfunctions;

— electric arc welding;

— storage batteries;

— fired equipment ignition devices;

— internal combustion engine electrical systems;

— lighting fixtures;

— radio-frequency energy;

— impressed current cathodic protection systems.

A.4.4 Mechanical sparks

A mechanical spark is energy generated by mechanical friction created by metal tools and falling objects. This energy is likely to be high enough to ignite a flammable mixture.

A.4.5 Lightning

Lightning is the discharge of an electric charge on a cloud to an opposite charge on another cloud or on the earth. Lightning can develop very high temperatures in any material of high resistance in its path. Lightning tends to discharge to high points such as antennae and flare/vent stacks. The design of offshore installations usually ensures that lightning is not a major source of hazard except to some well operations involving explosives and at any unignited vent.

A.4.6 Static electrical sparks

If two objects are in close physical contact and then separated, the objects sometimes collect an electric charge through friction or induction. Similarly, electric charges can be generated by rapid flow of gases or liquids.

If the objects are not earthed, grounded or bonded, they may accumulate sufficient electric charges that a spark discharge may occur. These static electrical sparks are normally of very short duration and do not produce sufficient heat to ignite ordinary combustible materials, such as paper. Some, however, are capable of igniting flammable vapours and gases. This situation is more common in a dry atmosphere. Static electrical sparks may be a problem in situations such as the following:

— fuelling operations;

— filling containers, tanks and pressure vessels;

— high fluid exit velocities (high-pressure water sprays, gas jets);

— drive belt operation;

— shot blasting;

— steam cleaning;

— snowstorm.

A.4.7 Flame

When fuels are burned, energy is released in the form of heat. The burning is generally accompanied by a luminosity called flame. Examples of situations where flames may be present on an offshore installation are the following:

— hydrocarbon flaring;

— fired equipment (boilers, heaters);

— gas welding and cutting;

— engine operation (backfire and exhaust gases);

— personnel smoking;

— operation of heating and cooking appliances.

A.4.8 Hot surfaces

Hot surfaces can be a source of ignition. These sources may include the following:

— welding slag and hot metal particles (sparks);

— fired vessel stacks;

— hot processing piping and equipment;

— engine exhaust systems;

— high-temperature electrical devices, such as incandescent lighting fixtures or heating elements;

— frictional heat such as slipping belt against a pulley, un-lubricated bearings;

— heating and cooking appliances;

— clothes dryers and exhaust systems.

A.4.9 Heat of compression

If a flammable mixture is compressed rapidly, it will ignite when the heat generated by the compressing action is sufficient to raise the temperature of the mixture to its ignition point. Combustion as a result of heat of compression may occur when hydrocarbon vapours or gases are mixed with air under situations such as the following:

— improper purging of pressure vessels and other equipment when introducing hydrocarbons;

— packing or seal failure that allows supply air to mix with supply or process hydrocarbons;

— lubricating system failure in air compressors;

— admission of air into the suction of hydrocarbon gas compressors.

Annex B
(informative)

Guidelines to the control and mitigation of fires and explosions

B.1 Installation layout

The installation should be oriented so that, if there is a dominant wind direction, it will minimize the likelihood of a gas release or smoke drifting towards the accommodation and primary evacuation points. If ingress of smoke or gas into the accommodation is possible, the design of any ventilation system should be such as to minimize the likelihood of contamination of the inside of the accommodation and spaces occupied during emergencies.On installations where the accommodation is on the same structure as the processing facilities, consideration should be given to the appropriate siting of the accommodation to minimize the likelihood of impairment by fires and explosions. In some cases, locating the accommodation on a lower level of the installation may be appropriate.

The amount of venting available and the degree of congestion in the area of the explosion significantly influence the severity of an explosion.

Examples which illustrate the effect of module geometry on explosions are provided in B.10 and B.11.

In this respect, the following points should be considered.

a) Long and narrow modules containing pressurized hydrocarbon systems should be avoided, as large distance between possible ignition points and the vent can contribute to high over pressures. If long, narrow modules cannot be avoided, vents or open areas should be located in the longer walls;

b) Explosion pressure is dependent on blockage, so blockage should be reduced;

c) Repeated obstacles should be avoided. If this cannot be achieved, vent openings along the wall with the repeated obstacles should be provided.

Where explosion vents are provided, the vents should be located to minimize the distance between any potential source of ignition and the vent. The vents themselves should have the maximum possible free area. The arrangement of equipment in an area, and particularly near the vent, can have a major influence on the peak overpressures expected in an area.

Main evacuation routes, essential safety systems and vulnerable process equipment should not be located in the path of explosion vents, due to possible damage by blast effects and flying debris. Furthermore, such equipment should not be placed close to barriers which may be displaced in an explosion.

Cable trays, junction boxes, piping and miscellaneous equipment should not be allowed to block the explosion vents and reduce the free vent area, nor should they be located where they will increase turbulence and thus explosion overpressures.

Services for essential safety systems should be routed to ensure they will be able to perform their function in an emergency. If it is not possible to eliminate exposure to fires and explosions or to adequately protect them, routing by diverse paths may ensure adequate integrity for essential safety systems. Care should be taken to ensure that loss of part of a system will not jeopardize the whole system.

Risers and conductors should be designed and positioned or protected to minimize the likelihood of damage, including that due to ship impact and dropped objects.

Topsides riser ESD valves should be located as low down the riser as practicable, so as to minimize the likelihood of damage below the ESD and release of non-isolatable pipeline inventories. Alternatively, riser ESD valves may be protected to withstand the effects of such accidental loadings. Riser ESD valves should be located to allow access for operation, maintenance and inspection.

The installation design should consider how an ignited blowout can be handled should such an event occur on the installation. The design should consider the strategy for well killing and the role of any multipurpose support vessel which may be available. The ability of the blowout preventer (BOP) and diverter assemblies to perform their functions under major emergency conditions should also be addressed.

Effective ventilation of hazardous areas will aid dispersion of small releases, reduce the likelihood of flammable atmospheres accumulating and minimize the duration of any accumulations which do occur.

Ventilation systems supplying air to hazardous areas should take air from nonhazardous areas.

Ventilation discharges from hazardous areas should be located so that any emissions will not present a hazard to personnel during normal operations and under emergency conditions.

Where utilities, such as cooling water, are shared by process systems and equipment in nonhazardous areas, the utility system should be designed to prevent migration of flammable liquids and gases into nonhazardous areas.

B.2 Emergency shutdown and blowdown systems

ESD systems may be based on one or more of a range of technologies including PLC (Programmable Logic Controllers), electronic, electrical, pneumatic and hydraulic systems. Whatever configuration is selected, the functionality and performance should ensure that the system is capable of fulfilling its role as stated in the FES.

ESD systems should be designed in accordance with recognized codes or standards applicable to the area of operation. Methods of determining functional requirements for electrical, electronic and programmable electronic systems and guidance on how these functional requirements can be achieved are given in Parts 1, 2 and 3 of IEC 61508. Loss of power or key input signals should be considered in determining the reliability of the ESD system.

The impact of loss of power and by input signals on the functionality of the ESD system should be considered. In many applications this may require that the ESD system is inherently "fail safe", such that the system achieves a safe condition. For more information on hydraulic and pneumatic systems which may supply power for ESD system operation, see clause B.13.

Simplicity of operation and maintenance should be considered in system design.

The requirements for ESD actions with regard to drilling and well-servicing activities need special consideration. Manual initiation of ESD actions, which affect drilling or well-service operations, is usual.

Platform-based wells capable of flowing to surface should be separated from the platform by automatic downhole safety devices. ESD valves on incoming pipeline risers and well heads should be provided. The requirements for boundary isolations should also address the needs of any gas-lift lines. Riser ESD valves may need to be supplemented by subsea isolation valves to limit the duration of leaks associated with failure of a riser. The potential benefit of such valves including those on export pipelines, should be considered in developing the FES.

ESD valves within the topsides process systems may be required to limit the amount of hydrocarbons released on loss of containment, to separate systems with differing operating conditions, and to facilitate EDP system design.

Fast effective EDP may reduce the duration of jet fires to the extent that the need for, or the amount of active and passive fire protection (AFP/PFP) can be reduced or omitted for some events. Reduction in system pressure by EDP will also reduce the leakage rates. However, failure of an EDP system pipework, for example in an explosion, may result in the release of part of the installation's pressurized inventory into the area.

EDP may be initiated either manually or automatically, but automatic systems are generally preferred where a delay in initiating EDP presents a significant risk to personnel or the installation. A sequenced EDP may be required on some installations to limit the peak flowrates in the vent or flare system. Where sequenced EDP is used, the failure modes of the timer systems should be considered to ensure that the overall system integrity is adequate. For automatic EDP systems, it may be acceptable to provide a cancel facility to stop or delay the EDP if the operator decides that EDP is unnecessary or unsafe (e.g. due to helicopter operations).

The consequences of venting or flaring gas when EDP is initiated should be evaluated to confirm that this does not introduce any unacceptable hazard due to, for example, liquid carryover, high levels of heat radiation or flammable /toxic gas affecting personnel on the installation.

The provision of an EDP system may not in itself be sufficient to prevent vessel failure if a vessel is engulfed in a fire. Protection provided by EDP systems will normally only be effective if the EDP is initiated at the earliest opportunity, which is likely to require automatic initiation by the fire and gas detection (F&G) system. Where an assessment indicates that such pressure vessel failures present a significant risk, additional forms of protection such as AFP/PFP should also be considered.

ESD and EDP valves should be accessible and equipped with position indicators locally and where appropriate. Valve-position indication should also be available at the control station.

The maintenance and testing requirements should be addressed during the design, and the necessary facilities to allow these activities without significantly reducing the level of safety should be provided. If maintenance and testing are not possible without significantly reducing the functionality of the system, special precautions and procedures should be developed to maintain an equivalent level of safety. In some cases this may require that maintenance and testing operations are only performed when the installation is shut down.

B.3 Control of ignition

Potential ignition sources are described in annex A.

Ventilation rates in open installation will vary considerably with weather conditions and layout. Consideration of a mixture of free and forced ventilation may be necessary.

In undertaking a hazardous area classification of the installation, the main factors affecting the zoning and the extent of the zones are the source and grade of release, the characteristics of the fluid released and the ventilation in the area of the release. Hazardous-area classification is intended to be applied when there may be a risk of ignition due to the presence of flammable gas and vapour mixed with air under normal conditions. It does not address major releases. The extent of each hazardous area or zone shall be determined using a recognized standard, such as IEC 79-10, Part 15 of the Institute of Petroleum Model Code of Safe Practice or API RP 500.

The rate of ventilation will influence the zoning. The effect of loss of forced ventilation or the frequency of periods of low natural ventilation should also be considered and, if appropriate, the precautions identified to deal with the consequent change in zone rating. Pressure differentials created by ventilation systems are also important in limiting gas spread.

Ventilation rates for enclosed hazardous areas should take into account the amount of gaseous hydrocarbons which may be expected in normal operations, although some area classification codes contain minimum air change or velocity requirements which may also be used. Air intakes for nonhazardous areas should be positioned as far as reasonably practical from hazardous areas.

All electrical equipment shall be suitable for use in the area in which it is installed.

Consideration should be given to minimizing the amount of electrical equipment installed in hazardous areas.

Electrical equipment outside the TR and control station which is required to operate during a gas emergency should be suitable for operation in a flammable gas atmosphere. If essential electrical equipment remains energized in an emergency, facilities should be provided to isolate it manually or automatically. Consideration should be given to tripping, either automatically or manually, all nonessential safety equipment once gas is detected in nonhazardous areas.

