
**Petroleum and natural gas
industries — Arctic operations —
Escape, evacuation and rescue from
offshore installations**

*Industries du pétrole et du gaz naturel — Opérations en Arctique —
Échappement, évacuation et sauvetage depuis les installations en mer*

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 8, *Arctic operations*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The International Standards on arctic operations (ISO 35101, ISO 35102, ISO 35103, ISO 35104, ISO/TS 35105 and ISO 35106) address design and operational requirements and provide guidance on their use by the petroleum and natural gas industries in offshore arctic and cold regions. These documents promote internationally agreed approaches for oil and gas operations in arctic and cold region offshore environments. They were developed in response to the offshore oil and gas industry's demand for a coherent and consistent definition of methodologies to design, analyze, assess and operate arctic and cold region offshore structures. Through their proper application, the intention is to help ensure the safety of life and to minimize damage to the arctic environment. These documents are intended to provide wide latitude in the selection of design and operational solutions without hindering innovation. Even so, sound engineering judgement is expected in the application of these documents.

Personnel working in petroleum and natural gas industries in the arctic offshore face a number of risks from the physical and work environments. These include prolonged periods of darkness (in the winter) and light (in the summer), remoteness, cold ambient air temperatures, wind chill, dense fog, cold water temperatures, sea ice in varying concentrations and thickness and potentially, icebergs. These environmental factors can affect worker safety, should the installation's integrity be compromised. Additionally, these harsh environmental factors can have a negative impact on equipment.

The escape, evacuation and rescue (EER) system facilitates the successful escape from an incident, subsequent precautionary or emergency evacuation from the installation, and the ultimate rescue of installation personnel. The EER provisions are the compensating measures mitigating risks which facilitate the safety of personnel working in arctic and cold region offshore environments.

This document specifies requirements and recommendations applicable to design and operational aspects of EER from oil and gas installations deployed in arctic and cold region offshore environments. Through their application, the intention is to achieve reliability levels appropriate for manned and normally unmanned offshore installations, regardless of the type of structure/facility and the nature or combination of the materials used and the severity of the environment to which the installation is subjected.

The EER provisions are largely performance-based stipulations which include verifiable attributes or benchmarks that provide qualitative levels or quantitative measures of performance. The key characteristic of a performance-based standard is that it is focused on what needs to be achieved rather than on how it should be done. One of the performance targets is that use of the EER minimizes the possibility of casualties in the process. The performance target is developed in the context of a design HSE case.

The main body of this document considers the overall EER system design and operational aspects. [Annex A](#) provides EER system design and operational background information and guidance intended to assist the user of this document in understanding the requirements and how they can be met. The clause numbering in [Annex A](#) is the same as in the main body text to facilitate cross-referencing. [Annex B](#) provides a risk analysis example and information pertaining to operational EER systems.

In this document, the following verbal forms are used:

- “shall” indicates a requirement;
- “should” indicates a recommendation;
- “may” indicates a permission;
- “can” indicates a possibility or a capability.

Users of this document are expected to be familiar with ISO 15544, ISO 17776 and ISO 31000.

Petroleum and natural gas industries — Arctic operations — Escape, evacuation and rescue from offshore installations

1 Scope

This document establishes the principles, specifies the requirements and provides guidance for the development and implementation of an escape, evacuation and rescue (EER) plan. It is applicable to offshore installation design, construction, transportation, installation, offshore production/exploration drilling operation service life inspection/repair, decommissioning and removal activities related to petroleum and natural gas industries in the arctic and cold regions.

Reference to arctic and cold regions in this document is deemed to include both the Arctic and other locations characterized by low ambient temperatures and the presence or possibility of sea ice, icebergs, icing conditions, persistent snow cover and/or permafrost.

This document contains requirements for the design, operation, maintenance, and service-life inspection or repair of new installations and structures, and to modification of existing installations for operation in the offshore Arctic and cold regions, where ice can be present for at least a portion of the year. This includes offshore exploration, production and accommodation units utilized for such activities. To a limited extent, this document also addresses the vessels that support ER, if part of the overall EER plan.

While this document does not apply specifically to mobile offshore drilling units (MODUs, see ISO 19905-1) many of the EER provisions contained herein are applicable to the assessment of such units in situations when the MODU is operated in arctic and cold regions.

The provisions of this document are intended to be used by stakeholders including designers, operators and duty holders. In some cases, floating platforms (as a type of offshore installations) can be classified as vessels (ships) by national law and the EER for these units are stipulated by international maritime law. However, many of the EER provisions contained in this document are applicable to such floating platforms.

This document applies to mechanical, process and electrical equipment or any specialized process equipment associated with offshore arctic and cold region operations that impacts the performance of the EER system. This includes periodic training and drills, EER system maintenance and precautionary down-manning as well as emergency situations.

EER associated with onshore arctic oil and gas facilities are not addressed in this document, except where relevant to an offshore development.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 15544, *Petroleum and natural gas industries — Offshore production installations — Requirements and guidelines for emergency response*

ISO 17776, *Petroleum and natural gas industries — Offshore production installations — Major accident hazard management during the design of new installations*

ISO 35102:2020(E)

ISO 19901-6, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 6: Marine operations*

ISO 19906, *Petroleum and natural gas industries — Offshore production installations — Arctic offshore structures*

ISO 31000, *Risk management — Guidelines*

ISO 35104, *Petroleum and natural gas industries — Arctic operations — Ice management*

ISO 35106, *Petroleum and natural gas industries — Arctic operations — Metocean, ice, and seabed data*

IMO International Convention for the Safety of Life at Sea (SOLAS), 1974

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <http://www.electropedia.org/>

3.1

abandonment

act of personnel on-board leaving an installation in an emergency

3.2

accommodation

place where personnel on-board sleep and spend their off-duty time

Note 1 to entry: It can include dining rooms, recreation rooms, lavatories, cabins, offices, sickbay, living quarters, galley, pantries and similar permanently enclosed spaces.

3.3

annual risk tolerability criterion

ARTC

value of the individual and collective *risks* (3.50) per year of a fatality for persons, considering the amount of time spent in the operation and considering all risk sources, including workplace accidents, other incidents and *EER* (3.18) risks

3.4

anti-icing

measures to prevent ice from forming on surfaces, structures or equipment

Note 1 to entry: The intent of anti-icing is to make the surfaces, structures or equipment immediately available for use.

3.5

as low as reasonably practicable

ALARP

implementation of *risk* (3.50) reducing measures until the cost (including time, capital costs or other resources/assets) of further risk reduction is grossly disproportional to the potential risk reducing effect achieved by implementing any additional measure

3.6

casualty

serious injury or fatality resulting from an accident that occurs during the *EER* (3.18) process

3.7**cold-climate conditions**

potential presence of combinations of low air temperatures, low seawater temperatures, wind, snow, ice, freezing fog, etc.

3.8**action**

measure to limit the extent and/or duration of a hazardous event to prevent *escalation* (3.16)

3.9**direct evacuation****dry evacuation**

movement of personnel from the installation directly to a *safe haven* (3.52) or to a vessel in the vicinity with the capability of safely reaching the platform without having to enter the sea or the ice cover

3.10**drills and exercises**

activities undertaken to ensure verification of performance criteria, targets or requirements

3.11**duty holder**

individual, legal entity or organization holding legal title to the equipment or process and accountable for the safety and welfare of all associated personnel

3.12**embarkation area**

place from which personnel abandon the installation during *evacuation* (3.20)

3.13**emergency breathing system****EBS****compressed air emergency breathing system****CA-EBS**

form of personal protective equipment that provides the user with a means to breathe underwater for at least one minute, overcoming the need to make a single breath last for the complete duration of an underwater *escape* (3.17) from a helicopter

Note 1 to entry: If used correctly, EBS can mitigate the *risk* (3.50) of drowning. EBSs are categorized as follows:

- Category A: capable of deployment in air and underwater within 12 s;
- Category B: capable of deployment in air within 20 s.

3.14**emergency**

hazardous event which cannot be handled by normal measures and requires immediate *action* (3.8) to limit its extent, duration or consequences

3.15**emergency response****ER**

action (3.8) taken by personnel on or off the installation to control or mitigate a hazardous event or initiate and execute *abandonment* (3.1)

3.16**escalation**

increase in the consequences of a hazardous event

3.17

escape

act of personnel moving away from a hazardous event to a place on the installation where its effects are reduced or removed

3.18

escape, evacuation and rescue

EER

range of possible *actions* (3.8) in an *emergency* (3.14)

EXAMPLE *Escape* (3.17), *muster* (3.38), *refuge*, *emergency or precautionary evacuation* (3.44) and *rescue* (3.48).

3.19

escape route

normally available and unobstructed route from locations where personnel can be present on the installation to the *temporary refuge* (3.61) or alternative protected muster point

3.20

evacuation

planned method of abandoning the installation in an *emergency* (3.14)

3.21

evacuation craft

survival craft

marine or amphibious craft used by installation personnel to evacuate to the sea or ice cover

Note 1 to entry: An evacuation or survival craft provides evacuees with protection from the incident and the physical environment.

Note 2 to entry: This is a generic term that can cover lifeboats, life rafts, personnel basket or similar.

3.22

immersion suit

protective suit made of materials which reduce loss of body heat of a person wearing it in cold water or on the ice

3.23

first-year ice

FYI

sea ice of not more than one winter's growth

3.24

floe

relatively flat piece of sea ice greater than 20 m across

Note 1 to entry: Typical subcategories are: small (20 m to 100 m across), medium (100 m to 500 m across), big (500 m to 2 000 m across), vast (2 km to 10 km across) and giant (greater than 10 km across).

3.25

freeboard

ice freeboard

vertical distance from the mean sea surface to the ice surface

3.26

hazard

potential source of harm

3.27

hazard zone

largest possible area within which personnel safety is at *risk* (3.50) due to the installation *hazard* (3.26)

3.28**iceberg**

glacial or shelf ice of greater than 5 m *freeboard* (3.25) that has broken (calved) away from its source

Note 1 to entry: Icebergs can be freely floating or grounded, and their shapes are sometimes defined as tabular, dome, pinnacle, wedge or block. Smaller pieces of ice are called bergy bits or growlers

3.29**ice detection**

discrimination of ice features from the surrounding environment

3.30**ice island**

large tabular-shaped ice feature that has calved from an ice shelf or glacier

3.31**ice management**

active processes used to alter the ice environment with the intent of reducing the frequency, severity or uncertainty of ice actions

3.32**ice management plan**

detailed plan outlining the objectives, active procedures involved and individual responsibilities for the implementation of the ice management strategy

3.33**indirect evacuation**

movement of personnel from the installation to an intermediate *safe haven* (3.52) off the installation, such as an *evacuation* (3.20) craft

3.34**indirect evacuation system**

system by which evacuees move from the *temporary refuge* (3.61) or muster point on the installation to a location outside the *hazard zone* (3.27) if they are able to do so

3.35**landfast ice****fast ice**

ice that remains attached to a shoreline, island or a grounded ice feature

3.36**major incident**

major accident

event with potential for multiple personnel casualties, significant environmental damage, installation failure, or any combination of these consequences

3.37**multi-year ice**

sea ice that has survived at least one summer melt season

Note 1 to entry: When the term “multi-year ice” is used in conjunction with the term “second-year ice”, the former should be interpreted as ice that has survived at least two summer melt seasons.