Nonelectrical equipment and hot surfaces may also be potential ignition sources. Precautions, such as automatic shutdown, should be provided to prevent ignition if a gas release should occur while the equipment is in use.

Diesel engines may provide a source of ignition for flammable vapours and also create a hazard by overspeeding through ingestion of flammable vapours. Diesel engines located in hazardous areas should be designed and installed in accordance with a recognized standard, such as EEMUA 170.

Diesel engines in nonhazardous areas powering essential safety systems should be provided with protection such that the diesel engine can continue to operate if gas can realistically reach the area in an emergency. This may include isolation of non-suitable electrical components, over-speed protection and, possibly, cooling of hot surfaces.

Gas turbine acoustic hoods contain potential ignition sources and hydrocarbon sources of release in close proximity. Provisions shall be made to supply ventilation air from a nonhazardous area at sufficient flowrates to remove heat from the surface of the equipment, to dilute any small leaks of flammable gas, and to purge the enclosure prior to start-up. Alternatively, inerting systems may be considered as a means to prevent ignition under a turbine acoustic hood if the ventilation system may shut down on gas detection. If inerting systems are used, it is vital to ensure that the turbine hood remains effectively sealed until any ignition source inside the hood are effectively disabled.

The integrity of physical barriers between hazardous and nonhazardous areas is important to prevent gas migration to nonhazardous areas. Penetrations between such areas should be kept to a minimum and any penetrations for piping, cables, ducts, etc. should be adequately sealed. For heating, ventilation and air conditioning (HVAC) penetrations, dampers where provided, or ductwork should be of the same fire integrity as the boundary through which any ductwork passes.

Portable or temporary equipment for use in hazardous areas shall be suitable for use in such areas. Where this is not possible, additional precautions should be introduced to minimize the likelihood that this equipment will ignite a release of hydrocarbons.

B.4 Control of spills

The capacity of the drainage system should be sufficient to handle credible spill coincident with deluge and/or fire-fighting activities. The design of drainage systems should make allowance for possible blockage which may restrict the capacity of the system. When a drainage system is provided, it should be designed to prevent burning fuel spreading fire to other areas.

Separate larger drainage systems may be necessary to control major releases and any associated firewater. In order to limit the size of drainage recovery systems it may be acceptable to provide firewater drains which discharge fire-water directly to the sea.

Consideration should be given to the role of the drainage system to prevent a major hydrocarbon spill accumulating under vessels or contaminating lower levels of the installation.

Consideration should be given to the need to prevent fires spreading to sea level where they may affect the integrity of the installation-supporting structure and impede evacuation.

Helidecks should be designed to quickly remove spills of aviation fuel from the vicinity of the aircraft without impeding the escape routes.

On some installations, hazardous and nonhazardous open drains may terminate in a common caisson or sump. This is acceptable providing that backflow into the nonhazardous open drains is prevented, for example by routing the drainpipe below sea/liquid level. Where such an arrangement is used, care is needed to ensure backflow does not occur due to corrosion of nonhazardous drains pipework.

Kerbs or drip-pans should be provided around vessels, pumps and other potential sources of leakage to limit the spread of small spills.

Storage arrangements for movable containers of flammable liquids or gases should take account of the possibility of leaks or spills and measures for handling these should be in place.

B.5 Emergency power systems

Emergency electrical power may be provided by one of the following systems:

— an emergency generator;

- installation mains power generation providing it can reliably provide power under emergency conditions;
- cables with suitable integrity from land or other installations;
- battery systems;
- or some combinations of these.

On small simple installations it may be possible to rely entirely on battery systems.

More details of typical emergency electrical power requirements are given in clause C.1.

Consideration should be given in the design of the emergency power system to ensure that there will be adequate arrangements to provide a reliable source of power during maintenance of the emergency power system. The design of the emergency electrical power system should consider providing automatic-start arrangements to avoid the need for manual intervention during emergency condition.

Emergency lighting should be provided on routes which may be used for escape and evacuation and for those places where personnel will muster. Where emergency lighting is predominantly supplied from an emergency generator, a portion of the light fittings should also have battery backup.

In order to manage evacuation of the installation radio communications are required. Emergency communications equipment with independent battery supplies should be provided.

The duration of the uninterruptable power supply (UPS) to systems such as the emergency lighting, F&G system, emergency communications, ESD systems etc. should be designed to cater for the emergency conditions which may be experienced. Where UPS systems are selected they should provide power for a period considerably longer than the TR endurance time to cater for those events where immediate evacuation is unnecessary or not practical.

The navigational aids should be provided with independent battery supplies.

Cabling for systems supplied with emergency power should be of a standard that will allow the system to operate long enough to perform its role under the conditions which may be experienced when the emergency power is required and should be routed to minimize damage.

Deluge-control valves and other critical valves may be held in the closed position by the instrument air system. In a major gas emergency, mains power generation may stop, resulting in the loss of the instrument air compressor(s). If the integrity of the air supplies cannot be guaranteed, the need to power an air compressor from the emergency generator should be considered. Similar considerations are relevant for hydraulic system.

B.6 Fire and gas detection systems

The issues which should be considered in determining the control actions initiated by the F&G system include:

- isolate the installation from the reservoir and pipelines;
- initiate EDP;
- isolate electrical equipment to prevent further development of electrical fires;
- initiate shutdown of ventilation system to minimize ingress of smoke or flammable gas;
- initiate isolation of electrical equipment and other potential ignition sources upon detection of flammable gas to minimize the risk of ignition;
- initiate AFP systems where these have been provided to control or mitigate hydrocarbon fires;
- initiate muster of personnel.

The number and location of fire detectors should be suitable to ensure timely detection of fires, taking into account the potential for escalation of fires in the area.

Different types of gas detector have different sensitivities to the range of hydrocarbon which may be experienced. The calibration should be based on the relevant range of hydrocarbons.

Multiple alarm levels for gas detection may be used to allow investigation or limited control action at low gas levels without stopping production.

F&G detectors should be subject to a regular maintenance and testing programme. The design of the F&G system field devices should consider the requirements for maintenance in order to minimize the need to provide special access arrangements for calibration, cleaning or testing.

Information on the level or quantity of gas present in an area should be available at a control station.

Where toxic gas detection is required for personnel protection, consideration should be given to the integration of the system into the overall F&G system.

The F&G system should be capable of operating under the conditions to be experienced at the time that the F&G detection is needed.

The F&G system should contain test facilities. Faults of detection systems should, once detected, raise an alarm at a control station.

Following the installation of the F&G system there should be a review to confirm that the layout of detectors is able to provide an adequate response.

Manual call points should be provided at convenient locations around the installation, to allow personnel to initiate an alarm of a hazardous situation and allow rapid initiation of any necessary control actions.

Where there is a likelihood of smoke and flammable or toxic gas affecting the TR, the F&G system should be designed to provide signals to allow effective shutdown of ventilation systems before impairment of the TR occurs.

F&G detection systems should be designed in accordance with recognized codes and standards applicable to the area of operation to achieve the level of performance stated in the FES. Methods of determining requirements for electrical, electronic and programmable electronic systems and guidance on how these requirements can be achieved will be given in Parts 1 to 7 of IEC 61508. Loss of power or key input signals should be considered in determining the reliability of the F&G system.

Where provided, the F&G system should be designed to perform the following functions:

a) Monitoring

— to detect hazardous accumulations of flammable gases/oil mist;

— where considered necessary, to detect leaks (e.g. near pump seals);

— to detect fires at an early stage;

— to detect ingress of smoke and flammable gas into places where they may present a hazard;

— to permit manual initiation of alarm.

b) Alarm

— to indicate the location of any fire or hazardous accumulation of flammable gaseous or oil mist;

— to immediately alert people of possible fire or gas incident.

c) Control action

— to immediately initiate appropriate control actions.

Clause B.7 gives guidance on audible and visual alarms being adopted in some parts of the world for alarm harmonisation.

Clause C.2 gives typical applications of fire/gas detectors.

B.7 Typical audible and visual alarms

The following guidance on audible and visual alarms is being adopted in some offshore operating locations, in an attempt to harmonize alarms across all installations operating in that area.

The primary alarm should be audible, supplemented by flashing beacons in high noise areas.

Table B.1 — Alarms

Alarm type	Primary	Supplementary
Muster	Intermittent signal of constant frequency	Flashing yellow
Prepare to abandon	Continuous signal of variable frequency	Flashing yellow
Toxic	Continuous signal of constant frequency	Flashing red in affected area

B.8 Active fire protection

B.8.1 General

Initiation of AFP systems may be automatic, manual or both. The means of activation will depend on the expected location, size and type of fire, and the fire-response strategy for the installation.

Many considerations will influence the selection of AFP systems, e.g. the size and complexity of the installation, the nature of the operations, availability of external fire-response equipment, and the fire-response strategy adopted by the operator.

The guidelines in B.8.1 to B.8.12 are not intended to imply that all of the AFP systems described will be needed on a particular installation.

Clause C.3 provides guidance on the selection of AFP systems for typical areas on a large, manned installation, and also gives examples of application rates of water-based AFP systems.

B.8.2 Fire-water pump systems

The fire-water pump system should be selected to deliver the pressure and flow required for the operation of water-based AFP systems (deluge waterspray, monitors, hoses, etc.) sufficient to meet the role of these systems as defined in the FES. This will typically be the single largest credible fire area (if deluge/waterspray systems are installed), plus any anticipated manual fire-fighting demand (monitors/hose streams). Where required in the FES, allowance should be made to cope with escalation of the fire to adjacent areas.

The fire-water pumps, their prime movers and starting arrangements should be designed so as to operate for a minimum period sufficient for them to fulfil their functions.

The speed of response of the fire-water pump unit should be selected so that fire-water is made available to the systems which use fire-water in time for them to fulfil their function.

The FES should identify the number of fire-water pumps required and the arrangement necessary to provide a reliable supply of fire-water. This should consider situations such as when a fire-water pump unit is unavailable due to maintenance or breakdown. On normally manned installations this may require at least two independent pump units.

If more than one fire-water pump is provided, fire-water pump units should be designed to minimize the risk of common mode failures occurring during emergencies. Pump inlets should be separated such that in the event of an incident rendering a pump inoperative, the other pump unit(s) will not be affected.

Suitable arrangements should be provided to allow verification of fire-water pump system performance over the full range of the fire-water pump curve.

Fire-water pump stop should be local only. Except during testing, any alarms from pump monitoring systems should not automatically stop the fire pump.

Fire-water pumps should normally have two different means to start the pump automatically.

Fire detection at the fire-water pump should not stop the pump or inhibit the start of the fire-water pump driver. Confirmed hydrocarbon detection in the air inlet of the driver should inhibit the pump start.

If not running continuously, the system should be designed to start automatically in a fire emergency. In addition, facilities should be provided for local and remote manual start of the pumps.

If the connection to the control room is lost, the fire-water pumps should start automatically.

The fire-water pump system should be located, or protected, so that it is able to supply water in a fire emergency. Protection against damage of associated power cables, hydraulic/piping and control circuits should be considered.

Fire-water pump units required to operate when gas is present should be designed to be suitable for such operation.

Water treatment may be necessary to prevent marine growth from impairing fire-water system performance. The requirements for inlet filtration should be considered where debris may damage the pump.

Sufficient instrumentation (both local and, where appropriate, remote) should be provided to enable personnel to ascertain the operational status of any pump unit.

The provision of relief devices or other arrangements may be required at the pumps to prevent damage to pipework due to high operating pressures or surge. Such devices should reset automatically once the excess pressure has been relieved.

B.8.3 Fire-water mains

Fire-water mains are the means by which water for fire-fighting is transmitted from the fire-water pumps to the points of use. The fire-water mains should be designed to provide an adequate amount of water to the discharge points at the required pressure.

Fire-water mains may be dry or filled. The speed of response required should be considered to determine if the fire-water mains should be filled and pressurized.

In developing the FES, incidents which could result in damage to the fire mains should be considered. Where necessary, fire-water mains should be routed or protected to avoid such damage. The design should consider whether arrangements are necessary to provide adequate fire protection when a section of the fire mains is isolated due to damage or maintenance.

Fire-water mains should be equipped with an adequate number of shut-off valves to allow sections of the mains and branches from the mains to be isolated. Easy access for operation of these valves should be provided.

Fire-water mains should be designed using a recognized technique for the hydraulic analysis of this system.

The operation of systems connected to the fire mains may lead to significant surge pressures, which may damage pipework and equipment. The need for surge protection should be considered in the system design.

Options to avoid surge problems should be investigated before surge-protection measures are considered.

Suitable provision should be made to protect fire-water mains against freezing during low ambient-temperature conditions. However, care is needed to ensure that such provisions do not introduce a problem of corrosion under any insulation provided.

The fire-water mains should be provided with suitable arrangements to permit testing of the pump units and the fire-water mains under full operating conditions to determine any deterioration in efficiency.

Selection of piping and valving materials and their proper installation is critical to the integrity and reliability of a fire-water system.

Materials readily rendered ineffective by heat should not be used for dry fire-water mains and fittings, unless provided with adequate fireproof insulation or otherwise protected.

B.8.4 Fixed deluge systems

Fixed deluge systems may be provided to:

- control pool fires and thus reduce the likelihood of escalation;
- provide cooling of equipment and structures not impinged by jet fires;
- provide a means to apply foam to extinguish hydrocarbon pool fires;
- limit effects of fires to facilitate emergency response and EER activities.

The four broad types of deluge protection include:

a) area protection designed to provide non-pecific coverage of pipework and equipment within hydrocarbon-handling areas;

b) equipment protection designed to provide dedicated coverage of critical equipment such as vessels and well heads;

c) structural protection designed to provide dedicated coverage of structural members;

d) water curtains to reduce thermal radiation and to control the movement of smoke in order to provide protection to personnel during escape and evacuation.

Fixed deluge systems should be designed using a recognized technique for the hydraulic analysis of these systems.

The speed of response required for a deluge system to fulfil its function should be determined and the system should be engineered accordingly.

The water pressure available at the inlet to the system or an individual section should be sufficient for the efficient operation of all nozzles in that system or section under design flow conditions.

The types of deluge nozzle selected and the location of these nozzles should be suitable to fulfil the role of the system during the fire events and the environmental conditions which may occur.

The sizes of nozzle and associated pipework should be selected to avoid blockage caused by corrosion products or build-up of salt deposits after operation and testing. Self-draining design is an important feature in this respect.

The location and orientation of deluge nozzles should be defined so that the required quantity of water will impinge on surfaces to be protected. Due account should be taken of the effects of obstructions and air movements on the stream of droplets.

For systems where local manual initiation is unlikely to be adequate, remote operation should be provided from a control station at which the operating status of the system (e.g. deluge valve open/closed) is indicated.

Isolation of any automatically operated deluge system should be possible by means of a manually operated valve located outside the protected area.

Piping should be designed to be robust and should be adequately secured and supported. The effects of surge should be considered. Consideration should be given to protecting deluge pipework against the effects of fires and explosions.

Means should be provided to enable the testing of deluge valve performance without discharging fire-water through the pipework and nozzles.

Fixed deluge protection should be considered for temporary equipment such as well test packages. The design of the installation fire-water pumping system should consider the needs of any anticipated temporary deluge systems.

B.8.5 Water-mist systems

Water-mist systems are an alternative to gaseous systems in some applications. Applications in relatively small compartments are well documented, but local application in large compartments or in the open is limited to well-defined fire situations. Local application requires even distribution of water and an appropriate droplet size distribution.

The mechanisms by which the water-mist extinguishes a fire is by the action of heat extraction and oxygen displacement within the flame. It is necessary for the water-mist to interact with flaming fires of a certain size to obtain a protection similar to gaseous extinguishing systems.

Considerations which should be addressed in evaluation of the use of water-mist systems include:

— suitability of the system for the particular application;

— provision of a suitable water supply and air supply, if needed for the particular system;

— the size of the protected area and the degree of congestion;

— the fuel type and the nature of the fires which may be experienced;

— the effect on electrical and other sensitive equipment within the area of water-mist application.

B.8.6 Foam systems

Foam-forming additives can significantly increase the effectiveness of water in controlling liquid hydrocarbon pool fires. A fire-fighting foam is a stable aggregation of small bubbles, of density lower than water or oil, having a tenacious ability for covering and clinging to horizontal or inclined surfaces. It has the capability of flowing freely over a burning liquid surface, cooling the liquid and forming an air-excluding, continuous blanket to seal volatile combustible vapours from access to air.

Foams are ineffective for fires such as pressurized oil/gas jet fires where smothering effects cannot be achieved.

Foams may be employed using hose stations, fixed systems, portable extinguishers or fixed monitors. The foaming agent may be applied by directly by introducing foam concentrate into the fire-water system in fixed proportions, or may be applied as a premixed solution of concentrate and water.

Where foam concentrates are introduced directly into the fire-water system, the method of proportioning should provide sufficient accuracy so that the required performance is obtained over the full range of flows and pressures which may occur in the fire-water system.

The foam concentrate selected should be suitable for use on the flammable liquids present in the protected area, in the expected environmental conditions and if appropriate through non-aspirating nozzles. Where foam concentrate is injected into the fire-water main it should be of a type which is compatible with sea water.

Where provided, the foam pump, its sources of power supply, foam concentrate and means of controlling the system should be readily accessible, simple to operate, capable of being put into operation rapidly and located/protected so that it will be able to operate when required.

Central foam systems should not be utilized as the primary source of supply of foam solution to hand-held equipment as accurate proportioning cannot be guaranteed at low flowrates.

The foam concentrate should conform to a suitable standard and should be suitable for use and storage at anticipated ambient temperatures. The foam generated should also be compatible with dry powder.

B.8.7 Automatic sprinkler systems

Automatic sprinkler systems are typically used in areas where fires are expected to involve cellulosic fuels, and where slow fire growth is expected. Once initiated sprinkler systems can be effective to control fire spread, to reduce fire and smoke damage and to provide alarm at a control station. They are not normally suitable for extinguishing fires in flammable liquid spills which can spread rapidly over large areas and exceed the capacity of the sprinkler system.

Automatic sprinkler systems should be connected to a water supply pressurized so that the system is capable of immediate operation and no action by personnel is necessary.

The standing charge in the system should not be seawater, due to potential corrosion problems and salt accumulations at the sprinkler head.

A means should be provided to indicate the pressure of the standing charge in the system and to alert personnel if the pressure drops to a predetermined low level.

Where an automatic sprinkler system is connected to an unpressurized main, it should have a reliable supply of water available with sufficient capacity to provide protection until the main is pressurized. Automatic supply from a pressurized fire main or deluge main which activates upon drop of pressure in the sprinkler system may be an acceptable water supply arrangement.

If sprinklers are provided in cooking areas, they should be prevented from impinging directly on to equipment used for heating cooking oil or fat. Electrical power supply to the galley should be switched off automatically in the event that the sprinkler system is operated.

Facilities should be provided to enable each part of the system to be drained and tested and to remove all air from water-filled systems.

For large sprinkler systems, consideration should be given to dividing the system so that each section can be monitored to indicate which section has operated.

B.8.8 Monitors

Fire-water monitors may be used to provide water-spray coverage or apply water-foam solution. They may also be provided to supplement fixed deluge systems.

The design of monitors should consider location, size of supply piping, arrangement of control valves.

Monitors may be operated either remotely or locally.

Monitors arranged for local operation should be provided with an access route, which is remote from the part requiring protection and so sited as to protect the operator from the effects of radiant heat, unless the monitor is also automatically/remotely operated.

Each monitor should have sufficient movement in the horizontal and vertical planes to permit the monitor to be brought to bear on any point of the part protected by that monitor. There should be means for locking the monitor in position.

Each monitor should be capable of discharging under jet and spray conditions. The locations and discharge characteristics of the monitor should be selected to suit the role and exposure protection required from the monitors and the local environmental conditions.

Monitors which can be remotely actuated should be arranged so that they cannot cause injury or impede escape routes when operated. Local manual override controls should be provided.

B.8.9 Hydrants and hose reels

Nozzles and hoses (and portable foam equipment if used) should be located in the most suitable positions considering the probable direction of approach of fire teams.

Where appropriate, enclosures should be provided to protect this equipment against mechanical damage and against the environment.

Fire-water mains should be equipped with hydrants to which hoses can be connected and/or provided with fixed hose reels. The number and position of hydrants/hose reels should be sufficient to permit effective fire-fighting by the Emergency Response team.

Where hydrants and hose reels are supplied by a fire-water main, the system should be designed so that the pressure available will allow safe operation of such equipment at the maximum pressures which may be present in the fire-water main.

Pressure-control devices should be provided where standing pressures can pose a hazard to hose-handling personnel.

Consideration should be given to the provision of suitable foam-making equipment and concentrate for use with hydrants and hose reels.

Hoses, nozzles, valve keys, etc. should be stored adjacent to hydrants. Couplings should be standard throughout the installation. Nozzles should be of robust construction, easy to operate and made of materials suitable for the intended duty.

Hydrants and hose reels should not be supplied from the same section of a fire main as a deluge or sprinkler system protecting the same area.

B.8.10 Dry chemical fixed systems

Dry chemical fire-fighting systems can provide an effective means for extinguishment. A major advantage is their self-contained feature which provides for protection without reliance upon an external energy source. The nature of potential fires should be carefully considered in selecting and sizing the type of dry chemical and equipment.

Dry chemical from fixed systems may be applied from hand hose line or fixed nozzle systems. To cover several areas with a single supply of agent, hand hose lines with local actuators may be connected by rigid piping to a single dry-chemical supply. A major disadvantage of using a single large supply unit for fire protection is the loss of fire-fighting capability if the unit malfunctions (e.g. due to compaction of the powder or nozzle blockage) or is damaged. This disadvantage may be overcome by using several smaller units.

Dry chemical systems provide no security against re-ignition, and it is also possible to have an explosion due to the subsequent build-up of a flammable atmosphere following the extinguishing of jet fires or those involving volatile liquids.

The discharge of dry chemical and expellant gas is a two-phase flow, and the flow characteristics depend upon the particular dry chemical, expellant gas and equipment being used. Therefore, it is important to use the manufacturers' data which have been established by investigation and tests when designing the piping.

When dry chemical and foam extinguishing agents are expected to be used at the same location, compatibility should be confirmed. Combined-agent self-contained systems are available for simultaneous use or sequential use of foam and dry chemical. Such systems offer the advantages of a rapid knockdown by dry chemical and the securing ability of foam.

B.8.11 Gaseous systems

Gaseous systems may be used to extinguish fires or, at higher concentrations, to inert a space and prevent ignition.

Gaseous extinguishing agent systems have traditionally been used for electrical equipment areas or areas which could be damaged by water or dry chemicals. Before selecting a fixed gaseous system, consideration should be given to the fire risk, the segregation from adjacent area or other approaches which may be appropriate for the identified possible fire events. Examples of such approaches are: sensitive F&G detection, isolation of power and rapid manual intervention.