3.38**muster**

movement of people to a designated area(s) so that the person in overall charge can account for all people and thereby facilitate *emergency response* (3.15) *actions* (3.8)

3.39

muster station

MS

muster area

assembly station

designated area(s) to which personnel report when required to do so in an *emergency* ([3.14](#))

3.40

offshore installation manager

OIM

person legally responsible for the installation and all operations on and around an offshore platform

3.41

pack ice

sea ice consisting of discrete *floes* ([3.24](#)) that are not *landfast ice* ([3.35](#))

3.42

performance-based standard

standard that specifies in qualitative and quantitative terms the requirements of safety-critical systems and their elements

3.43

personnel on board

POB

total number of personnel on board the installation

Note 1 to entry: This includes visitors, vessel crews, cross-shift personnel on the installation transferring to vessel, helicopter or other means, etc.

3.44

precautionary evacuation

controlled means of removing personnel from the installation prior to an uncontrolled or escalating incident that can otherwise dictate an *emergency evacuation* ([3.20](#))

3.45

preferred means of evacuation

method of choice for evacuating personnel based on the lowest *risk* ([3.50](#)) and on the familiarity, frequency of use, availability and suitability under prevailing conditions

Note 1 to entry: This is the method normally used to transfer personnel to and from the offshore location and could possibly not be available in an emergency.

3.46

primary means of evacuation

method of evacuating personnel that can be carried out in a controlled manner under the direction of the person in charge

Note 1 to entry: This is the *preferred means of evacuation* ([3.45](#)) of the installation in an emergency.

3.47

recovery

retrieval

transfer of evacuees to a rescue vessel, helicopter, safe installation or other *safe haven* ([3.52](#))

3.48

rescue

process by which those who have evacuated, survived until a *safe haven* ([3.52](#)) is available and are retrieved to a place where medical assistance is generally available

3.49
ridge
ice ridge

linear ice feature, formed of ice blocks created by the relative motion between ice sheets

Note 1 to entry: A pressure ice ridge is formed when ice sheets are pushed together, and a shear ice ridge is formed when ice sheets slide along a common boundary.

3.50
risk

probability that a specified undesirable event will occur combined with the severity of the consequences of that event

3.51
rubble field

region of broken ice blocks floating together as a continuous body

3.52
safe haven

area outside the *hazard zone* (3.27) in which personnel safety is no longer at *risk* (3.50) due to the installation *hazard* (3.26) or physical environmental risks, and where medical attention is normally available

EXAMPLE A safe haven can be a rescue helicopter or a *standby vessel* (3.58).

3.53
safety-critical element
SCE

item of equipment, procedure or structure whose failure can lead to a *major incident* (3.36) or whose purpose is to prevent or limit the consequences of a major incident

3.54
scenario risk tolerability criterion
SRTC

upper limit of the individual and collective *risk* (3.50) for any *EER* (3.18) scenario

3.55
secondary means of evacuation

method of evacuating personnel in an *emergency* (3.14) when the *primary means of evacuation* (3.46) cannot be used, which can be carried out in a fully controlled manner under the direction of the person in charge, independent of external support

Note 1 to entry: This means of *evacuation* (3.20) does not provide as much protection from *hazards* (3.26) and the elements as does the *primary means of evacuation* (3.46) but it can avoid immersion in the sea/ice.

3.56
second-year ice

sea ice that has survived one summer's melt season

Note 1 to entry: Second-year ice is sometimes referred to as *multi-year ice* (3.37).

3.57
stamukha

grounded ice feature composed of broken ice pieces or rubble

Note 1 to entry: The plural form of "stamukha" is "stamukhi".

3.58

standby vessel

SBV

vessel stationed near the installation at all times that provides *rescue* (3.48) assistance if needed within defined performance times and can accommodate installation *personnel on board* (3.43) and typically can offer medical assistance to survivors

3.59

standby ice management vessel

SIMV

icebreaker standby vessel

standby vessel (3.58) used during the ice season that is capable of clearing ice and ice rubble away from the installation to create a clear route in the event of an *emergency* (3.14)

3.60

station bill

posted list showing the duties and duty stations of designated personnel on the installation with *emergency response* (3.15) organization roles and responsibilities

3.61

success

conduct of an *EER* (3.18) operation with zero casualties

Note 1 to entry: See also definition of *casualty* (3.6).

3.62

temporary refuge

TR

place provided where personnel can take refuge for a predetermined period whilst investigations, *emergency response* (3.15) and *evacuation* (3.20) preparations are undertaken

Note 1 to entry: Where provided, a TR might not necessarily be useable under all incident scenarios.

Note 2 to entry: The specified period that a TR is deemed to provide a *safe haven* (3.52) is called the TR impairment time.

3.63

tertiary means of evacuation

method of evacuating personnel in an *emergency* (3.14) that relies heavily on an individual's own *actions* (3.8), is used when the primary and secondary means are not available, and that has an inherently higher *risk* (3.50)

3.64

training

activities undertaken to ensure that competence is increased or maintained on an individual and team level

3.65

winterization

measures taken in the design and preparation of a facility or installation to facilitate operations in cold climates

Note 1 to entry: Winterization is primarily focused on the adverse effects and control of freezing, icing, wind chill, snow, falling ice and material properties in cold temperatures.

4 Abbreviated terms

CCR	central control room
ECP	emergency control point
ERO	emergency response organization
ERP	emergency response plan
HAZID	hazard identification
HSE	health, safety and environment
H ₂ S	hydrogen sulphide gas
HVAC	heating, ventilation and air conditioning
LSA	life-saving appliance
MOB	man overboard
PA	public address
PPE	personal protective equipment
QRA	quantitative risk analysis (assessment)
SAR	search and rescue
FEED	front-end engineering design
HEP	human error probability
PSV	platform supply vessel
PEERS	probabilistic EER simulator
P&ID	pipng and instrumentation drawings
PLB	personal locator beacon
RPT	risk and performance tool
SOLAS	international convention for the Safety Of Life At Sea
SSIV	subsea isolation valve
TEMPSC	totally enclosed motor propelled survival craft

5 General requirements and conditions for EER systems

5.1 Fundamental requirements

The EER system shall:

- a) be designed:
 - with the safeguarding of human life as the top priority;

- to help ensure continuous protection for personnel engaged in EER activities in response to all credible hazards;
 - to be robust and adaptable with respect to changing conditions.
- b) establish and maintain installation personnel preparedness (competency);
- c) maintain year-round readiness of all its components (e.g. the TR, escape and evacuation routes, muster and embarkation areas, LSAs);
- d) provide space and means (e.g. first aid kits and other medical equipment) to accommodate and treat injured installation personnel in the TR(s), primary and secondary means of evacuation;
- e) provide medical support to evacuees who have been rescued.

5.2 Methods — Design

5.2.1 General

To the extent possible, data and lessons learned from the performance of previously deployed EER systems in arctic and cold regions shall be used to help verify new EER system designs. Appropriately scaled physical models and mathematical models can also be used to determine the response of EER systems to ice actions, in combination with current, wind and wave actions. If using such models, these shall be calibrated using data from full-scale measurements where available.

The EER system shall be functional in all applicable arctic physical environmental conditions in the region operated. The functionality can vary widely from location to location, both seasonally and annually.

Identification, investigation and determination of site-specific conditions for sea ice, icebergs, ice islands and other environmental factors and any possible combination thereof on EER system performance shall be made with due consideration of the phenomena and effects of their impact (see [Clause 7](#)).

The EER system, including all subsystems, shall be designed for operation in an environmentally sound manner during emergency scenario drills and when maintaining EER system hardware. Conditions that can influence the functional and operational requirements, particularly those associated with the arctic physical environment, shall be identified. It shall be demonstrated that the EER system performs as intended.

The evaluation of possible hazard scenarios shall include:

- potential occurrences of design-basis extreme ice features;
- the local consequences of impacts from such ice features; and
- arctic-specific geohazards that can negatively impact EER system performance.

The following aspects shall be considered in the EER system design or addressed periodically during operation of the offshore installation:

- a) the potential for changes in storm frequency and magnitude;
- b) ice and icing conditions;
- c) ocean circulation;
- d) air temperatures;
- e) permafrost;
- f) snowfall;

- g) wave heights and water levels during the design service life of the structure, including the decommissioning phase.

5.2.2 Structural configuration — Design

Structure configuration shall consider the layout of facilities and separation distances from hazards (as applicable) and environmental constraints as it impacts the EER system design.

The EER system design shall:

- a) Take into account the impact of different substructure geometries (shapes, orientations and profiles) as well as the topsides arrangement.
- b) Address the impacts of ice conditions during the offshore installation's design life, including the decommissioning phase. Such ice conditions shall include but not be limited to:
- all relevant ice drift directions and velocities;
 - ice types and concentrations;
 - ice rubble build up locations, dimensions, and durations;
- all in the context of the installation's ice resistance and ice management provisions.
- c) Account for topsides arrangements with respect to the functional and operational requirements, such as resupply, offloading, flaring, and with respect to wind and ice encroachment.
- d) Consider winterization measures to help ensure the safe operation of EER systems and equipment during operations. Such measures shall help ensure that personnel can conduct the required tasks in an ergonomically sound way with respect to ambient temperature, wind, visibility and restrictions imposed by PPE and installation conditions.
- e) Be suitable for periods of installation transportation, e.g. during a manned tow, and installation, accounting for the ice and/or metocean conditions along the transportation route, which can be different than environmental/ice conditions at the set-down location, and during the installation design service life.
- f) Take into account any restrictions to system availability and/or performance associated with transportation and installation when the installation EER provisions are relied upon, e.g. during a manned tow.

5.3 Methods — Operations

5.3.1 General

The level of safety and performance with respect to the operational aspects of the EER system shall be established as part of the overall EER plan. These shall be consistent with goals and guidelines established in the EER design basis.

Where practical, rational operational EER methods based on recognized operational practices in open water seas during the open water season may be considered. If rational optional EER methods are considered, it shall be demonstrated that they are effective for periods when sea ice and/or icebergs are present and ice accretion is to be considered.

EER systems and subsystems shall be operated in an environmentally sound manner. Any condition that can potentially adversely influence the functional and operational capabilities of the EER subsystem shall be identified and mitigated.

Appropriate procedures for issues concerning health and safety in an arctic environment where they pertain to EER shall be established and maintained.

The operational plan shall include consideration for any changes in:

- storm frequency/magnitude;
- ice conditions;
- air temperatures;
- snowfall;
- wave heights and water levels that can occur during the design service life of the structure.

NOTE These aspects can negatively impact the performance of the EER system.

The operational plan shall be updated as necessary throughout the installation life cycle.

Inspection and maintenance procedures for any tanks, pipes or liquid transfer processes associated with the EER system, including temporary EER arrangements during tow, set-down and when ice is present, that can leak or spill under non-emergency situations shall be developed.

Means for the containment and clean-up of spills from the EER system shall be proven to function under the expected range of arctic physical environmental conditions.

5.3.2 Structural configuration — Operations

The impacts of structural configuration provisions, as applicable, on the operational aspects of the EER system, including the layout of facilities and separation distances from hazards and physical environment constraints, shall be assessed.

The operational impact on EER due to the orientation of the substructure from the perspective of the anticipated ice conditions, prevailing ice drift directions and ice rubble build-up shall be taken into account. Functional and operational impacts on the topsides with respect to resupply, offloading and flaring on the EER system performance, and wind and ice encroachment shall be considered.

Winterization measures shall be maintained during operations to help ensure the functionality of EER systems and equipment. The winterization measures shall enable personnel to conduct the required maintenance and repair tasks in an ergonomically sound way with respect to cold ambient outside air temperature, wind, visibility and restrictions imposed by PPE.

The EER system design shall be integrated into any offshore component of the operations, maintenance and repair process. The planning of operations, maintenance and repair activities shall include adequate consideration for periods of extremely low ambient temperatures. EER system materials and equipment shall be adequately protected where deemed necessary by the provision of heating, insulation, enclosures or other means.

EER system operation shall take into account any system restrictions on availability and/or performance associated with transportation and installation when the installation EER provisions are relied upon (e.g. during a manned tow).

The EER system shall be in place for periods of installation transportation and decommissioning. The EER system shall account for the ice and/or metocean conditions along the transportation route, which can differ from those at the set-down location, and during the commissioning, hook-up and decommissioning phases.

Marine operations associated with the transportation and installation of the structure shall be in accordance with ISO 19901-6. Marine operations shall be addressed in the EER plan.

6 Escape, evacuation and rescue strategy

6.1 General EER strategy

The EER system components consist of hardware, procedures, organization and personnel. The EER system components shall include the EER strategy physical environment in [Clause 7](#), the EER strategy reliability in ISO 19906 and continuous assessment in [Clause 9](#).

The EER system shall:

- a) be developed for the full suite of credible incident scenarios and under the design arctic physical environment and operating conditions;
- b) be regularly monitored, tested, maintained and improved or corrected to maintain optimal performance;
- c) be designed and operated based on the preservation of human life, minimizing casualties and minimizing potential adverse effects on the arctic environment;
- d) promote the successful escape from an incident and if necessary, the subsequent evacuation from the installation and the ultimate rescue of personnel in the arctic environment;
- e) be designed and activated during operations in response to an emergency or during training and drills, ensuring continuous protection for all installation personnel in the arctic environment from any credible incident.

The EER system design shall be:

- a) robust and capable of responding to changing conditions in an emergency;
- b) deployed without any significant degradation in performance due to the arctic physical environment.

Management of the EER system shall be kept under close management review on an ongoing basis.

6.2 Human and hardware performance in EER

When developing the EER design basis, the following shall be considered:

- a) hardware performance and integrity;
- b) human performance, including performance under the stressors of life-threatening conditions, harsh arctic environment.

Reliabilities of both EER hardware and human performance, under the design arctic environmental conditions and credible incident scenarios, shall be assessed and determined to be acceptable.

Performance-based provisions shall be specified, taking into account the arctic environment and remoteness. Verifiable attributes or benchmarks which provide qualitative levels or quantitative measures of performance shall be achieved. Performance targets shall be developed in the context of a design safety case. Performance targets shall be verified before start-up of operations.

7 Physical environment

7.1 General physical environment

An assessment shall be made of the physical environment's influence on the EER system through the stages of design, operations and decommissioning.

Metocean, ice and seabed data used to design and support operation of the EER system shall be in accordance with ISO 35106.

Where deemed applicable to the EER design basis, the following impacts shall be taken into account:

- a) physical environmental conditions on ice management in accordance with ISO 35104;
- b) environmental conditions on ice management and the forecasting and monitoring of physical environmental conditions in accordance with ISO 35104.

7.2 Physical environmental conditions — Design

The EER system shall be designed to achieve a consistent level of safety and effective operation throughout the complete range of physical environmental conditions (i.e. climatic, ocean and ice) expected for a given location over the design service life of the installation.

Physical environmental conditions studied shall include, but not be limited to, the following factors and any associated issues affecting the performance and reliability of the EER system:

- a) atmospheric parameters (e.g. daylight, visibility, precipitation, geomagnetic storms — potential impact on communications relied upon during EER);
- b) wind, including wind speed, direction and chill;
- c) air and sea water temperatures;
- d) water depth, tides, storm surge, including sea level and long-term sea level fluctuations, and currents (e.g. local residual wind-driven and tidal);
- e) sea state (e.g. wave height, wave period, wave direction, including ice-wave combinations);
- f) tsunami (e.g. seismic sea waves or waves resulting from glacier calving);
- g) snow and ice accretion (e.g. marine and atmospheric icing);
- h) ice parameters in accordance with ISO 35104;
- i) coastal and nearshore considerations as applicable.

Arctic environmental condition data used in the quantitative assessment of the EER system risk and reliability under applicable environmental conditions shall be evaluated for statistical variability. Appropriate measures of variability (e.g. standard deviation, mode, mean values) shall be incorporated in the EER risk calculations, to provide measures of the variability of the risk results.

Changes in climatic conditions (e.g. sea ice extent, thickness and drift) that could occur during the expected installation operating service life, including the decommissioning phase, and that could adversely impact performance and/or reliability of the EER system shall be taken into consideration.

7.3 Physical environmental conditions — Operations

The offshore installation operator shall have the means and competency for evaluating risk associated with the arctic physical environmental conditions on the operational performance and/or reliability of the EER system.

8 Escape, evacuation and rescue hazard identification and risk analysis — Design and operations

8.1 General

Risk assessments shall be performed in accordance with ISO 31000, ISO 17776 and ISO 15544, related to the processes of risk analysis, hazard identification and requirements for emergency response.

8.2 General HAZID and risk analysis

The EER system consists of the equipment and procedures for EER, including the entire hierarchy of preferred, primary, secondary and tertiary evacuations, and any other levels of systems. The HAZID, QRA and qualitative risk analyses shall be:

- a) performed in the context of EER for hardware, procedures and personnel;
- b) performed for the phases of the offshore operation during which time personnel can be exposed to hazards;
- c) fully documented, typically in a design HSE case, in an auditable decision record for the EER system.

The authority having jurisdiction might have specific requirements on the scope of the HAZID and risk analysis methodologies to use.

Operability criteria for the EER system choices with respect to escape routes, TR, muster locations, choice of evacuation systems and their locations and safe havens for different physical environmental and incident conditions, shall be documented. This documentation allows effective decisions to be taken as to which method to use in an emergency under the prevailing environmental conditions.

ARTC and SRTC shall:

- a) be set by the operator and/or installation owner prior to conducting the HAZID and risk analyses;
- b) apply to all phases of the operation and EER procedures that pose hazards to personnel;
- c) be maintained and updated periodically throughout the service life of the facility and whenever there are changes in the operation.

The owner shall ensure that EER system ARTC and SRTC, which are performance-based standards, are:

- a) established at the earliest stages of design for all phases of the installation design service life;
- b) coordinated with other interrelated ER performance-based standards; and
- c) appropriately implemented.

Documented conformity with EER standards shall be available to support ARTC ALARP. Each EER scenario shall be shown to conform to the SRTC demonstration as part of the installation HSE case prior to commencing operations.

The duty holder (owner) shall ensure that:

- a) the equipment provided for the purpose of protecting personnel during the EER process satisfies the SRTC performance-based standards and is maintained in a state of readiness;
- b) the implemented EER measures, associated design and procedure decision processes are documented for the examination (by a competent and independent organization) of the system, comprising:
 - escape (from workplace to the TR or MS);
 - evacuation from MS or TR off installation to beyond hazard zone; and

- rescue, i.e. survival outside the hazard zone off-installation (e.g. in an evacuation craft or on the ice) and recovery to a safe haven such as an SIMV or conventional SBV.

8.3 EER HAZID

HAZID study techniques shall be applied to each component (i.e. equipment and activity) of the EER system and to the system as a whole for all credible hazard scenarios.

EER HAZID studies shall:

- identify and record major incident hazards and their consequences, so far as they can influence the selection of EER system design, components, support services and procedures;
- determine environmental factors that can influence the selection of EER system design, component specifications and support services or affect related procedures;
- establish the safety-critical systems and their elements on which the EER system performance-based standards shall be based;
- establish for each scenario approximate risk levels (context of SRTC and ALARP) for application during ranking of various system design options to achieve or improve the targets;
- provide primary input to QRA which, when undertaken, shall demonstrate that risks to personnel during the EER process meet EER SRTC criteria and are ALARP.

8.4 EER risk analysis

EER risk analyses shall be undertaken to support ALARP demonstrations that are required for installation HSE cases and to demonstrate EER SRTC are met.

Each EER scenario shall be analyzed, considering relevant hazards, environmental conditions, failure mechanisms, controls and safeguards provided to satisfy the SRTC performance-based standards.

9 Continuous assessment

9.1 Continuous assessment — Design

The EER system and its various components shall be assessed at regular intervals throughout the design service life of the offshore installation, from the concept phase to preparation for operation.

To help ensure that EER system integrity is maintained, risk analyses shall be updated for changes impacting the HSE case and/or the assumed or actual external EER resources and their capabilities.

9.2 Continuous assessment — Operations

The EER system and its various components shall be assessed at regular intervals throughout the service life of the offshore installation during operations through to decommissioning.

The installation's EER system and ER organization shall be tested through the implementation of emergency scenario drills and exercises. All deficiencies shall be addressed and mitigated as soon as possible following their detection.

Detailed assessment of evacuation scenarios should include human factors issues relating to environmental conditions and expected emergency rescue time. This is important since it can govern the means of rescue chosen and how it is deployed. For example, it can be deemed necessary to maintain rescue facilities for some installations by using an appropriately equipped rescue vessel in standby mode. This can be the best way to meet a performance-based standard that specifies the emergency response time. The same vessel may be equipped with smaller rescue craft (e.g. fast rescue craft or daughter craft) capable of performing rescue in certain conditions. An adequate place of safety

would include the availability of specific human and physical resources to rescue evacuees and provide necessary medical treatment.

All POB on the installation shall be trained in escape procedures and the use of the evacuation means including any special training required for designated personnel to operate the equipment.

The operator shall ensure that all persons onboard or in transit to/from an installation:

- a) receive appropriate and approved instructions;
- b) are familiar with safety and evacuation procedures;
- c) are taught what their roles and responsibilities are during emergency response.

The impact of any identified deficiencies on the installation's ability to continue operations in a safe manner shall be assessed, as the non-availability of a particular EER system can require a precautionary down-manning of the facility, a restriction of activities or both (e.g. a lifeboat can become damaged or unavailable by the initial hazardous event). Risk assessments should help identify and evaluate credible hazards and put in place mitigating measures and protection strategies.

The operator shall:

- a) establish effective inspection, testing and maintenance operational procedures in accordance with ISO 15544, accounting for the arctic physical environment and remoteness, to help ensure that EER material and equipment are properly maintained;
- b) ensure that all communication methods, passive and active protective measures and personal survival equipment on board are fit for purpose and maintained;
- c) use established performance-based standards and an approved inspection and maintenance program.

The effects of human performance, snow, icing and ambient low temperatures shall be factored into the preventative maintenance procedures of evacuation means.

10 Escape, evacuation and rescue system capabilities

10.1 EER system capabilities — Design

The EER system shall:

- a) be available to all persons on board the installation;
- b) help ensure that, in the event of a potential or actual emergency, installation personnel are protected and can be moved to a safe haven.

The EER system design shall:

- a) be fully integrated within the overall ER system in accordance with the governing principles described in [Clause 6](#);
- b) take into account the assumption that under certain credible incident scenarios, personnel might potentially have to abandon the installation via direct evacuation to the sea/ice cover and possibly without the benefit of external support;
- c) account for the impact that substructure geometry can have on ice, wave and ice/wave combination conditions near the installation, and thus on the performance of evacuation and rescue systems;
- d) account for trap risks created by enclosed areas/winterized work places and impacts on safety exits, escape ways/routes at the very beginning of the design stage and for any modification or upgrade of the installation carried out during its service life.

- e) account for as appropriate:
- ice thickness and strength [e.g. impacts evacuation onto ice and capability required for standby icebreakers (if so equipped)];
 - ice concentration (e.g. impacts manoeuvrability of evacuation and rescue craft);
 - ice drift (e.g. impacts ice encroachment and ice rubble/stamukha generation on the substructure and potentially the evacuation craft landing area);
 - ice deformation (e.g. impacts personnel mobility while on ice);
 - any other ice properties/characteristics that could adversely impact evacuation and/or rescue.

NOTE ISO 35104 provides for full details on ice parameters.

- f) take into consideration winterization requirements;
- g) take into consideration the requirement for regular inspection, maintenance, repair and testing, including functionality readiness assessments.

Installation LSAs exposed to an arctic environment shall be protected from the effects of cold ambient air temperatures, snow accumulation and marine/atmospheric icing to ensure availability when needed.