Carbon dioxide and halogenated hydrocarbons have commonly been used in fire-extinguishing systems. Halogenated hydrocarbons are being phased out due to environmental concerns and should not be used in new applications. New gaseous extinguishing agents are being developed and may be considered where gaseous extinguishing is found to be required, providing the gaseous agent selected is suitable in terms of fire-fighting effectiveness, toxicity to personnel and effects on the environment.

The discharge of any gaseous extinguishing agent may expose personnel to a combination of noise, turbulence, high velocity and low temperature.

The use of some gaseous agents in enclosed areas can produce an oxygen-deficient atmosphere which may adversely affect human health. Such an atmosphere could produce dizziness, unconsciousness and eventually death, if personnel remain in the area. Although some gaseous extinguishing agents have a low toxicity during fire, their decomposition products can be hazardous. Where such hazards are confirmed, appropriate safety measures should be implemented.

If admission of a gaseous agent could be harmful, then the feed pipe on such total flooding systems should be provided with an isolating valve arrangement which will be closed before personnel enter the area.

Automatic discharge of gaseous extinguishing agents should be inhibited when personnel are in an area, if there is a likelihood of harm to the personnel as a result of the discharge.

Means of initiating the systems should be readily accessible and simple to operate. Where systems are arranged for remote and/or automatic release, they should also be capable of manual operation with manual release points located at strategic points, generally at the control valves and at entries to the protected space.

Where appropriate, the system should be monitored to enable the detection of faults which may affect the operational efficiency of the system.

Clear audible and, if necessary, visual warnings should be given automatically within the space both prior to and during release of the system.

Visual indication of system status should be provided at each entry point to the protected space.

Enclosure boundaries should be designed so that an extinguishing concentration can be maintained for a minimum period as identified in the FES. Means should be provided for automatically stopping all ventilation fans and closing openings serving the protected space before the agent is released.

Where a gaseous extinguishing agent system is provided for ventilated machinery rooms, the discharge period should be extended to allow for losses during the shutdown of the machinery and automatic gastight dampers should be provided on all ventilation ducts.

Discharge nozzles should be so positioned that a uniform distribution of the extinguishing agent is obtained.

If a static electricity hazard may exist when discharging a gaseous extinguishing agent, then consideration should be given to grounding nozzles and objects exposed to the gaseous extinguishing agent.

B.8.12 Mobile and portable fire-fighting equipment

Mobile and portable fire-fighting equipment are intended as a first line of defence against fires of limited size and should be provided even when other AFP systems are provided.

Suitable extinguishers should be provided such that personnel in an area have ready access to permit rapid intervention while fires are still in their incipient stage. Various standards, such as API RP 14G, contain guidance on the number and location of portable fire-fighting equipment.

The extinguishing media for portable fire extinguishers should be appropriate to the anticipated type of fire. Particular attention should be paid to the distribution, siting and visibility of portable extinguishers in order that they are accessible and can be clearly distinguished. Extinguishers should be clearly marked, to identify the extinguishing medium contained, and the type of fire for which it is suitable. Extinguishers should be provided with suitable means for mounting.

Portable fire extinguishers containing an extinguishing medium which, either by itself or under expected conditions of use, gives off toxic gases in such quantities as to endanger persons should not be used.

Portable fire extinguishers should be simple to operate and be designed in accordance with a recognized standard which is suitable for anticipated environmental conditions.

Means should be provided to control the discharge of mobile extinguishers.

Suitable arrangements should be made for mobile extinguishers to accommodate the hose so that the hose can be handled quickly and will not kink.

Mobile extinguishers should be fitted with discharge hoses of length sufficient to reach any part of the protected area. The hose should not be of such length as to preclude efficient discharge of the extinguisher's contents.

B.8.13 Helideck fire protection

The type and quantity of fire-fighting equipment should be based on the types of fire which may occur and should be summarized in the FES. Protection requirements may vary depending on helicopter types, the size of facility, the manning arrangements and the area of operation. Existing practices include portable fire extinguishers, local dedicated foam systems and foam monitors connected to the fire main. Helidecks should comply with the standards of any authority having jurisdiction for the helideck, as well as International Civil Aviation Organization (ICAO).The helideck fire protection should be designed to deal with fires on the helideck without placing helideck crew in undue danger.

Typically on manned installations, AFP systems suitable for fires involving aircraft engines, crash incidents or fuelling activities should be provided. Fire-extinguishing equipment should be readily accessible at the helideck. Where fire-water is required, location of fire-water pump start facilities should be considered at each helideck emergency response location, and the supply arrangements should ensure that there will be no interruption in fire-water supply during fire-fighting.

A central foam system which injects foam concentrate into the fire-water mains at the fire pump discharge should not normally be used as the primary means of helideck protection, unless it can be shown that the delay in the fire-water/foam solution reaching the helideck foam monitors is acceptable. Such a central foam system may, however, be used as a back-up system for protection of the helideck, should the dedicated helideck foam system be unavailable. Central foam systems may be used if foam is immediately available for induction at the helideck foam system.

Where foam is applied by means of fixed monitors, sufficient monitors should be provided, spaced at approximately equal distances around the helideck.

B.9 Passive fire protection

B.9.1 General

Screening evaluations of credible fire scenarios may be sufficient to determine the passive fire protection (PFP) requirements without more detailed calculations. These evaluations may show that certain fire scenarios are beyond the capability of essential safety systems. It may then be necessary to undertake risk evaluation to evaluate whether it is reasonably practicable to provide additional PFP for these cases or to use some other approach to prevent, control or mitigate the identified fire hazardous events.

Annex C provides guidance on typical PFP applications for enclosed offshore installations. On small, open-type offshore installations PFP is not as widely used, but should be considered in the developing the FES.

Fire-resistance tests may be undertaken by the manufacturer as part of general approvals and by the operator for a specific application.

B.9.2 Fire-resistance test criteria

The fire-resistance test should be based on exposure to an established fire time-temperature curve or a simulated fire test, appropriate for the expected type of fire. The expected fire may be a jet fire, a pool fire or a cellulosic fire.

The standard fire tests for cellulosic and hydrocarbon fires are limited by the size of the furnace in which they are tested. Hence it is important to take into account, in the planning of a test, the important details of the objects being protected.

The standard fire tests represent a variety of fire situations and will normally give the tested object a more severe impact than many accidental fires. However, the limited scale of the test means that caution should be used when extrapolating to very large applications, when failure modes not revealed by the test may occur. Some important fire types, such as jet fires with high momentum and efficient combustion, may exceed the conditions experienced in a standard test. Test procedures for jet-fire impingement are now being developed to include procedures for small structural sections and bulkheads.

An actual fire may have characteristics different from those which can be reproduced in a fire test. If critical, an alternative approach to demonstrate that a particular system is adequate should be developed. This may require 'ad hoc' tests or demonstrations to be undertaken.

It must be stressed that many important parameters concerning the fitness of PFP materials or systems are not taken into account in the standard tests and in the reporting of the test. Such parameters include resistance to different environmental conditions, ageing and mechanical impact.

Functional requirements for PFP materials include the period of resistance, expressed in time, to a certain fire exposure before the first critical point in behaviour is observed.

The functional requirements of PFP barriers may be split into three categories:

- Stability to maintain the load-bearing capacity (structural capability) of a structural member or a fire barrier;
- Integrity to maintain the integrity of a fire barrier by preventing the transmission of flame, smoke, hot and toxic gases;
- Insulation to keep the unexposed side of a barrier cool when the other surface is exposed to a fire.

Standard fire tests should be used to qualify PFP materials and systems. ISO 834 is a recognized standard for testing of PFP performance in cellulosic and pool fires. There is no recognized fire test at present for jet fires, but a small-scale interim fire test procedure is given in OTI 95 634.

Consideration should also be given to resistance to explosion effects, when establishing the functional requirements for PFP materials.

B.9.3 Selection of materials

The selection of the different materials should consider the type and size of fire, the duration of protection, the environment, application and maintenance, and smoke generation in fire situations.

PFP materials should be approved for their intended use. Where general approvals from a recognized third party or governmental body are not available, their fire performance should be documented by test reports from a recognized fire test laboratory.

Interpolation of test results for the optimization of the quantity of material to be applied should be documented.

Documentation for a passive fire-protection material can vary according to the type of application and may include:

a) quality control aspects:

   — verification of application temperatures and humidity requirements,

   — installation time,

— inspection and control requirements,

— surface preparation;

b) mechanical tests:

— abrasion and impact damage,

— mechanical damage,

— destructive compression,

— sea-water absorption,

— flexure,

— adhesion and vibration,

— deluge and hose-stream resistance;

c) corrosion protection:

— corrosion protection properties and inspection requirements for substrate,

— effects of temperatures and thermal shocks,

— cathodic disbondment,

— ozone and/or ultraviolet ageing,

— ease of reinstatement following inspection of substrate;

d) fire resistance tests:

— cellulosic fire performance,

— hydrocarbon fire performance,

— jet fire performance,

— fire spread characteristics,

— combustion products;

e) long-term performance/weathering;

f) explosion resistance;

g) full-scale experiments where limitations of tests are obvious;

h) occupational health aspects.

The test requirements should not be defined by the above. The need for each type of test should be based on engineering judgement and expected usage. For example, sea-water absorption may only need to be considered for PFP materials submerged or directly exposed to sea water.

B.10 Explosion mitigation and protection systems

The effects of explosions that should be considered when developing the FES are summarized below:

- equipment rupture;
- blast overpressure, which is a function of among other parameters type and amount of flammable material, overall dimensions and geometry, obstacle-generated turbulence and confinement of the area;
- drag forces which are developed behind the flame front, and which may impose significant loads on equipment, pipework or structure and which may escalate the damage created by the explosion.

The severity and consequences of an explosion can be minimized by the use of blast barriers, equipment installation layout, the use of active explosion suppression systems or sufficient equipment strength to prevent escalation. However, the preferred method of protection should be by the avoidance of features which will cause high overpressures and by providing adequate venting to allow unburned gas and combustion products to flow out of the compartment before dangerously high pressures develop.

Blast overpressures can be effectively reduced by adopting the approach of inherent safety by design. This requires that the layout and location of equipment is such as to minimize equipment and pipework congestion, limit the use of confining walls, limit module volumes and provide adequate venting. For these reasons, open-type installations are generally preferred. It should be noted that this often conflicts with requirements for weather protection. Special attention is needed to develop solutions accounting for both explosion safety and weather protection.

The use of deluge will in many instances effectively control an explosion by reducing flame speeds and thereby explosion overpressures. In particular this may work in naturally ventilated areas. An evaluation of the possible benefits of applying deluge shall be performed for each specific area, as adverse effects of deluge on overpressures have been demonstrated for some arrangements.

Explosion-suppression systems which are initiated by detection of the early stages of an explosion are not normally used on offshore installations due to the cost of these systems. If considered, however, the system performance should address the response time for the detection system, time for suppressant release and the location and qualities of the agent used. Suppression systems are unlikely to prevent re-ignition if a flammable mixture and an ignition source are still present.

The performance of blast-relief and ventilation panels should be verified by suitable type testing. As a minimum, the following test data should be available:

— the normal ambient conditions inside the module;

— the relief pressure;

— the time to relief.

Blast protection may provide an effective means of controlling lesser explosion overpressures, even though it may not be practicable to design against the overpressures generated in the worst-case scenarios.

If it is established that the hazardous events involving explosions are not tolerable, then the following explosion-mitigation measures should be explored:

— equipment in hydrocarbon service should be located in areas which are well ventilated, where the consequences of an explosion are limited or where the structure can be designed to withstand the forces generated by an explosion;

— accumulation of flammables could be avoided by limiting the provision of walls to separate areas or modules, avoiding perimeter cladding or using grated flooring;

— the layout of equipment and piping within a module/area and location of walls and blast relief panels should be optimized according to the guidance discussed below.

The following is a list of the design principles which should be adopted for equipment layout, in order to minimize explosion effects due to overpressure and drag forces:

a) design ventilation to minimize the probability of build-up of the most likely types of release (the most probable releases);

b) minimize number of ignition sources;

c) minimize congestion;

d) orientate horizontal vessels so that the longest dimension is in the direction of main vent flow;

e) do not obstruct the openings in the module boundaries;

f) maximize openings, particularly in floors and ceilings if possible;

g) consider grated floors and ceilings;

h) recognize that the accuracy of any predictions of explosion overpressures is not fully known, and in particular depends on the predictive tool being used;

i) make critical equipment/structures/barriers as strong as reasonably practicable, and do not limit the design to a calculated explosion overpressure;

j) consider mitigation by venting, water sprays, chemicals and dilution;

k) design collapse in a cascade fashion such that failure occurs first in less critical directions;

l) avoid long narrow modules;

m) minimize flame path.

The damage created by drag forces may lead to further escalation which is not tolerable. Resistance to such drag forces can be achieved by increasing the strength of supports for piping, vessels and equipment.

The hazard posed by projectiles needs to be assessed by considering the likelihood of impact and damage caused by the projectile.

The combined effect of venting and layout modifications is complex and should be validated by blast calculations and/or experimental scaling. However, these effects can only be assessed quantitatively for specific situations. The degree of accuracy of these techniques is still being determined and improved, but the models may be used effectively to compare alternative layouts and effects of different location of ventilation openings.

Models used to calculate explosion loading should be validated as far as possible and allowance should be made for the uncertainty in the model.

A decision to use design overpressure less than the predicted maximum should be based on an evaluation of the implications of the decision on the safety of personnel on the installation.

Explosion-protection requirements for structures, equipment, piping and supporting structure should normally be documented, with structural calculations which take into account the dynamic behaviour related to the short duration of explosion loading. In special cases, simulated tests may be accepted according to recognized standards or procedures. In other cases, an engineering judgement may be accepted.

Guidance regarding the design of structural members for explosion loading is provided in ISO 13819-1 and ISO 13819-2.

B.11 Module geometry to mitigate explosion effects

See Figure B.1.

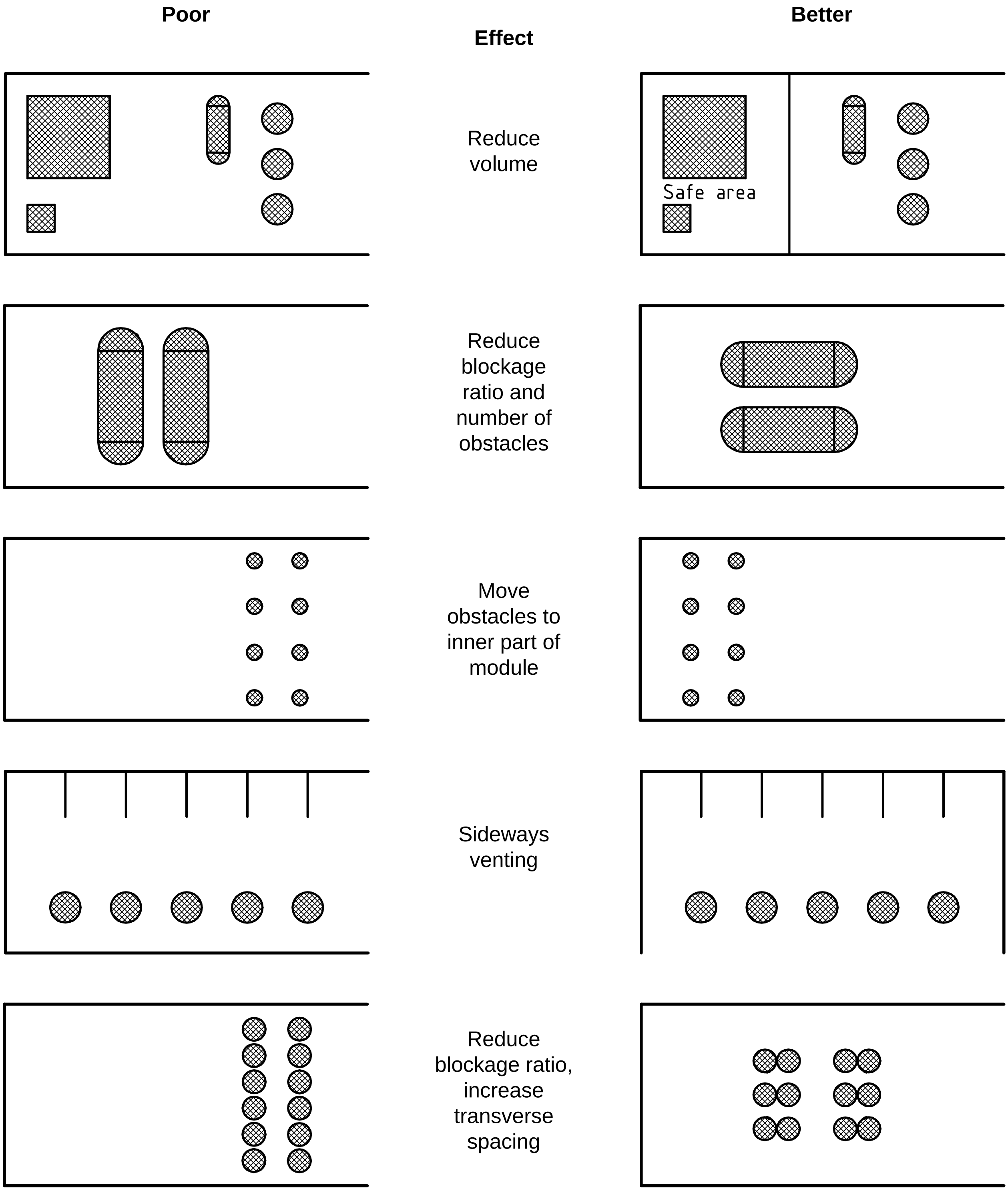

Figure B.1 — Effect of layout on explosion severity

B.12 Evacuation, escape and rescue

B.12.1 EER assessment

The purpose of this assessment is for the operator to consider the likely EER situations and make a comparison with EER objectives and the operator's criteria of acceptability.

An important part of the EER assessment is the estimation of the time required for escape and evacuation, taking into account human factors in emergency situations and the need to handle casualties. This assessment should be based on a realistic judgement or calculation of the time required to implement each stage of the strategy.

The results of the EER assessment should be considered when planning drills, exercises and emergency response procedures. The results of these drills and exercises should be evaluated and, if required, the EER strategy should be modified accordingly.

The strategy should consider the arrangements and procedures for the following elements:

— escape from the immediate effects of an emergency;

— the temporary refuge;

— primary method (for evacuation);

— secondary method (for evacuation);

— tertiary methods (for escape);

— communications during emergencies;

— means to recover/rescue people who have used secondary or tertiary methods and provide, if necessary, medical assistance;

— information needed to make a decision on whether and when to abandon the installation.

B.12.2 Escape routes

Escape routes from all manned areas should be marked and lit so that they are readily identifiable by all personnel in an emergency.

Signs should be provided as necessary to allow personnel to identify escape routes, including indication of the direction to muster areas, embarkation areas and means of escape to the sea. The type and location of signs should be selected to be suitable for the conditions, such as smoke, which may be present when the signs are needed.

On large or complex installations, escape-route plans, showing local routes and orientation to the full plan, should be placed in prominent positions around the installation where necessary to assist personnel.

Escape routes should, wherever practicable, be designed to remain passable by position rather than by special protection. To achieve this, external escape routes should wherever practicable be physically separated from explosion vent panels, sacrificial walls and open hazardous modules. Where this is not possible, alternative routes should be provided which are unlikely to be affected in the same incident.

The dimension of escape routes should be adequate for the number of people who may be required to use them. In general, escape routes should be greater than 1 m wide. For routes which are unlikely to be used frequently (and then only by a small number of people), a reduction in this width may be acceptable. External escape routes and those used by personnel escaping from more than one area may need to be wider. All escape routes should have adequate vertical clearance.

Lifts, where provided, should not be used as part of escape routes.

B.12.3 Command structure

The command structure should identify the individual who has overall responsibility for taking charge in an emergency. Additionally, a clear chain of command should be established and steps taken to ensure that the persons in this chain are competent to discharge the duties required of them.

Personnel with a specific role during evacuation, escape and rescue should be competent to carry out that role.

The command structure should be capable of functioning in different circumstances and, in particular, there should be contingency arrangements to ensure that if individuals are, or become, unavailable there will be others identified as capable of discharging the relevant responsibilities so that the emergency response remains effective.

The respective responsibilities between offshore and onshore support facilities, and between those on the installation should be specified and clearly understood by all those involved. There should be adequate arrangements for handover of command and control functions, where necessary for different stages of the emergency.

B.12.4 Mustering

The temporary refuge (TR) is a place where people can muster whilst investigations, emergency response and evacuation pre-planning are undertaken. The TR should have sufficient capacity to protect the maximum complement of the installation.

The TR may be an enclosure, more than one enclosure, or only an area of open deck. The TR is required to maintain the safety of personnel during the period required for the evacuation process to be completed. This includes the following activities:

— time to complete the full muster at the TR;

— time to account for personnel not reporting to their assigned muster stations;

— time to evaluate the situation and make decisions;

— time to initiate responses to minimize the consequences and control the emergency, if possible;

— time to complete the evacuation (if required). This may be done in a phased manner, initially evacuating non-essential personnel;

— contingency time to allow for the unforeseen.

These times are not all necessarily additive, but the installation should be designed so that the conditions which could impair the TR do not arise whilst people are still in or at the TR. These conditions are:

- loss of life-support (e.g. due to smoke/gas , excessive heat stress, oxygen deficiency, toxic gas accumulation);

- loss of structure (e.g. collapse of supporting structure, impairment of exterior fabric of an enclosed TR);

- loss of essential command support (e.g. loss of essential communications within an enclosed TR and with third parties, ESD, F&G and monitoring, emergency power/lighting). It is essential to provide effective communications between multiple TRs. The level of ESD and F&G and monitoring facilities required at a TR should be considered in developing the EERS.

On small platforms, a TR may not be integrated with the living quarters and may not be enclosed. The primary purpose of the TR may be only to serve as a temporary muster point with protection against fire, heat and explosions for a short period, until the platform can be safely evacuated. Such short duration protection can be provided by partially enclosing the TR or by locating the TR away from the source of possible hazardous events.

Where it may not be possible for all personnel to reach the TR under certain emergency conditions, there may be a need for alternate arrangements to allow safe evacuation of these personnel.

Where a control station is occupied in an emergency and is not situated at a TR, it should be possible for the personnel at the control station to subsequently reach a TR if the situation makes it necessary. An auxiliary TR may be needed to ensure this.

B.12.5 Communications during an emergency

An essential feature of the EERS for manned installations is the provision of effective communications systems. In an emergency situation the telecommunication systems provided for normal operation should remain active, provided that their continued operation does not create additional hazards. In order to prevent an incident such as a fire or explosion from disabling any part of the emergency communications critical to the EERS, the following should be considered:

a) system diversity/duplication;

b) separation/mechanical protection;

c) selection of materials (e.g. fire-resistant cables).