The EER system on a given installation shall be installed, tested, maintained and operated based on the established performance-based standards.

Power supplies, including emergency power, shall be available to allow all safety-critical equipment to perform its emergency function for the required duration.

Rescue systems shall be compatible with the evacuation system design in the context of the arctic or cold region physical environment to facilitate the safe passage of personnel between the systems.

10.2 EER system capabilities — Operations

Integration of the EER system with the installation's overall ER system shall be regularly assessed.

The design assumptions that the installation's substructure geometry has on ice, wave and ice/wave combination conditions, and thus on the performance of evacuation and rescue systems, shall be verified during operations. In the event that the ice and/or wave environmental conditions are magnified by the substructure to the extent that they are worse than assumed in the design, an EER analysis shall be performed to identify appropriate mitigating actions and measures.

The functionality of EER hardware and appropriateness of procedures shall be assessed during operations. Mitigations shall be taken to address any significant deficiencies.

Inspections of LSAs exposed to arctic conditions shall be undertaken on a regular basis and more frequently in response to cold temperatures, icing events and snowstorms.

The operator shall ensure that all personnel on-board the installation, as well as those supporting the EER plan off the installation:

- a) are provided with appropriate training;
- b) are familiar in the use of the evacuation and rescue systems;
- c) are familiar with the emergency procedures under both precautionary and emergency incident scenarios.

11 Emergency response organization

11.1 ERO — Design

The ERO shall be developed based on the assessments, philosophy and design basis described in this document and in accordance with ISO 15544.

In the design stage, the installation ERO shall be documented and summarized (e.g. in a station bill) for posting at strategic locations throughout the installation.

The installation's ERO and associated command structure shall be dimensioned to meet the performance requirements for all credible hazard and incident scenarios.

The need for back-up ER personnel shall be assessed. If deemed necessary, a plan shall be developed that addresses the risk of fatigue during an emergency.

11.2 ERO — Operations

The installation's ERO and associated command structure shall meet the performance requirements under all credible incident scenarios.

The installation's ERO shall be tested in the implementation of emergency scenario drills as described in [16.2](#), [17.2](#) and [18.2](#). Deficiencies identified shall be addressed as soon as possible following their detection.

The ERO shall be updated as necessary throughout the installation life-cycle and current versions posted at strategic locations on board.

When developing the ERO, personnel fatigue shall be addressed, taking into account the planned organization, the tasks assigned and associated fatigue related to working in an arctic offshore environment.

If a person is expected to fill more than one ERO role, an assessment shall be performed to ensure that the assigned roles are not in conflict; i.e. the person does not have to simultaneously carry out multiple duties or be in two different locations at the same time.

Interfaces between the installation's ERO and external organizations/resources shall be:

- a) clear and unambiguous;
- b) understood by the organizations involved in providing ER support.

12 Competency assurance

12.1 Competency assurance — Design

The installation design shall provide for testing the EER system in a realistic manner through a year-round systematic programme of emergency scenario drills with specific pre-planned learning objectives. This helps to ensure that the installation tests and assesses EER performance in arctic conditions of cold weather, ice, snow and extended darkness. The risks associated with the drills should be assessed. Those risks that pose undue risks should be modified so that the drills do not pose undue risks.

The EER system shall be designed so that it does not pose hazards to the safety of personnel undertaking emergency scenario drills. Realistic scenarios shall be planned that adequately test individuals' competencies without exposing them to prolonged cold temperatures and/or other undue hazards.

12.2 Competency assurance — Operations

Individuals, including their deputies/back-ups, responsible for emergency duties shall undergo periodic qualification and competency assessments that apply their training, experience and knowledge to carry out the tasks for which they are responsible. Where practical, the assessment shall be carried out under realistic simulated conditions, either individually or with the appropriate EER team throughout the year (e.g. open water season, shoulder season and when ice is present, to account for the different cold-climate condition seasonal challenges).

Key persons in the ERO shall be proven competent to perform their emergency duties before they are appointed. These key persons shall have the necessary regulatory and company attestation, including pertinent knowledge of the arctic environment, to perform their roles before taking on that responsibility offshore.

For normally manned installations, sufficient competent personnel shall be present on the installation at all times to carry out the required emergency duties year-round, including the operation of equipment specifically provided for emergencies.

The required level of competence shall be assessed for:

- a) the general installation workforce;
- b) installation personnel having specific emergency duties;
- c) senior staff in the company's organization, including the person in charge overall;
- d) personnel on other installations or vessels (if part of the ERP) onshore who have an ER role;
- e) any personnel having a specialized role (e.g. ice forecaster), if applicable.

Individual competencies shall be periodically evaluated to determine whether further training and knowledge is required to allow them to effectively perform their ER duties associated with EER. The ERO relating to EER shall include the measures to be taken to maintain this competence by, for example, the conduct of emergency scenario drills and refresher training.

So far as practical, the ERO for EER shall reflect the organization used in normal operating conditions. In this way, EER is emphasized as a responsibility embodied in the normal management structure. In the case of non-routine activities, such as combined operations with a crane barge or flotel, an alternative organization for EER might be appropriate.

The training and competency assurance system shall help ensure redundancy of trained personnel (e.g. by means of a deputy system), demonstrating a level of competence equivalent to the primary person whom they need to replace.

The operator shall ensure that all installation POB:

- a) are adequately familiar with the operator's safety management system, including the emergency EER response plans and hardware systems;
- b) are adequately trained and competent in accordance with their safety and ER-related responsibilities and duties.

Personnel shall be given appropriate installation-specific EER training for arctic regions and/or drills (i.e. for the use of the LSAs and PPE carried aboard the installation). Competency of personnel shall be maintained and regularly tested. Installation-specific training shall take into account the open water, shoulder- and ice-season operating environments. Installation-based training shall include any specialist training required for designated personnel to operate the equipment.

A systematic programme of emergency scenario drills with specific pre-planned learning objectives shall be implemented in a realistic manner as described in [16.2](#), [17.2](#) and [18.2](#).

Operational reviews by qualified personnel shall be conducted to help ensure that the EER system does not pose hazards to the safety of personnel undertaking drills during any season of the year.

Competency assurance in the use of PPE shall be evaluated at regular intervals. This is especially with reference to cold weather clothing appropriate for the lowest temperatures likely to be encountered and the effects that wearing bulky clothing/mittens can have on the ability to operate equipment and permit ease of movement around the installation (e.g. during escape) and in evacuation craft. Where deficiencies are identified, a corrective action plan shall be developed and implemented.

If weapons or hazing devices are required as part of the EER plan for protection from wildlife when evacuating to the ice or while awaiting rescue, training in their safe use, storage and maintenance shall be provided. Designated user competency related to weapons or hazing devices shall be assessed.

13 Communications and alarms

13.1 Communications and alarms — Design

The communication and alarm system shall be designed to operate (within the operational network offshore, onshore, on SBV support if applicable, and on-board the installation) under all credible emergency scenarios, taking into account geography, distance from the shore base and the arctic physical environment. The communication system design shall include the capability to communicate from the TR/CCR with standby and service vessels, helicopters, shore base and nearby installations and any other location deemed necessary as identified in the EER plan.

PA announcements, visual and audible communications, including external communications (e.g. with standby/icebreaker/service vessels, helicopters, shore base, nearby installations and any other location deemed necessary as identified in the EER design basis) shall be operable from the TR/CCR and wherever identified as necessary.

The alarm system design shall include the capability to make PA announcements, visual and audible communications from the TR and any other location deemed necessary as identified in the EER plan.

Redundant communication and alarm systems that are capable of functioning in cold-climate conditions shall be available for use in the event that the primary communication system fails.

The need for intrinsically safe communication systems shall be assessed in the EER system design and verified in the EER analysis.

The number and location of visual and audio alarms specified in the design shall be verified in the EER analysis and revised as appropriate.

The plan for communication with personnel working in normally unmanned locations, including unheated spaces, shall be assessed and addressed.

EER system design shall allow for assessing off-installation environmental conditions (i.e. ice conditions, wave state, wind speed and direction) from the TR for those installations requiring the information as part of the EER plan.

The design shall allow for communication between the MS and incident responders following a general or abandonment alarm for the duration of the incident or until installation abandonment has been completed.

Emergency information, signage and auditory systems shall account for language/culture differences and be strategically located throughout the EER system.

Key components of the EER system (e.g. escape routes, evacuation boarding areas, TR) as determined by the EER analysis shall be illuminated for the required duration to facilitate carrying out EER functions regardless of the season.

Communication and alarm systems shall be operable with back-up emergency power systems in addition to the main installation power. The provision for battery back-up shall be assessed as part of the EER analysis. If battery back-up is deemed necessary, the impact of cold temperatures on communication and alarm systems' battery life shall be accounted for in the design.

The design shall account for powered, photoluminescent and retroreflective signs, as appropriate, located on open decks to function normally within the arctic design low temperature and anticipated snow and ice accumulation/accretion. If de-icing protection is not suitable, signs shall be equipped with anti-ice accretion protection to help ensure that they will not be damaged.

Audible alarm devices and loudspeakers and visible alarm devices located in open spaces and unheated compartments shall:

- a) function normally at the lowest design temperature;
- b) be equipped with anti-icing protection, if necessary, to help ensure that they will not be damaged or their functionality compromised due to icing and snow accumulation;
- c) be protected against mechanical damage caused by manual de-icing/snow removal measures, in cases where manual de-icing and snow removal is employed, including signage.

13.2 Communications and alarms — Operations

Regular inspections and testing of all auditory and visual, including illumination, communication systems required to support EER shall be carried out in accordance with the manufacturer's or owner's, whichever is more onerous, preventative maintenance and inspection schedule.

The inspection frequency shall take into account the impact of cold-climate conditions (i.e. cold temperature, icing and snow) on communications and alarm system functionality.

Necessary repairs and upgrades shall be effected in a timely manner regardless of the season, to help ensure that communications and alarm equipment is kept in good working order throughout the installation service life.

Functionality of the communication systems, including the emergency power supply required to support EER, shall be tested and validated during the conduct of emergency scenario drills carried out throughout the year as described in [16.2](#), [17.2](#) and [18.2](#).

Powered, photoluminescent and retroreflective signs located on open decks shall be kept free of snow and ice. The effectiveness of snow and ice removal preventative maintenance shall be assessed. Powered, photoluminescent and retroreflective signs shall be protected against mechanical damage caused by manual de-icing and snow removal.

In cases when communications and/or alarms are temporarily out of service for maintenance and/or repair, either measures shall be implemented to temporarily duplicate their functions or work activities shall be restricted until such time as repairs are effected and system functionality restored.

14 Personal protective equipment (PPE)

14.1 PPE — Design

The need for, the quantity, types and storage locations of PPE shall be determined in the EER analysis.

NOTE ISO 35101 provides general guidance on PPE.

PPE deployment locations shall include the living quarters, TR and other strategic areas.

Evacuee PPE shall include devices to facilitate evacuee movement from the sea to the ice (if required by the EER analysis).

If evacuation onto the ice is part of the EER design basis, the PPE shall include appropriate thermal protection and proper footwear with suitable traction to aid in the traverse over ice and snow to facilitate rescue.

Consideration shall be given to providing thermal protection for injured parties (i.e. stretcher cases) that might not be physically able to don an immersion suit.

Externally stored PPE shall be capable of withstanding the lowest design temperature as well as snow and ice accumulations. The requirement for heated storage areas shall be assessed.

PPE performance shall provide adequate protection under cold-climate conditions.

The need for weapons or hazing devices for protection against wildlife risks shall be assessed.

14.2 PPE — Operations

PPE shall be regularly inspected, maintained, upgraded as deemed necessary and donned during drills. Equipment whose expiry date has elapsed or which has been damaged, shall be replaced or refurbished and recertified at the first opportunity.

The condition of PPE stored on deck shall be assessed periodically to confirm its availability to support EER.

Immersion suits and lifejackets shall be stored in locations (e.g. heated storage lockers on exposed decks, inside heated spaces such as the TR/quarters/command centre), conducive to maintaining suit pliability when donning. Provisions to help ensure that immersion suits and lifejackets exposed to cold climate conditions maintain sufficient pliability shall be regularly assessed.

The MOB recovery ER crew shall have dedicated PPE specific to that task readily available for rapid donning in the event of an emergency requiring launch of the MOB recovery craft.

15 Man overboard recovery

15.1 MOB recovery — Design

The installation and/or SBV or SIMV shall have redundant means to recover a MOB, including injured personnel, under the anticipated incident and arctic physical environmental conditions. Redundant MOB boat systems also require redundant launching arrangements.

A performance-based standard that establishes a target recovery time shall be developed for the design that results in a high probability of successfully rescuing personnel from the sea/partial ice cover in the environmental conditions specified in the EER analysis.

Where utilized as part of the MOB plan, a rescue craft shall meet the LSA Code if applicable local regulations are less stringent.

15.2 MOB recovery — Operations

MOB drills shall be carried out periodically to validate the performance-based standard including responder competency, to verify that the target retrieval times are met and to validate the adequacy of hardware capabilities under the arctic physical environmental conditions anticipated.

Off-installation support (e.g. SIMV/SBV, shore base resources if relied upon) shall be considered as part of the MOB response plan when carrying out MOB drills.

16 Escape

16.1 Escape — Design

16.1.1 General escape — Design

Escape system design shall consider communications and alarms, escape routes, TR (if so equipped), MS and PPE locations and quantities and their integrated function in the escape process.

Escape system design shall:

- a) help ensure that all parts of the escape system are fully functional in the physical environmental conditions, including cold temperatures, darkness, icing, snow accumulations and remoteness or malfunction due to low ambient air conditions;
- b) be documented, specifying the types of equipment, their capacities and arrangements and how the design meets the associated performance-based standards.

Provisions for medical first-aid shall be available at TRs and MSs. First-aid provisions shall be protected from the effects of freezing, snow and marine/atmospheric icing.

16.1.2 Escape routes — Design

An escape route impairment analysis shall be performed as part of the EER analysis to help ensure that personnel can safely leave all normally manned work spaces in the case the incident causes a blockage of one of the routes. The impairment analysis shall take into account the aspects of escape route impairment from relevant incident scenarios, including arctic conditions that can hamper and delay the escape process (e.g. snow, ice, winds, darkness).

Escape routes design shall:

- a) account for impairment associated with hazards, to help ensure that personnel can safely move from any part of the installation via at least one safe route to the TR or MS under all credible incident, physical environmental and operational conditions;
- b) be obstruction free and reduce the risks of tripping and falling;
- c) provide sufficient width for the safe and unobstructed passage of the maximum estimated number of personnel expected to move through the escape route without creating bottlenecks, including the ability to manoeuvre injured personnel on stretchers;
- d) ensure that personnel traffic moves in one direction and does not allow personnel flow to join from the opposite direction, unless needed due to hazard avoidance.

Escape routes, stairways, ladders and landings shall be sized to take into account bulky cold-weather PPE and to maximize the flow of personnel in an emergency. Exit doors, stairways and ladders shall be appropriately designed, taking into account icing and/or snow accumulations and the direction of escape.

The escape system shall be implemented and maintained in accordance with the documented design.

Wind socks or other types of wind direction indicators (e.g. signs, PA announcements) shall be available to assist personnel in selecting the appropriate escape route.

Sealed/enclosed or semi-enclosed escape ways (e.g. stairways and tunnels) designed to protect against the outside environment shall minimize the potential for smoke and gas ingress in their design through properly dimensioned and purpose-made ventilation/dilution/sealing solutions.

Both visual signage and audio communications shall be provided to clearly designate all escape routes, including any turns, stairs, ladders or any other changes along each route. Escape routes shall be well marked and illuminated by emergency lighting leading to the TR, including signs or other visuals that clearly show the preferred direction of escape. Signs shall be designed to remain visible in the physical

environmental conditions, including extended darkness, icing, snow and dense fog and for situations where loss of central power can occur. Ice accretion and snow build-up shall be taken into account in the escape routes design.

Escape routes shall be designed:

- a) free of obstructions to reduce the risks of tripping and falling when visibility can be reduced due to congestion and flow of people;
- b) to minimize the accumulation of snow and icing, in which permanent engineered solutions is preferred over temporary operational or procedural solutions. In case the latter, the EER plan can include procedures to remove snow and ice along the escape route so that escape performance is not negatively impacted, in the case an incident occur;
- c) with sufficient drainage to remove melt and wash water. If deemed necessary, drainage systems shall be provided with anti-freezing protection to help ensure that they are not blocked or impaired by internal freezing.

The need for adding heat to walkways and hand rails shall be assessed in the design.

Door handles and means of quick release located outside the heated compartments shall be designed to function under the cold-climate conditions, particularly low temperatures, snow accumulation, atmospheric and sea spray icing. The need for ice removal protection provisions shall be assessed. Ice accretion protection measures shall not impose any additional ergonomic challenges for users.

Hand rails and other handholds located on outdoor spaces shall be fully functional in cold climate conditions at all times. If necessary, they shall be equipped with active ice build-up prevention protection. Ice build-up prevention protection measures shall not impose any additional ergonomic challenges.

The surface coating of decks, walkways, platforms, stairs, ladder rungs, etc. exposed to the arctic environment and/or operations shall remain non-slip under expected environmental and operational conditions.

When designing evacuation routes for floating installations requirements of the IMO International Convention for the Safety of Life at Sea, 1974 (SOLAS 74), Chapter II, Part D, Evacuation, Regulation 13, Evacuation routes, shall be used for design.

16.1.3 TR — Design

At least one TR shall be provided, except where the EER analysis or risk assessments demonstrate that none is required.

The TR shall act as a safe haven providing protection to installation personnel from any incident and physical environment effects for a time sufficient to allow control of the emergency or until a decision is made to abandon the installation.

The TR shall be located as far as reasonably practical from hazardous zones.

The length of time that a TR is rated to withstand the effects of any incident (i.e. the TR impairment time) shall be sufficient to allow muster and evacuation plus a safety margin. The TR impairment time shall take into account the possibility of longer evacuation times (e.g. due to challenging ice conditions).

A TR impairment analysis shall be performed as part of the EER analysis, taking into account:

- a) the aspects of impairment including ice and other physical environmental conditions that can delay evacuation;
- b) the time required to assess the incident;
- c) the time required to complete the evacuation process.

The TR shall have stored and available air supply sufficient for the maximum POB expected for the requisite time.

The TR design shall prevent or avoid impairment due to cold temperatures, icing, snow accumulation or other physical environmental conditions, to the extent possible.

The TR HVAC system inlet design shall account for the effects on functionality of marine and atmospheric icing and snow accumulation.

Power to the TR shall be supplied by the main source and backed up by the emergency power supply.

Passive fire protection materials, if used in the TR design, shall account for environmental and operational conditions (factors), including extreme low temperature, marine and atmospheric icing, snow accumulation and manual ice removal measures, if planned.

Where required by the EER analysis, the TR shall be a single location in which other structures provide protection from the drilling operation, process events, helicopter incidents and falling structures or large objects, as applicable.

The primary TR shall have sufficient capacity for the maximum permitted POB. If the main installation control point is not in the TR, then an ECP should be located in the TR. Similarly, if the main installation radio room is not part of the primary TR, there shall be an emergency radio point located within the TR.

The TR design shall:

- a) have minimal door openings, generally equipped to maintain positive pressure relative to the outside environment and have a back-up air supply;
- b) secure communications, command and control facilities;
- c) have sufficient space for assembling, donning arctic PPE and evacuating to the embarkation area.

Where a secondary TR is deemed necessary by the EER analysis, it shall be subordinate to the main TR. A secondary TR shall have an independent means of evacuation as determined by an EER analysis. Secondary TRs shall be able to accommodate all individuals potentially isolated from the primary TR, plus a contingency, as determined by the EER analysis. A means of communication between the two TRs shall be available.

16.1.4 MS — Design

As determined by the EER analysis, strategically located MS(s) shall be present, which:

- a) have dimensions that can accommodate the maximum anticipated POB;
- b) provide protection from the physical effects of the arctic environmental and incident conditions;
- c) provide sufficient space for bulky cold-climate condition clothing/immersion suits and other PPE that personnel will be wearing and/or will need to don at the MS.

When dimensioning MSs, consideration shall be given to accommodating injured personnel on stretchers, as well as extra personnel who have arrived by helicopter in the event the helicopter cannot depart, personnel on the installation from an SIMV or other vessel and visitors.

The MS shall be provided with emergency lighting sufficient for the entire period for which personnel might have to use the area.

Appropriate facilities for internal and external communication to cover emergency communication demands shall be provided in muster areas.

If deemed necessary by the EER analysis, alternative MSs shall provide protection from the effects of the incident and environment for a period of time sufficient to allow control of an emergency or until a decision is made to abandon the installation.

16.2 Escape operations

16.2.1 General escape — Operations

Escape system operations shall include consideration of communications and alarms, signage, marking, escape routes, the TR, MS and PPE locations and their integrated function in the escape process.

The following operational escape management activities shall be carried out regularly as deemed necessary by the EER analysis and/or mandated by operating procedures:

- a) maintenance, including removal of snow, ice and other obstructions;
- b) inspections, including equipment function testing, repairs and upgrades;
- c) operational EER trainings, drills and exercises.

Maintenance inspections and servicing of essential safety systems (e.g. fire and gas detection systems, ventilation systems, communication and alarm systems) shall be carried out in accordance with the manufacturer's recommendations or more frequently if warranted due to arctic environmental conditions.

16.2.2 Escape routes — Operations

Escape routes shall be routinely cleared of snow and ice as required to help ensure that escape times and the ability to use escape routes are not adversely impacted.

The availability of lighting, signage and functionality of audio communications along escape routes shall be assessed periodically as part of the EER preventative maintenance work. Corrective actions shall be taken to address deficiencies especially after a snowstorm or icing event.

During periods when any of the safety systems (e.g. detectors, alarm devices) are temporarily out of service for maintenance and/or repair, measures shall be taken to temporarily duplicate their functions. In the event alternative safety systems are not available, work activities in areas protected by the system in question shall be suspended until their function has been fully restored.

An assessment shall be made to determine whether additional heat directed at walkways and hand rails is required to mitigate snow and ice build-up.

Exit doors, stairways and ladders shall be accessible at all times, taking into account icing and/or snow accumulations and the direction of escape.

Escape routes shall not be blocked by the temporary storage of equipment and/or materials.

Both scheduled and unscheduled (i.e. no prior notification) emergency scenario drills that include escape to the TR or MS shall be conducted regularly to help assure the competency and familiarity of installation personnel.

Observation of personnel performance during drills along escape routes, stairways and ladders shall be made and compared to the EER plan assumptions with regards to functionality and timing. Any deficiencies noted shall be rectified.

Whenever possible, escape drills shall be conducted over a range of environmental conditions including periods with ice and/or snow accumulations (or these conditions simulated) and darkness, provided safety can be reasonably assured.

Scheduled drills shall include utilizing escape routes from each personnel work location, including the longest or most difficult, to escape locations along each preferred and alternate route and escape to the TR and each of the alternate muster points.

Operators shall help ensure that all personnel are familiar with their roles and responsibilities related to maintenance of escape routes.