The size and complexity of the installation will, to a large extent, determine the complexity of the systems provided. The range of communication facilities provided should meet the objectives of the EERS, in a manner appropriate to the specific installation. The following features should be considered in the developing of the EERS:

— the means to alert and muster personnel — this can be achieved through the provision of a public address system, and/or platform alarm system;

— the means for communication between muster stations and with isolated personnel - this can be met by hand-held portable radios and/or a fixed intercom system;

— the means for communication between the emergency response teams and the team managing the situation — this requirement can be met by the provision of a fixed intercom system and/or hand held portable radios. A switched telephone system could provide a back-up means of communication;

— the means to communicate with onshore organizations, other offshore installations or ships — this can be achieved through the provision of a telephone system (microwave link or cable), ship-to-shore service, marine radio or satellite link (e.g. Inmarsat);

— the means to communicate with helicopters — systems which would normally be used to meet this requirement include aeronautical systems;

— the provision of survival craft communications — this requirement would normally be met by the provision of marine band transceivers. Survival craft should also be equipped with radio beacon transmitters to assist search and rescue operations.

B.12.6 Evacuation and escape to the sea

All systems for evacuation and escape to the sea should be supported by personnel training or familiarization, based on the system requirements.

The normal method of getting to and from offshore installations will generally be the preferred primary method (for evacuation). However, in many circumstances it is recognized that the primary method of evacuation will not be available and thus there is a need to provide a secondary method (for evacuation) to allow a fully controlled escape to the sea from an installation, independent of external assistance. In some locations the secondary means (for evacuation) may be the same as the primary means (for evacuation), providing it is always available and has sufficient capacity such that it is capable of dealing with the full complement of the installation in a controlled manner without undue delay, for example, due to awaiting the arrival of external assistance.

In many locations, the optimum approach to providing secondary means of evacuation will be totally enclosed motor-propelled survival craft (TEMPSC) in accordance with IMO and other acceptable standards. It is important that full consideration is given to the type and design of the TEMPSCs, their location, their ability to be safely launched and the conditions they will experience once launched (e.g. weather conditions, fires on the sea, smoke and radiation from topside fires). In some circumstances, the use of survival craft which are not totally enclosed may be acceptable.

Where provided, the TEMPSC should be readily accessible from the main TR and have a total capacity of at least the maximum personnel on board. The EER analysis may identify the need for additional TEMPSC so that the minimum capacity can be successfully reached and used for evacuation considering all credible scenarios and conditions. Consideration should also be given to severe weather conditions in which the positions of certain TEMPSC may be particularly vulnerable and further redundancy may be required.

Tertiary methods (for escape to the sea) are intended for use only in circumstances where evacuation by primary or secondary methods (for evacuation) is not possible.

The use of a tertiary method (for escape to the sea) is likely to introduce additional problems due to immersion of personnel in the sea and the requirement for subsequent rescue. Notwithstanding these problems, tertiary methods (for escape to sea) should be considered for all installations to allow access to the sea. However, to maximize the chances of survival of personnel entering the sea, life-jackets and, where relevant due to sea temperature, survival suits, should be provided at suitable locations on the installation.

The general principles in the provision of tertiary methods (for escape to the sea) are:

— they should take into account the likely scenarios;

— escape should be possible from several locations on the installation;

— life-rafts which are capable of being easily launched should be provided to protect personnel who enter the sea if the EER assessment demonstrates these may be of benefit;

— systems should be designed such that personnel who enter the sea can realistically use any available life-raft;

— effective training and procedures should be provided for the use of tertiary methods (for escape to the sea).

In selecting the types, numbers and locations of tertiary methods (for escape to the sea), the likely demands from scenarios and the maximum personnel distribution should be considered. It is important that enough diversity and choice is available to enable personnel in a variety of situations to use them.

B.12.7 Personal survival and escape equipment

All personnel onboard should be provided with the equipment found necessary in developing the EERS. Equipment to be considered includes:

— a survival suit which ensures that the survival time in the water exceeds the time required for rescue;

— a life-jacket;

— a device providing respiratory protection from smoke or toxic gas which may be encountered during evacuation and escape;

— a torch (flashlight);

— heat-resistant gloves;

— any other equipment found necessary in developing the EERS.

Additional survival suits (where provided) and life-jackets should be available for personnel at places which may be used for access to the sea, such as TEMPSC embarkation areas and at locations which may be used for tertiary escape.

B.12.8 Recovery and rescue

The evacuation and the escape process is only complete when all personnel reach a place offering a level of safety no less than that existing before the event leading to the need for EER, and providing suitable medical facilities.

Recovery and rescue arrangements will be required for all personnel using secondary or tertiary methods to abandon the installation. These arrangements may be provided by the installation operator (e.g. stand-by vessel) or use may be made of resources provided by other operators and national resources (e.g. search and rescue helicopters, passing vessels). The availability and suitability of such resources should be considered when developing the EER strategy.

It is necessary to take into account the needs of any special categories of personnel (e.g. divers in saturation). Additional facilities and arrangements may be needed to ensure they reach a suitable destination.

B.13 Pneumatic and hydraulic supply systems

B.13.1 Purpose

Many of the essential safety systems on an installation require a pneumatic or hydraulic supply system in order to execute the appropriate actions. These systems may provide motive power, e.g. for valve movement or engine start, or may be required for effective control of the system, e.g. instrument air. In order to function reliably, the fluids in these systems should have the required cleanliness and be available at sufficient pressure to perform their functions when called upon to do so.

B.13.2 Fluid supply properties

Fluids which may be used include instrument air, plant air, nitrogen, natural gas, oil-based hydraulic liquids and non-oil based hydraulic fluids. The initial specification of the system should identify the requirements of any pneumatic and hydraulic systems. This should include consideration of the maximum acceptable content of:

- water (both free water and water vapour);
- hydrocarbon;
- solids;
- possible corrosive contaminants.

When air is used as a pneumatic supply source, the system should be designed to prevent the mixing of air and hydrocarbon from the process or utility systems under both normal and abnormal conditions. If an alternative pneumatic supply source is provided, the alternative medium shall be of a composition that will not create a combustible mixture when combined with the primary source.

The effect of venting natural gas should be considered in the classification of the area in which the equipment is located.

B.13.3 Supply and response

The design of the supply system should be sufficient to assure that there will be adequate pressure to allow the system to fulfil its function. This should include consideration of the maximum usage which could be experienced at one time and the possible need for repeated operations. Where power for the supply systems is provided by the installation utility systems, the possibility of these systems not being available during an emergency should be considered and, if necessary, dedicated reservoirs or accumulators provided.

The failure mode of the essential safety system supplied by a pneumatic or hydraulic system should be considered, to ensure that the required integrity is maintained. It is generally preferred to have an arrangement where the pneumatic or hydraulic supply keeps the system in a normal operating condition and that failure of the pneumatic/hydraulic supply will cause the system to move to a safe condition.

To achieve the required speed of response, consideration should be given to line sizes, safety device bleed-port sizes and the need for auxiliary quick-bleed devices. Lines that supply and bleed should be sized for optimum bleed conditions. Because of volume and flowrate characteristics, a line that is either too large or too small will require excessive time to bleed. API RP 500 may be used as a guideline when designing instrument and control systems.

The design of the pneumatic/hydraulic system should consider the vulnerability of components to damage, both during normal operations and under emergency conditions. It is preferable to have the pneumatic/hydraulic components located as close as practical to the essential safety system they serve.

B.14 Inspection, testing and maintenance

B.14.1 General

Inspection, testing and maintenance frequencies should be determined as part of the FES development, reflecting the role and importance of the system in managing fires and explosions.

The following subclauses discuss the issues to be considered and offer guidelines for the inspection, testing and maintenance of the essential safety systems and equipment covered by this International Standard.

Annex C provides detailed guidance for typical inspection/maintenance frequencies.

B.14.2 Fire and gas systems

Fire and gas control panel: functional checks should be conducted to ensure that detectors annunciate correct zones and initiate the appropriate alarms or extinguishing systems.

Detectors (flame, heat, smoke and gas): should be tested for operation and recalibrated if required. The frequency of testing detectors will be dependent upon the type.

General alarm: alarms initiated from the fire and gas detection system should be regularly tested.

B.14.3 Emergency shutdown and blowdown systems (ESD)

Periodic operational tests should be performed, to substantiate the integrity of the entire system.

B.14.4 Fire-water pump systems

a) Inspection and tests

   Drivers and pumps should be regularly started and operated for a period sufficient to establish normal operating conditions. They should start reliably and run smoothly at rated speed and load.

   Pump performance (flow volume and discharge pressure) should be tested to ensure the pumping system satisfies the fire-water system functional requirements.

b) Maintenance

   Engines should be kept clean, lubricated and in good operating condition. Correct oil and coolant levels should be maintained.

   Diesel fuel tanks should be checked after each engine run to assure an adequate fuel supply exists.

   Fuel-gas scrubber vessels on natural-gas fuel engines should be drained before and after any engine run. Pressure-gauge readings on fuel-gas lines should be checked during engine tests to verify the fuel gas delivery pressure.

   At a frequency dictated by flow test and experience, submerged pumps should be lifted to inspect for corrosion and/or wear which could cause failure when required to function during an incident.

B.14.5 Deluge and sprinkler systems

Deluge systems may be susceptible to plugging due to corrosion, biological fouling or other foreign objects. An effective means (e.g. inspection, testing) should be established to verify that the system has the capability to function as designed. It is recommended that the established procedures allow for verification of the integrity of the system.

Where installed, sprinkler system water-flow alarms should be tested for correct operation.

Testing of alarms/actions (e.g. fire-water pump start) should be possible from deluge/sprinkler systems.

B.14.6 Fire hoses, nozzles and monitors

Where necessary to confirm integrity, all fire hoses should be tested by subjecting them to the maximum fire-water system operating pressures.

Nozzles should be function-tested for proper operation.

After each use, fire hoses should be inspected for damage and returned to their storage device.

Cotton-jacketed hoses should be carefully cleaned and dried after use.

B.14.7 Fixed dry chemical systems

All dry-chemical extinguishing systems and other associated equipment should be inspected and checked for proper operation.

All expellant gas containers should be checked by pressure or mass against required minimums.

All stored dry-chemical pressure containers should be checked by pressure and mass against specified data.

Except for stored pressure systems, the dry chemical in the system storage container should be sampled from the top centre and near the wall. Any samples which contain lumps that will not be friable when dropped from a height of 100 mm shall result in the replacement of the chemical.

After use, hoses and piping should be cleared of residual dry chemical.

B.14.8 Gaseous systems (including water-mist systems)

Discharge of the systems during function-testing should not be required.

All stored pressure containers should be checked by pressure and mass against specified data.

B.14.9 Mobile and portable fire-fighting equipment

Extinguishers should be visually inspected on a frequent basis to ensure that they are in the designed location, to ensure that they have not been activated or tampered with and to detect any obvious physical damage, corrosion, compaction of powder or other impairments.

Hand-portable extinguishers should be hydrostatically tested in accordance with a recognized standard.

Any cylinder which shows evidence of corrosion or mechanical damage should be either hydrostatically tested or replaced.

Nitrogen cylinders used for inert gas storage and used as an expellant for wheeled extinguishers should be hydrostatically tested in accordance with a recognized standard.

At regular intervals, extinguishers should be thoroughly examined. Deficient extinguishers should be repaired, recharged or replaced, as appropriate. Manufacturer's recommendations with respect to cleanliness and dryness should be followed for refilling extinguishers.