Enclosed and semi-enclosed parts of escape routes used during normal operations shall be regularly cleaned of dirt/debris and snow brought in by personnel entering them from open areas. Personnel shall be instructed to remove dirt and snow from their clothing and footwear prior to entering enclosed and semi-enclosed areas, if dirt/snow can adversely affect escape route integrity.

16.2.3 TR — Operations

An assessment shall be made during operations to verify the assumptions made during design when defining the TR impairment time (e.g. if ice conditions could potentially pose longer delays to completing evacuation). If the TR impairment time is deemed insufficient, a focused EER analysis shall be undertaken to identify mitigations. The identified mitigations should be implemented.

TR functionality, including positive air pressure and air capacity testing, of the hermetic seal from other areas and the outside environment within the timeframe specified in the design basis shall be assessed on a regular basis. Any deficiencies shall be rectified. The need for more frequent assessments, particularly during weather events (e.g. snow storms and periods of significant marine icing build-up), shall be evaluated.

The functionality of TR air vents shall be assessed more frequently during snowstorms and marine/atmospheric icing events to help ensure that snow and icing accumulations do not impede TR air vent closure in an emergency.

During drills, the efficiency of access and donning of survival suits in the TR shall be observed. Any shortcomings shall be noted for rectification.

Entrances, emergency exits and escape/evacuation routes shall permit the free movement of people, with low levels of congestion.

Entrances and emergency exits shall be protected against environmental factors (e.g. atmospheric and marine icing, snow). If necessary, ice build-up prevention/ice removal protection measures shall be considered.

Air inlets and air ducts as well as associated protective devices (e.g. hermetic seals, fire and gas dampers) shall be regularly cleaned of dirt, snow and ice.

Maintenance and/or repair of any TR component or safety system shall not have any negative impact on TR integrity or the EER system in general. Repairs associated with the TR shall be carried out in as short a time as reasonably possible.

Measures shall be implemented to prevent or avoid TR impairment due to cold temperatures, icing, adfreeze, snow accumulation or other physical environmental conditions.

16.2.4 MS — Operations

Each MS shall be inspected on a regular basis. Any deficiencies shall be corrected, including snow and icing accumulations in cases where the muster point is exposed to the outside environment.

During drills, the efficiency of access and donning survival suits at each MS shall be observed. Any shortcomings shall be noted for rectification.

All persons on board the installation shall have a clear understanding of the MS locations and how to efficiently reach these locations from typical work areas, via signs, station bills, instructions/orientations and regular drills and exercises.

17 Evacuation

17.1 Evacuation — Design

17.1.1 General evacuation — Design

Precautionary and emergency evacuation methods shall be designed and operated in accordance with the risk criteria established in [Clause 8](#), with the design based on an appropriate analysis in accordance with this document and ISO 15544.

The methods of evacuation, whether installation or off-installation based, shall be assessed in the EER analysis according to the number, location, orientation and type of evacuation system used.

The design and selection of multiple and distinctly different types of evacuation methods shall include a risk assessment of the lowest probability of incurring casualties, taking into account the range of design arctic physical environmental conditions during precautionary and emergency evacuations and during simulated scenario drill evacuations.

Evacuation methods (e.g. boarding, securing, deployment, clearing the hazard zone) shall be designed to perform reliably for the credible physical environmental, operational and incident condition combinations as determined by the EER analysis. Dry evacuation shall have highest priority. Where possible, at least one evacuation method shall not require personnel to enter the sea or ice cover.

Any restrictions on the design of evacuation systems in open water and/or ice environments shall be identified. Alternative EER systems with sufficient capacity to mitigate such restrictions shall be available.

The evacuation system shall be designed such that it is visible and identifiable and provides location information to search and recovery platforms under design installation hazard and environmental conditions.

The need for personnel in the TR and/or MSs to have access to real-time ice and metocean data as part of the evacuation plan to assist decision-making on evacuation timing shall be assessed.

Personnel moving from the TR or MS to the primary embarkation areas shall be protected from the installation hazards and physical environment during an incident.

MSs shall be well marked and lit. There shall be sufficient emergency lighting of the sea surface in the evacuation area to clear the area before launching. The lighting shall be sufficient to detect ice and other impairments that can pose a danger.

The installation operator shall have an understanding of the expected capabilities of the means of evacuation in the range of physical environmental conditions that can be expected to occur in the operating area, taking into account the location and arrangement of the evacuation stations.

In choosing the means of evacuation, the installation operator shall recognize explicitly how the physical environmental conditions affect or limit the performance capabilities of evacuation systems/means. The deterioration in performance up to the operational physical environmental limits shall be taken into account.

17.1.2 Evacuation method — Design

The primary independent method (i.e. means) of evacuation shall accommodate the full complement of POB, taking into account occupant size and weight, including injured personnel and visitors, under any credible emergency incident scenario requiring evacuation, under all credible weather conditions and at any given time of the year.

The capacity (i.e. to accommodate the maximum POB) and arrangement of the various evacuation systems shall be determined and justified on the basis of an assessment of the credible incident

scenarios and distributions of personnel during operations, including peak (i.e. maximum POB) manning operations.

Any restrictions on the design of evacuation systems (in open water and/or ice environments) shall be identified. Alternative EER systems of sufficient capacity to cover for such restrictions shall be available.

Each means of evacuation shall be assessed to help ensure that it accommodates the number of personnel it is designed for when donning immersion suits or cold weather attire. Occupant space and restraint design shall consider bulky cold-region PPE, the distribution of individuals, their mass and physical dimensions as well as acceleration.

The means of evacuation shall be assessed to ensure that it can be operated by personnel wearing bulky clothing (e.g. the opening of hatches, operation of levers, control knobs).

If determined by the EER analysis, the evacuation means shall be capable of being operated by personnel wearing respiration protection, for launches in toxic atmospheres (e.g. smoke, H₂S) in cases where pressurized access routes have not been provided.

The design integrity of each independent means of evacuation shall be assessed in terms of impact with other evacuation methods, the installation, environmental conditions including ice cover and with rescue craft.

Evacuation means shall be designed and located to minimize the effect of the surrounding ice cover in their deployment and movement beyond the incident hazard zone.

The need for an ice management plan that directs the SIMV to proactively maintain a clear route to the evacuation craft launch zone, if part of the evacuation design basis, to support evacuation, shall be assessed.

NOTE ISO 35104 provides details of ice management plans.

The layout design of the boarding area for evacuation means, as well as the launching equipment and method, shall consider the safety and exposure of personnel during emergency use as well as when carrying out drills and maintenance.

The means of evacuation shall be integrated and compatible with the means of rescue. Evacuation shall not be planned in scenarios or physical environmental conditions in which the means of rescue are not available or in which the risks are higher than staying on-board the installation.

Evacuation means shall be designed to protect personnel from the effects of the incident and arctic or cold region environment until recovered to a place of rescue.

The evacuation system, the rescue system or both, shall have a provision on-board for retrieval of personnel, including injured personnel, from the sea or ice, if applicable.

The requirement for protection from snow, icing and/or cold temperatures shall be assessed as part of the evacuation system design. Due consideration shall be given to preventing the blocking of vents, unless part of design for H₂S and other toxic gases. and the requirements to help ensure an adequate air supply inside the evacuation means while not adversely compromising the thermal protective capabilities of such means. The need for keeping medical kits and emergency supplies (e.g. water) warm/protected from freezing shall be assessed.

The need for low-temperature lubricants and fuel additives, engine heaters, cabin heaters, battery heaters, heat tracing, protective enclosures, etc., shall be evaluated and, if required, specified in the design. The engine shall be rated with sufficient capacity to enable the evacuation craft to proceed from the launching point to the place of rescue in expected prevailing ice, if required based on the EER analysis, and metocean conditions. Considerations shall be given to the design of pressure relief valves, air intake valves, release mechanisms, hatches, valves, in the design of cold climate lifeboats to avoid suffocation of survivors inside lifeboat due to engine air consumption.

Helicopters used as a preferred means of evacuation shall be:

- a) capable of operating in cold-climate conditions associated with arctic offshore environment,
- b) staffed and equipped to perform transportation of evacuees from the installation to a safe haven.

17.2 Evacuation — Operations

17.2.1 General evacuation — Operations

The functionality of monitoring ice and metocean conditions from the TR and/or MS(s) shall be assessed, if used as part of the evacuation plan, to assist decision-making on evacuation timing.

Evacuation route(s) on-board the installation shall be kept accessible year-round.

The installation operator shall help ensure that the functionality of all evacuation equipment on board is maintained in accordance with performance standards and original equipment manufacturers' recommendations.

The installation operator shall ensure that in circumstances that can necessitate a precautionary or emergency evacuation, all personnel have access to the means of evacuation.

In cases where the cold-climate condition evacuation plan includes lowering the evacuation means directly onto the deck of an SBV (conventional or icebreaker), there shall be regular trials with the vessel to help ensure that it is able to approach the platform, hold station and successfully embark the craft in the prevailing conditions up to predefined metocean limits documented in the installation's evacuation procedures.

For EER strategies in which evacuation craft are lowered directly to the SIMV, the SIMV shall keep its deck clear of snow and ice.

Any restrictions on the use of evacuation systems in open water and/or ice environments shall be documented in the installation's evacuation procedures. The evacuation and rescue design should consider limitations for the effective function of evacuation systems and rescue operations.

17.2.2 Evacuation method — Operations

The total POB, including injured personnel and visitors, shall not exceed the capacity foreseen by the design philosophy for each of the primary, secondary or tertiary evacuation means at any time, under all credible emergency incident scenarios and environmental conditions. A methodology shall be developed to help ensure that the capacity of the evacuation means is not exceeded.

Each method (i.e. means) of evacuation shall be inspected and maintained in accordance with the manufacturer's recommendations, the offshore installation's preventative maintenance requirements or the operator's performance-based standards, whichever is more onerous.

Down-manning (i.e. removal of non-critical personnel) shall be carried out at times when the evacuation system(s) cannot accommodate the manufacturer's or design assumption capacity.

Periodic inspections and assessments shall be carried out to verify that both visual signage and audio communications required as part of the evacuation (precautionary or emergency) process are available and functioning to warn personnel. Deficiencies shall be rectified without delay.

Both scheduled and unscheduled (no prior notification) evacuation drills shall be conducted according to plans specified by the EER plan, to help ensure that personnel are familiar with the evacuation methods. Evacuation drills shall include verification that performance requirements are met.

Observation of personnel performance during evacuation drills, including timing and proficiency, shall be made. Any deficiencies in procedures or systems configuration shall be noted and rectified.

Whenever possible, evacuation drills shall be carried out under various environmental conditions, including ice and/or snow accumulations and during periods of darkness, provided the risk to personnel safety is minimized to an acceptable level.

If utilized, the effectiveness of low-temperature lubricants and fuel additives and the functionality of engine heaters, cabin and battery chargers and heaters, heat tracing, protective enclosures, etc. shall be assessed and included as part of the preventive maintenance plan.

The integrity of each independent method of evacuation shall be periodically verified in terms of impact with other evacuation methods, the installation, environmental conditions, including the ice cover and their match with a corresponding capability and availability of means of rescue.

The ability of the SIMV to pro-actively maintain an ice free path to the evacuation craft launch zone, if part of the evacuation design basis, to support evacuation shall be assessed. In the event of ice pressure or heavy ice, the SIMV should attempt to clear a path. If not able to do so within the prescribed time, consideration shall be given to limiting hazardous/higher risk operations on-board the installation.

18 Rescue

18.1 Rescue — Design

The rescue process within the rescue system consists of two principal phases:

- phase 1: Survival
- phase 2: Retrieval.

The evacuation process consists of moving personnel from the installation's MS or TR to a safe distance beyond the immediate or potential hazard zone of the installation. Next, in phase 1 of the rescue, the evacuees need to survive until a safe haven (SBV, helicopter, land or other installation) is available for them. This can be a very short time, if an SBV or SAR helicopter is available. In general, survival in an evacuation craft or on the ice surface under Arctic conditions can be hazardous. Arctic hazards, if the evacuees are in an evacuation craft, include possible ice convergence which can crush the craft, high winds and sea states if the craft reaches open water, or icing from spray causing craft instability. If the evacuees are on the ice surface, they can face intense cold, predators such as polar bears, ice surface instability, or simply running out of emergency supplies. Then, in phase 2, the evacuee retrieval to a safe haven also has additional hazards associated with Arctic conditions. Broken ice conditions can prevent approach of the survival craft to the SBV or its rescue craft, low visibility, snow storms, and intense cold and wind impair personnel transfer, or high winds and storms will ground SAR helicopters. In the rescue system design, appropriate provisions for applicable Arctic impediments should be included.

Rescue systems shall be designed to help ensure that evacuees can be rescued within the design ice and metocean conditions.

A means shall be available to retrieve evacuees from the sea, the ice cover or from evacuation systems to a safe place where medical attention is typically available.

Rescue recovery appliances/systems for retrieval of evacuees from the means of evacuation shall be designed such that evacuees need not enter the sea or reach the ice cover to be retrieved to a safe haven.

The rescue system, including any lifting appliances/systems, shall be designed:

- a) to help ensure:
 - normal function under the full range of design environmental conditions;
 - operation by personnel wearing bulky arctic clothing and PPE;
 - suitability for retrieval of evacuees wearing bulky PPE and cold weather clothing.

- b) that the capacity of the rescue system(s) is sufficient to rescue all personnel evacuating the installation at any given time under the prevailing arctic physical environmental conditions;
- c) to minimize the time that evacuees, including injured personnel, whether in the water, on an ice cover or in an evacuation craft, should have to survive without external support;
- d) taking into consideration the need for, location and level of support (e.g. hospital, clinic) of off-installation medical assistance for recovered casualties;
- e) that is sufficiently robust to help ensure its availability when needed for the duration of the rescue effort.

Performance requirements that establish target rescue times shall be developed that result in a high probability of successfully rescuing personnel from the sea, from the evacuation means or from an ice cover under the environmental conditions specified in the EER analysis.

Safe haven(s) shall have equipment and capabilities suitable for locating and retrieving evacuees directly from the sea or an ice cover, either individually or by retrieving the entire evacuation craft.

Rescue team personnel shall be able to perform their duties while exposed to the physical effects and consequences of the incident and under the prevailing arctic environmental conditions.

18.2 Rescue — Operations

The following rescue system operational management activities shall be carried out:

- a) rescue system communication tests;
- b) regular preventive maintenance;
- c) inspections;
- d) repairs and upgrades;
- e) training of installation and off-installation personnel (including cross-shifts) in the use of the various rescue means employed under year-round prevailing environmental conditions.

The response capability and readiness of off-installation medical assistance for casualties shall be assessed periodically throughout the year to help ensure proper medical treatment when needed.

Emergency scenario drills shall include retrieval of simulated evacuees (dummies) from the sea, the ice and from evacuation systems onto a rescue platform to demonstrate rescue system crew competency and rescue platform capability.

Participant safety shall be taken into account when planning and carrying out rescue drills.

The rescue system, including lifting appliances if so equipped, shall be protected from adverse environmental conditions to maintain its state of readiness.

Annex A (informative)

Additional information and guidance

NOTE The clauses and subclauses in this annex provide additional information and guidance on the clauses in the main body of this document. The same numbering system and heading titles have been used for ease in identifying the subclause in the body of this document to which it relates.

A.1 Scope

No additional guidance provided.

A.2 Normative references

No additional guidance provided.

A.3 Terms and definitions

No additional guidance provided.

A.4 Abbreviated terms

No additional guidance provided.

A.5 General requirements and conditions for EER systems

A.5.1 Fundamental requirements

The EER system should be addressed as part of the HSE case.

A casualty in the context of EER is an injury or fatality resulting from an incident that occurs during EER, where the probability of occurrence can be reduced by informed decision-making. The EER system should be designed such that additional casualties are minimized beyond those that arise during the initial incident. If a casualty relating to EER occurs, improved design and/or procedures should be implemented.

The “minimal injuries to personnel” provision applies to the period between first warning and all personnel reaching a safe haven. It does not refer to major incident-related casualties. The “minimal injuries to personnel” provision applies during EER and is one of many criteria that are necessary to include in performance-based standards for the installation's SCEs that should be included as part of the EER system “goal”. It is, then, the responsibility of the asset owner/duty holder to demonstrate that the risks have been reduced to ALARP, thereby demonstrating a good prospect of avoiding a casualty during EER.

A plan should be followed as far as practical for the inspection, maintenance and repair of any tanks associated with the EER system (e.g. fuel, hydraulic oil, freeze protection) containing fluids or materials that can potentially pollute, especially during the ice season where any spill to the ice cover could be challenging to clean up.

A.5.2 Methods — Design

A.5.2.1 General

For designs developed in accordance with the EER system design process and methodologies provided in this document, the general levels of safety and performance of structures are established in ISO 19906, while hazard and risk analysis for EER in the Arctic are defined in [Clause 8](#).

An alternative rational design methodology based on theory, analysis and recognized engineering practice can be used in lieu of the EER system design process and methodologies specified and described in this document, provided that it establishes levels of safety and performance that are at least equivalent to those established in ISO 19906 and this document, and that it addresses the impact of the arctic physical environment.

Given that arctic and cold region environments can be more sensitive and vulnerable to pollution and more challenging to clean spills in the presence of an ice cover than warmer environments, EER systems and subsystems should be designed to minimize the potential for pollution during non-emergency EER training or emergency scenario drills as far as is reasonably practical.

A.5.2.2 Structural configuration — Design

The reliability of arctic EER system performance can potentially be improved through:

- proactive ice management in accordance with a defined ice management plan to remove broken ice/ice rubble/ice rubble field/stamukhi around the platform;
- duplication of arctic LSAs and facilities (e.g. evacuation craft, a secondary TR) on multiple sides of the installation;
- large crane booms or gangways to reach over ice rubble field;
- standby icebreaker performance, if part of the EER design basis;
- utilization of robust and reliable arctic capable EER system LSAs;
- winterization (and/or providing heated enclosures) for all critical EER components.

A.5.3 Methods — Operations

A.5.3.1 General

EER system commissioning/decommissioning crews should receive both classroom and field training in proper spill clean-up techniques, including oil spill clean-up in ice.

A.5.3.2 Structural configuration — Operations

The design assumptions of topsides layout and substructure geometry, particularly those pertaining to sea ice and ice secretion on EER system performance should be periodically reconfirmed during operations.

A.6 Escape, evacuation and rescue strategy

A.6.1 General EER strategy

On most arctic offshore installations, the EER philosophy focuses on incident avoidance through robust systems and hardware, personnel competence and procedures and controls. The EER philosophy should take into account the prolonged, harsh arctic environment and the impact that an ice cover can have on accessing undersea systems (e.g. subsea isolation valve, if so equipped). Alternatively, consideration should be given to designing subsea systems (e.g. isolation valve) on-board the installation.

As environmental conditions in the Arctic typically vary significantly between the open water period and when there is an ice cover, EER design approaches relied upon during the open water season and when there is an ice cover can also be quite different. The EER strategy should reflect this.

ISO 15544 describes the concept of an EER strategy and can be referred to for additional guidance. An example of the hierarchy, or taxonomy, governing ER documents as described in International Standards relating to ER is shown in [Figure A.1](#).

NOTE This EER taxonomy is made up of operator, corporate and facility-specific standards.

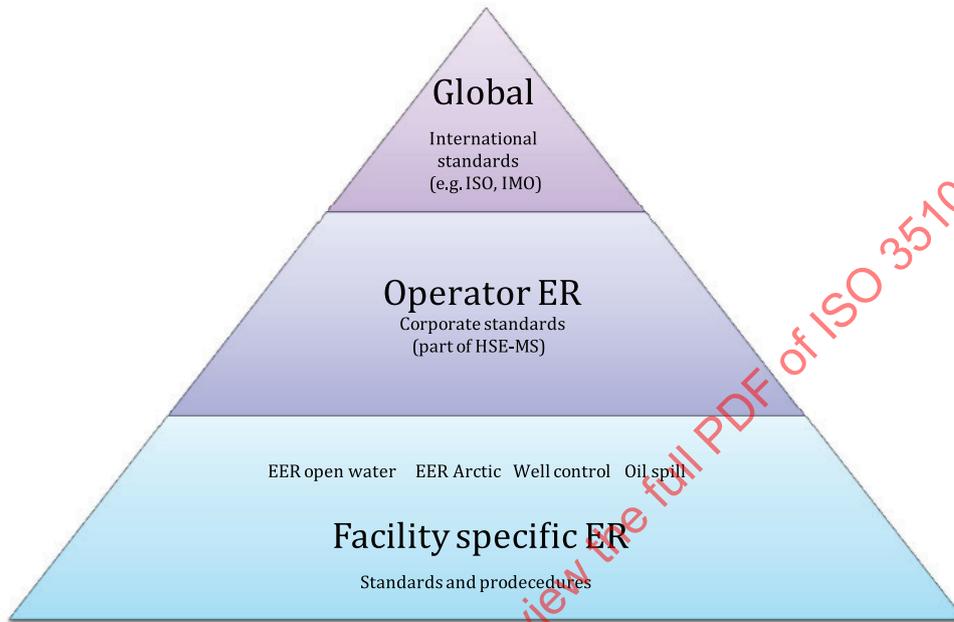


Figure A.1 — EER taxonomy

A.6.2 EER governing principles

A.6.2.1 Statement of principles and breakdown of components

The first governing principle is that the system for managing EER should be designed and implemented using a systematic approach which accounts for the arctic physical environment. This concept is illustrated in [Figure A.2](#) in terms of an EER triangle having three main components: hardware integrity, personnel competence, and EER procedures and controls. These components play equally important parts in the design and operations phase of the EER system for an arctic or cold region offshore installation hydrocarbon facility.

The second governing principle is that of continuous assessment and improvement. This involves not only a static phase of designing the EER hardware system to meet EER performance criteria, but also a dynamic phase demonstrating continuous assessment and improvements. This latter aspect requires the operator to demonstrate that a performance-based improvement process is in place and that it can be verified via benchmarked industry data.

The components of hardware integrity, procedures and controls and personnel competence shown in [Figure A.2](#) are part of a continuous assessment process with respect to physical environmental condition preparedness and other risk mitigations that can be implemented as part of the overall HSE management system. The three principal components of the EER process are described in [A.6.3](#).