Extinguishers out of service for maintenance or recharging should be replaced by an extinguisher(s) having the same classification and at least equal rating.

Each extinguisher should have a permanently attached identification tag indicating the maintenance or recharge date and the initials or name of the person who performed the work.

The mixing of different powders can cause a corrosive mixture and abnormal pressures to develop, resulting, in the extreme, in explosion of the extinguisher. Extinguishers should only be refilled with the same type powder originally contained in the unit.

B.14.10 Batteries and charger systems

Storage batteries should be kept charged at all times. They should be regularly tested, to determine the condition of the battery cell.

The automatic-charging feature of a battery charger is not a substitute for proper maintenance of the battery and the charger. Periodic inspection is required to ensure that the charger is operating correctly.

B.14.11 Emergency systems

The emergency (support) systems provided for the management and control of an incident include the communications systems, escape and evacuation arrangements, power generation system(s) and explosion protection (vents/suppression system). Periodic functional tests of these systems should be performed, to substantiate the integrity of each system.

Specific test procedures should be in accordance with regulatory agency requirements and equipment manufacturer's recommendation.

B.14.12 Passive fire protection

The following outlines the approach to be adopted for the inspection of applied passive fire protection:

Generally, passive fire protection systems have few maintenance demands . However, periodic visual inspections are recommended, with repairs to damaged areas as appropriate. The inspections should identify damage such as cracks or voids, either in the top coating or the fireproofing itself. Repairs should be carried out in accordance with manufacturer's recommendations.

These periodic inspections are important in order to maintain the integrity of the fireproofing coating and to provide early detection of substrate corrosion. If partial debonding of the fireproofing coating has occurred and there are surface cracks in the area of the debonding, moisture may migrate into the substrate, establish a corrosion cell and become a source of corrosion. This corrosion potential highlights the need to have a fireproofing coating application procedure which ensures that a proper bond is established between the fireproofing compound and the substrate.

Annex C
(informative)

Typical examples of design requirements for large integrated offshore installations

C.1 Typical emergency electrical power requirements

The essential safety systems which may require emergency power include:

- emergency and escape lighting;
- vent and obstruction warning lighting;
- identification lights and navaids;
- telecommunication equipment;
- fire and gas detection and protection systems;
- ESD systems;
- public address equipment and intercom systems;
- installation of visual and audible alarms;
- ventilation/cooling for the equipment contained in this list;
- drilling emergency systems such as:
  - BOP closing unit,
  - instrument air compression,
  - diesel transfer pump;
- embarkation areas, sick bays and other areas necessarily manned in an emergency;
- any diving equipment reliant on electrical power;
- any equipment necessary to maintain the stability of the facility.

The emergency generator should be capable of supplying the essential safety systems for a period suitable to manage an emergency situation which may not require evacuation; 18 h to 24 h is a typical period of power provision from the emergency generator.

In addition, certain of the essential safety systems, including many of those listed above, may require emergency power from a UPS supply. The duration of the UPS supplies to these services should be sufficient to allow the emergency generator to be started or to cover for unavailability of the emergency generator for a period sufficient to complete emergency response activities. A list of the services which should be considered for UPS supplies and typical duration of these supplies for a large integrated installation is given in Table C.1.

Table C.1 — List of services

Service	Suggested period
Fire and gas detection and alarm systems	180 min
Emergency shutdown and depressuring (ESD/EDP) control systems	30 min
Process monitoring and control systems	45 min
Public address, platform audible alarms and status lights	180 min
SOLAS communications equipment	24 h
Emergency and escape lighting	90 min
Navigational aids including helideck lights	96 h

It is important to ensure that critical emergency power system cables are not affected by a fire associated with main power cables, and are routed or protected to avoid being affected by fires or explosions in hazardous areas. Critical cables are generally those between emergency generator, emergency switchboard, UPS battery chargers/inverters, and sub-distribution boards. These cables shall either be segregated from main power cables to SOLAS requirements, or be fire-resistant.

The prime mover of the emergency generator should be diesel-fuelled, with a reliable and secure diesel supply system sufficient to supply all emergency loads for the required period.

Fuel supplies should preferably be gravity-fed. Where this is not possible the diesel transfer pump should be supplied from the emergency switchboard.

The emergency generator should start and connect automatically on loss of main power supply, but the start sequence should be inhibited, or the generator stopped, in the event of confirmed high level gas detection within the emergency generator enclosure, emergency switchgear room or at the engine air intake.

Consideration should be given to the arrangements required to provide power to start up the installation when all services and utilities have been shut down.

C.2 Typical applications of fire/gas detectors

Table C.2 — Typical applications of fire/gas detectors

Fire & Gas system				
Hazard	Type of detector		Typical application	Typical actions
Fire	Heat	pneumatic	Process, wellhead, utilities	Alarm, ESD, EDP, closure of the SSSV, active fire protection
		electric	Turbine hoods, workshops, stores, engine rooms, process, wellhead, utilities	Alarm, ESD, EDP, active fire protection
	Flame		Process, wellhead utilities, generators, gas turbines	Alarm, ESD, EDP, active fire protection
	Smoke		Control rooms, electrical rooms, computer rooms, accommodation	Alarm, isolate power, active fire protection (if present)
			Air intakes to TR and control stations	Alarm, isolate ventilation
Flammable gas			Process, wellhead utilities areas [a], engine rooms [a]	Alarm, ESD, EDP, isolate power
			Air intakes	Alarm, ESD, EDP, isolate power, ESD ventilation system
Oil mist			Enclosed areas handling low GOR liquid hydrocarbons	Alarm, ESD, EDP, isolate power
	Manual call point		All areas, escape routes, muster points, TRs	Alarm, start of fire pumps

NOTE Process areas include drilling areas.

[a] Only for rooms containing essential safety systems.

C.3 Guidance on the selection of AFP systems on typical areas

Annex C gives guidance on the selection of AFP systems on typical areas on offshore installations. In addition, it also provides examples of application rates of water-based AFP systems.

Table C.3 may be used in initial design. Final selection of types and quantities/rates should be based on fire analyses and evaluations of fire-fighting systems.

Table C.3 — Selection of AFP systems on typical areas

Area/room	Type of protection in addition to portable	Typical minimum water application rates l/min/m^2	Comments
Wellhead/manifold area	Deluge/foam/dry chemical	10 (or 400 l/min/well)	
Process areas	Deluge/foam/dry chemical	10	
Pumps/compressors	Deluge/foam	20	
Gas treatment area	Deluge/dry chemical	10	Foam if area contains significant flammable liquids
Methanol area	Alcohol-resistant foam or deluge	10	Portable foam units, if the methanol area is small
Water-injection treatment area	None, if no HC risk		
Drill floor	Deluge	10	Only if FES shows role for this system
BOP area	Deluge/foam	400	
Drillers cabin	None		
Degasser room	Deluge/foam	10	Only if FES shows role for this system
Shale shaker room	Deluge/foam	10	
Active mud tank room	Deluge/foam	10	
Sack/bulk storage room	None		Provided that no flammable materials stored
Mud lab	None		
Cementing unit room	Water-mist/deluge/foam		Water-mist according to supplier requirement
Control station	None		To be confirmed in developing FES
Central control room (CCR)	None		To be confirmed in developing FES
Instrument room adjacent to CS/CCR	None		To be confirmed in developing FES
Local equipment room	None		To be confirmed in developing FES
False floor and ceiling in CS/CCR and instrument rooms			Lifting gear for floor hatches. Gaseous system with lance
Turbine hall	Deluge	10	Dedicated system only if flammable inventories within the hall
Turbine hood	CO_2, gaseous or water-mist		Interlock access to hood, if gaseous
Switch board room	None		To be confirmed in developing FES
Battery room	None		
Emergency generator room	Water-mist/foam/deluge	10	Effect of water on equipment in the room should be evaluated
Fire pump room	Water-mist/foam/deluge	10	Effect of water on equipment in the room should be evaluated
HVAC room	None		

Table C.3 *(continued)*

Area/room	Type of protection in addition to portable	Typical minimum water application rates l/min/m^2	Comments
Mechanical workshop	Sprinkler	6	
Instrument workshop	Sprinkler	6	
Storage of gas bottles	None		Provided stored externally and not exposed to radiant heat
Paint store	Sprinkler		
Accommodation	None		Section flammable materials to limit fuel at risk
Vent extract from galley	Gaseous		Operated local in galley
General galley area	None		
Galley cooking appliances and range	Proprietary systems		According to supplier recommendation
Crane cabin	None		
Crane engine room	Portable/water-mist		Deluge, water-mist for diesel drives
Helideck	Foam/dry chemical	6	
Hangar	Sprinkler/foam/dry chemical	10	
Chain locker	Water	60	
Ballast control room	None		
Turret area	Deluge/foam	10	
Pump room in column	None		Unless flammable liquid present
Vertical and horizontal structures	Deluge	10 (4 l/min/m^2 for horizontal)	
Escape and evacuation routes	Water curtain	15 l/min/m to 45 l/min/m	

C.4 Typical PFP applications

C.4.1 General

Fire barriers, load-bearing structures and critical components that may fail in fire should be protected in accordance with the FES. For large installations, PFP is normally provided. Tables C.4 to C.6 provide typical applications.

The tables in the annexes are based on the judgement and recent experience of some operations involved in offshore E&P activities. Care is needed to evaluate the actual requirements for a particular installation and not to accept values in the tables without due consideration of the requirements of the FES and EERS.

C.4.2 Typical fire integrity for load-bearing structures

The fire integrity given in Table C.4 may be used as guidance in determining the PFP requirements for structural members required to support the protected area including its external boundaries. During the design of an installation, an equivalent table may be prepared to reflect the decision made with respect to the role of PFP.

Table C.4 — Typical fire integrity requirements for load-bearing structures

Fire area	**Area relying on structure in fire area for integrity**				
	Accommodation blocks (AB/TR)	Nonhazardous utility areas (UA)	Wellhead areas and drilling areas (WH)	Process areas including gas compression areas (PA)	Control stations (CS)
AB/TR	1/CF/400	1/CF/400	Not applicable	Not applicable	1/CF/400
UA	1/CF/400	1/CF/400	1/CF/400	1/CF/400	1/CF/400
WH	1/JF[a]/400	1/JF[a]/400	1/JF[a]/400	1/JF[a]/400	1/JF[a]/400
PA	1/JF[a]/400	1/JF[a]/400	1/JF[a]/400	1/JF[a]/400	1/JF[a]/400
CS	1/CF/400	1/CF/400	Not applicable	Not applicable	1/CF/400

NOTE 1 Rating is specified as: Period of resistance (hours)/Type of fire/Critical temperature (°C).

NOTE 2 Type of Fire: HC = Hydrocarbon pool fire, CF = Cellulosic fire, JF = Jet fire.

[a] 'HC' type of fire may be appropriate if the evaluation of the fires likely in the area indicates that 'JF' is not a credible basis for the design of the passive fire protection.

The above-referenced temperature (400 °C) has been used as a typical value for structural steel. For aluminium, the corresponding temperature is 200 °C. For other materials, the critical temperature is the temperature at which yield stress is reduced to the minimum allowable strength under operating loading conditions.

Table C.4 is read as follows:

Should the supports for an accommodation block depend on structures in a process area, then this load-bearing structure should be protected against a jet fire for one hour where the limiting temperature of the steel structure is 400 °C.

Where several different fire types are possible in an area, the case which results in the most onerous PFP requirements should usually be selected, unless it can be demonstrated that this is an unrealistic case to use as the basis for design.

The nomenclature adopted in Table C.4 does not follow any existing conventions with respect to the rating or classification of fire barriers. In using Table C.4, it will be necessary to consider how standard fire tests can be used to verify the required performance for offshore applications. Further detailed guidance is given in related International Standards.

C.4.3 Typical fire integrity requirements for fire barriers between major areas

The ratings (which are directional) given in Table C.5 may be used as guidance in determining the PFP requirements for any separation barrier of the protected area. During the design of an installation, an equivalent table may be prepared to reflect the decision made with respect to the role of PFP.

Rating is specified as: Endurance duration, in hours/ Type of Fire for protection/insulation requirements, in minutes, to reach 139 °C above ambient temperature on the nonexposed surface in accordance with ISO 834. For example:

JF-'*x*' indicates requirements to maintain stability and integrity against jet fires for 1 h with insulation requirements for *x* min.

HC-'*x*' indicates requirements to maintain stability and integrity against hydrocarbon pool fires for 1 h with insulation requirements for *x* min.

CF-'*x*' indicates requirements to maintain stability and integrity against cellulosic fires for 1 h with insulation requirements for *x* min.

Table C.5 — Typical fire integrity for fire barriers

Fire area	**Adjacent protected area**				
	Accommodation blocks (AB)	Nonhazardous utility areas (UA)	Wellhead areas and drilling areas (WH)	Process areas including gas compression areas (PA)	Control stations (CS)
AB	1/CF-60	1/CF-60	Not to be adjacent	1/CF-60	1/CF-60
UA	1/CF-60	1/CF-0	1/CF-0	1/CF-0	1/CF-60
WH	Not to be adjacent	1/JF [a]-0	1/JF [a]-0	1/JF [a]-0	1/JF [a]-60
PA	1/JF [a]-120	1/JF [a]-60	1/JF [a]-0	1/JF [a]-0	1/JF [a]-60
CS	1/CF-60	1/CF-60	1/CF-60	1/CF-60	1/CF-60

[a] 'HC' type of fire may be appropriate if the evaluation of the fires likely in the area indicates that 'JF' is not a credible basis for the design of the passive fire protection.

The nomenclature adopted in Table C.5 does not follow any existing conventions with respect to the rating or classification of fire barriers. In using Table C.5, it will be necessary to consider how standard fire tests can be used to verify the required performance for offshore applications. Further detailed guidance is given in related International Standards.

C.4.4 Typical fire integrity requirements for equipment

The fire integrity given in Table C.6 may be used as guidance in determining the PFP requirements for critical equipment which may require PFP in order to allow it to fulfil its function in an emergency. During the design of an installation, an equivalent table may be prepared to reflect the decisions made with respect to the role of PFP.

Table C.6 — Typical protection criteria for critical equipment

	Protection criteria	
	Surface temperature °C	**Protection period** min
Riser sections	< 200 [a]	60 [b]
Riser supports	< 400	60 [b]
Riser topside SDV	< 200	60 [b]
Fire pumps	< 200	60
Emergency generators	< 200	60
UPS systems	40 [c]	30
Control panels for SSIV/SSSV/BOP	40 [c]	15

[a] In the absence of any knowledge as regards the relative location of the fire on the riser, the ESD valves and the contents of the riser, it has been assumed that the fire is near the ESD valves and the riser is filled with liquid hydrocarbon. As a result, 200 °C has been used as the default surface temperature for the riser sections to ensure the integrity of the ESD valves.

[b] Or the minimum time period considered sufficient for a complete evacuation of the installation.

[c] PFP may be provided to prevent temperature in the enclosure containing this equipment rising to these levels when subjected to an external fire.

C.5 Typical inspection and testing frequencies

As a minimum, plans for and periodicity inspection and testing should be established to ensure that there are no hidden failures which would prevent a system achieving the essential functions and reliability targets given in the functional requirements.

Table C.7 gives a summary of typical inspection and testing frequencies for the main equipment and systems discussed in this International Standard which have been derived from API RP 14G.

Table C.7 — Inspection and testing matrix

<table>
<tr><th colspan="6">Inspection testing and maintenance upkeep matrix</th></tr>
<tr><th rowspan="2">Equipment</th><th colspan="5">Periodicity</th></tr>
<tr><th>1 week</th><th>1 month</th><th>3 months</th><th>6 months</th><th>1 year</th></tr>
<tr><td>Fire & gas detection systems</td><td colspan="5"></td></tr>
<tr><td>Control panel</td><td></td><td></td><td></td><td></td><td>F</td></tr>
<tr><td>Fire & gas general alarm</td><td></td><td>F</td><td></td><td></td><td></td></tr>
<tr><td>Detectors (flame, heat, smoke, gas)</td><td></td><td></td><td colspan="3">C/F</td></tr>
<tr><td>Fire protection systems</td><td colspan="5"></td></tr>
<tr><td>Fixed gaseous systems [a, b]</td><td></td><td></td><td></td><td colspan="2">I/F</td></tr>
<tr><td>Deluge/sprinkler systems</td><td></td><td></td><td></td><td></td><td>F</td></tr>
<tr><td>Deluge/sprinkler valve</td><td></td><td></td><td></td><td colspan="2">F</td></tr>
<tr><td>Fixed dry chemical systems [a, c]</td><td></td><td></td><td></td><td>I</td><td></td></tr>
<tr><td>Fire hoses, nozzles & monitors</td><td></td><td>I/F</td><td></td><td></td><td></td></tr>
<tr><td>Mobile & portable fire-fighting equipment</td><td></td><td>I</td><td></td><td></td><td></td></tr>
<tr><td>Fire-water pump systems [d, e, f]</td><td>F</td><td></td><td></td><td></td><td>I/F</td></tr>
<tr><td>Communication systems</td><td colspan="5"></td></tr>
<tr><td>Public address systems [g]</td><td>F</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Main bearer radio</td><td></td><td></td><td></td><td></td><td>F</td></tr>
<tr><td>Marine/aeronautical VHF systems</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Fixed [h]</td><td></td><td></td><td></td><td></td><td>F</td></tr>
<tr><td>Portable</td><td>I/F</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Aeronautical beacon</td><td>F</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Lifeboat radio</td><td>I/F</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Emergency shutdown systems</td><td colspan="5"></td></tr>
<tr><td>Control panel</td><td></td><td></td><td colspan="3">F</td></tr>
<tr><td>ESD I/O loops [i]</td><td></td><td></td><td colspan="3">F</td></tr>
<tr><td>Critical alarms/trips e.g. HH, LL</td><td></td><td></td><td></td><td></td><td>F</td></tr>
<tr><td>ESD/EDP valves</td><td></td><td></td><td></td><td></td><td>F</td></tr>
<tr><td>Electrical equipment</td><td colspan="5"></td></tr>
<tr><td>Emergency generator</td><td></td><td>F</td><td></td><td></td><td></td></tr>
<tr><td>UPS battery chargers</td><td></td><td></td><td colspan="3">I/F</td></tr>
<tr><td>Emergency lighting</td><td></td><td>F</td><td colspan="3"></td></tr>
<tr><td>Escape & evacuation equipment</td><td colspan="5"></td></tr>
<tr><td>Lifeboats [j]</td><td></td><td colspan="4">I/F</td></tr>
<tr><td>Life rafts [k]</td><td></td><td>I</td><td></td><td></td><td></td></tr>
<tr><td>Tertiary escape equipment</td><td></td><td>I</td><td></td><td></td><td></td></tr>
<tr><td>BA sets [l]</td><td></td><td>I</td><td></td><td></td><td></td></tr>
</table>

C = Calibration; F = Function test; I = Inspection without dismantling.

[a] Gaseous systems include water-mist systems.
[b] Inspection to include container mass/pressure checks.
[c] Dry chemical storage cylinder to be inspected for contamination (annually).
[d] Overhaul to be based upon weekly function test.
[e] Pump performance test (annually).
[f] Discharge test from at least two discharge points (annually).
[g] PA central equipment to have daily function check.
[h] Fixed VHF equipment require daily function check.
[i] Overhaul/recalibration dependent on function test results.
[j] Overhaul as required.
[k] Recertified every 12 months.
[l] Recertified every 5 years.

Bibliography

[1] ISO 834:1975, *Fire resistance tests — Elements of building construction.*

[2] ISO 10418:1993, *Petroleum and natural gas industries — Offshore production platforms — Analysis, design, installation and testing of basic surface safety element.*

[3] ISO 13819-1, *Petroleum and natural gas industries — Offshore structures — Part 1: General requirements.*

[4] ISO 13819-2, *Petroleum and natural gas industries — Offshore structures — Part 2: Fixed steel structures.*

[5] ISO 14001:1996, *Environmental management systems — Specification with guidance for use.*

[6] ISO 14004:1996, *Environmental management systems — General guidelines on principles, systems and supporting techniques.*

[7] IEC 60079-10, *Classification of Hazardous Areas.*

[8] IEC 61508, *Functional safety — Safety related systems,* Parts 1 to 7.

[9] API RP 14J, *Recommended Practice for Design and Hazard Analysis for Offshore Production Facilities.*

[10] API RP 14 G, *Recommended Practice for Fire Prevention and Control on Open Type Offshore Production Platforms.*

[11] API RP 75, *Recommended Practice for Development of a Safety and Environmental Management Program for Outer Continental Shelf (OCS) Operation and Facilities.*

[12] API RP 500, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities.*

[13] UKOOA — *Guidelines for Fire and Explosion Hazard Management.*

[14] UKOOA — *Guidelines for Emergency Response.*

[15] UKOOA — *Guidelines for Safety-Related Telecommunications Systems on Normally-manned Fixed Offshore Installations.*

[16] E&P Forum report No. 6.36/210, *Guidelines for the Development and Application of Health, Safety and Environmental Management System.*

[17] E&P Forum report No. 6.39/214, *Guidance on Halon-Free Fire Protection.*

[18] Christian Michelsen Research, *Gas Explosion Handbook.*

[19] Engineering Equipment and Materials Users Association (EEMUA), publication: 170, *Recommendations for the Protection of Diesel Engines in Hazardous Areas.*

[20] International Conference for the Safety of Life at Sea, 1974 (SOLAS 1974), Amendments 1986, IMO.

[21] Institute of Petroleum, *Model Code of Safe Practice, Part 15*: *Area Classification Code for Petroleum Installations.*

[22] Steel Construction Institute, *Interim Guidance Notes for the Design and Protection of Topsides Structures against Explosion and Fire.*

[23] SINTEF, *Modelling of Hydrocarbon Fires Offshore*, Final Report.

[24] TNO, *Methods for the Calculation of the Physical effects of the Escape of dangerous materials.*

[25] Offshore Technology Report OTI 95 634, *Jet Fire Test for Determining the Effectiveness of Passive Fire Protection Materials*. UK Health and Safety Executive.

[26] National Fire Protection Association (NFPA) Standards.

ICS 75.180.10

Price based on 56 pages

Nom du document: C022675E.DOC
Répertoire: H:\SGML\CRC
Modèle: Y:\MODWW6\ISO30.DOT
Titre: ISO/CEN 13703 E seul
Sujet: Petroleum and natural gas industry -
Auteur: Billet Josiane
Mots clés:
Commentaires: Dessins à insérer
Date de création: 98-08-28 14:25
N° de révision: 39
Dernier enregistr. le: 99-03-05 11:56
Dernier enregistr. par: Wanner Claude
Durée totale d'ouverture du fichier: 387 minutes
Dernière impression sur: 99-03-05 11:56
Tel qu'à la dernière impression
Nombre de pages: 62
Nombre de mots: 26 191 (approx.)
Nombre de caractères: 149 291 (approx.)