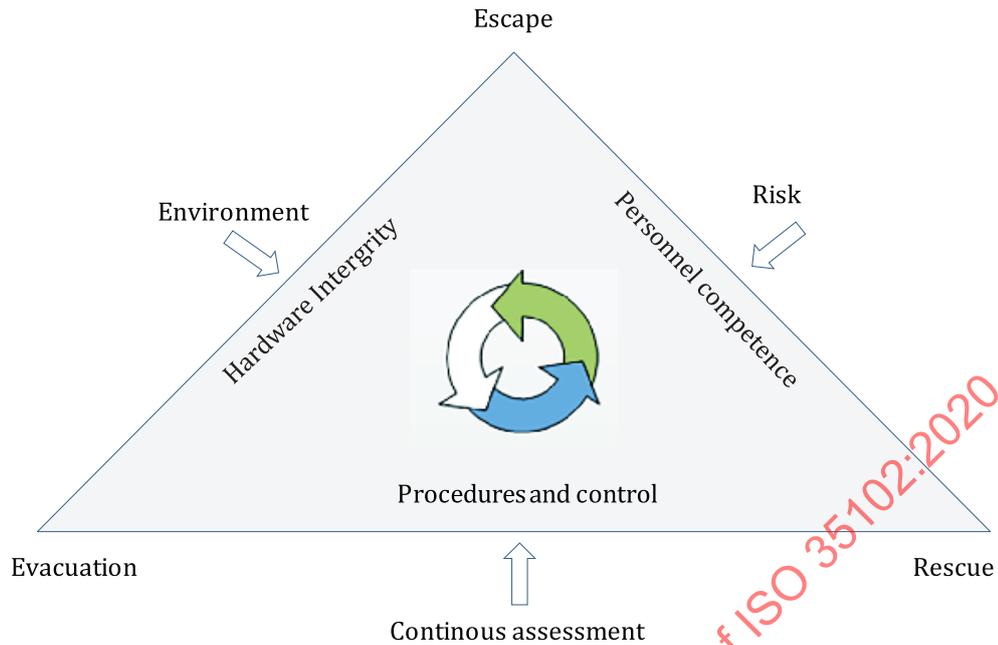


Figure A.2 — Schematic of the EER philosophy for arctic offshore hydrocarbon facilities

A.6.3 Human and hardware performance in EER

A.6.3.1 General

As noted in 6.2, the two key components of the EER system reliability, or probability of successful EER, are the adequacy of the hardware and the human performance under the full range of physical environmental, operational and incident conditions expected.

A.6.3.2 Hardware integrity

EER system development (and related minimum standards) starts with the design of hardware components, such as escape routes, the TR, evacuation methods and other systems. The equipment should be adequately designed in conformance with EER system performance-based standards and maintained to meet the expected environmental, operational and emergency conditions.

A.6.3.3 Human performance

The ability of people to carry out an activity successfully has been shown to be a function of the level of stress to which the persons are subjected (see References [9] and [10]). Both too little or too much stress can lead to unreliable or deficient performance. Excessive stress is what occurs under a life-threatening situation, such as a gas blowout on an exploration platform. Stress can be compounded by the arctic environment. The HEP increases by a factor of 10 to 100 depending on the characteristics of the life-threatening situation, the evacuees' degree of training, and nature of the activities needed to accomplish a successful evacuation (see Reference [10]). Human performance can also be impacted by conditions such as seasickness.

Errors made under stress result from induced cognitive dysfunction and perceptual narrowing, or inability to think and tunnel vision (see Reference [11]). Thus, in the EER process, it is important to minimize the need to make complex decisions or look for different alternatives. Evacuees should be trained to carry out any EER scenario at any time of year with as little thinking as possible, i.e. automatically, just as they train for helicopter underwater escape.

Alternatively, given the arctic environment's impact on human performance, consideration should be given to the automation of certain processes to remove the decision-making from the human. For

example, an autonomous evacuation system that moves away from the installation after launch to a pre-designated place of rescue, or a remote control from a shore facility to avoid reliance on stressed and possibly injured installation personnel.

EER reliability probabilistic modelling employing a mathematical model of EER processes which is first validated against drill situations and then adjusted for increased HEP that occurs under life-threatening stress was reported in References [12] and [13]. Results clearly show that under high stress, reliability is lower for activity-intensive EER processes than for those requiring minimal decision-making and cognitively dependent actions. The model can be run for different levels of emergencies (drill, precautionary, life-threatening), evacuee training and other conditions impacting the reliability of human performance.

A.6.3.4 Personnel competence

The second principal component that should be developed in parallel with the hardware design relates to EER personnel competence requirements. These should be defined up-front to allow for timely EER safety training, and for the development and assessment of critical roles and responsibilities of the EER chain of command. Personnel should be trained, assessed and organized to deal with the expected environmental operational and emergency conditions, particularly those unique to the Arctic. Information regarding each deployment, training exercise/drill, inspection and maintenance activity should be documented in the installation's log.

A.6.3.5 Procedures and controls

The third EER component relates to the timely development of EER procedures and controls, to complement the hardware integrity and personnel competence components. Typically, these cover EER mustering procedures, communications requirements, EER scenario developments and related emergency drills. Once in the operations phase, they also cover EER integrity maintenance procedures to address both hardware and personnel competence. These procedures should be designed for the full range of expected conditions.

It is important to appreciate that all three of these components should be applied to each part of the EER triangle well in advance of the beginning of each distinct project phase, including simultaneous operations. Resultant procedures should be in place, checked and tested prior to personnel working offshore during any/all phases of the facility's design service life including initial survey, construction, commissioning, operation, decommissioning and abandonment. They form an integral part of the EER statement of operational readiness. These EER principles and principal components are normally captured in the facility-specific HSE case, typically containing a section describing the facility risk analysis and mitigation, the HSE critical roles and competency requirements, etc.

In certain operating regions, ice is only prevalent at certain times of the year. EER elements (hardware, people, procedures and controls) should also be developed to meet the requirements of open water periods or when there is a minimal ice cover.

A.6.4 EER strategy aspects — Design and operations

Central management of the EER system is typically carried out in the TR for installations having one.

The TR impairment time should account for the potential of delayed evacuation and longer rescue times due to the prevailing ice conditions or other physical environmental conditions associated with the Arctic.

When developing the EER strategy, a prudent approach should be taken with regard to assessing factors that are relevant to planning and implementation of emergency preparedness, including health, safety, the harsh arctic environment and the remote operating region.

A.7 Physical environment

A.7.1 General physical environment

The physical environments of arctic and cold regions can profoundly influence the EER system design and its performance and reliability during operations. The relevant physical environmental conditions should be considered in the development and execution of the EER plan.

If the physical environmental conditions are such that one type of EER LSA cannot provide coverage throughout the year, it can be necessary to install a second or even a third type that will be operable in conditions in which the first (and second) type cannot be relied upon. Limitations due to arctic physical environment parameters, such as sea ice conditions, should be clearly stated and addressed when developing the arctic EER plan.

Environmental conditions impacting EER can be different from those affecting the design and operation of the installation. For example, satellite imagery showing ice (concentration or features) might not have the resolution necessary for assessing the ice conditions in the vicinity of the platform that can impact the launch and/or operation of evacuation craft if relied upon in the EER plan. Local ice condition observations from the SIMV and the evacuation craft launch zone taken from the installation immediately before launch are typically relied upon.

General requirements and information for metocean data and ice properties are provided in ISO 19906 for arctic regions. ISO 35106 provides details of environmental metocean, ice and seabed data requirements and recommendations. The impacts of physical environmental conditions on the selection of LSAs and EER PPE, including immersion suits, are addressed in ISO 15027, whereas ISO 18215 addresses mechanical systems and ISO 19897 addresses icing on equipment.

As it relates to cold-climate conditions, low air temperature can influence EER design and operational aspects, such as:

- work restrictions due to personnel exposure, including wind chill, etc.;
- material properties and behaviour (ductile to brittle transition, etc.);
- equipment functionality and reliability (freezing of liquids, lubricant viscosity, battery life, etc.).

Air temperature should be in accordance with a recognized standard for a representative return period (e.g. ISO 35101 for working environment; ISO 19906 lowest anticipated service temperature [LAST] for fixed structures; or IACS, see Reference [7] for vessel applications).

Attention should be given to the application (e.g. personnel exposure limits are often based on short durations while steel grade selection for floating structures is typically associated with average temperatures). Likewise, functional operation of equipment differs depending on system exposure, heat, redundancy, etc. Thus, selection of the appropriate air temperature should consider the season and duration of operations, contact surface material behaviour, whether internal/external heating to the system or compartment is planned, the criticality of the item, etc.

The design and operational air temperature might differ in each case listed above and constitute the averaged or extrapolated value based on long term historical data. When based on statistical analysis of average values, the operational air temperature should be stated to permit assessment of lower temperatures experienced during operations or an incident (which might be of shorter duration).

Attention should be paid, and appropriate adjustments made where applicable, using air temperature data from nearby locations or from those which are land-based (rather than offshore) and account for the influence of sea ice.

A.7.2 Physical environmental conditions — Design

Arctic physical environmental conditions that should be taken into account in the EER system design include, but are not limited to:

- a) Atmospheric parameters (e.g. daylight, visibility, precipitation, geomagnetic storms) including the full range of natural daylight anticipated ranging from 24 hrs daylight to 24 hrs darkness, the effects such as adequate lighting and good visibility for EER systems, including overboard lighting, dense fog/low cloud on flying operations and casualty recovery efforts, and the impact that geomagnetic storms can have on the EER system (e.g. on communications).
- b) Wind, including the impairment of evacuation craft or foot traffic across the ice caused by blowing and drifting snow and/or affecting flying conditions, launch of evacuation systems, ice drift, personal protection and frostbite danger, visibility including the effects of blowing snow, dense fog/ice fog and local visibility due to protective face/head gear restricting one's field of vision.
- c) Air and sea water temperature, including the effects of material embrittlement, winterization and cold-weather starting of mechanical and hydraulic systems, personal protection, reduced manual dexterity and the associated requirement for proper ergonomic design enabling operation of exposed controls while wearing protective cold-weather clothing.

Lubricants, fuels and hydraulic fluids should be selected to suit the expected minimum temperature. Engines should be able to handle the additional demands of cold-temperature starting (preheaters, high capacity batteries). Ventilation and cooling systems (radiator and/or seawater) should be designed to prevent blockage from the freezing of inlets and blockage from frazil ice. Design for ergonomic or human factors can account for personnel wearing bulky arctic clothing. Low temperatures dictate that personnel wear suitable warm clothing and footwear, which makes movement more difficult. Face and head protection can impair communications and visibility. Operating machinery with heavy gloves can be difficult and sometimes problematic if the controls are not properly designed. Alternatively, the clothing can be designed to be less bulky, but still provide the wearer with adequate warmth.

- d) Cold open water, including the effects of personal survival (potential for rapid, acute hypothermia without suitable PPE) and sea state limits on the reliability of evacuation and rescue systems.
- e) Water depth, sea level, tides, storm surges and currents impacting:
 - ice rubble formation at the substructure or along protected pipelines;
 - sea spray icing on EER equipment;
 - freezing green water on deck;
 - rescue of evacuees and MOB casualties due to possible drift in water or on ice floes.
- f) The effect of local residual, wind-driven and tidal currents on the selection and implementation of an effective water motion and ice drift tracking model to support;
 - SAR operations including the difference in drift rate between immersed and ice-borne survivors;
 - deep-draft ice features responding to currents at depth and surface.
- g) Sea state, affecting ability of rescue craft to manoeuvre safely close in to the structure and causing higher risk to the safe evacuation from an evacuation craft to a place of rescue, i.e. transfer from an evacuation craft to an SBV or transfer of the entire evacuation craft to an SBV. Ice-wave combinations, including effects of degraded EER system reliability where waves can impart substantial energy to, for example, growlers and bergy bits, raising the risk associated with impact and subsequent loss of structural integrity of an evacuation craft. SIMV propeller wash caused by aggressive icebreaking manoeuvres trying to get close to the evacuation craft which can push ice towards the craft and destabilize the craft if not done with extreme care.

- h) Tsunami creating large waves and ice-wave combinations, destruction of stable landfast ice where used as part of the evacuation plan, greater icing and ice loads on EER LSAs (e.g. evacuation craft, davits, cantilevers), reduction in performance of rescue operations by the rescue vessel.
- i) Sea spray and atmospheric icing, including effects such as safe footing, escape route integrity, access to evacuation equipment, protection of critical mechanical components, frozen latches, vessel stability, helicopter and deck operations and snow making transit across the ice more difficult.
- j) Ice conditions affecting the choice of evacuation systems and potentially the availability of other options, including the use of a stable ice cover at certain times of the year to serve as an intermediate safe haven or to support survival craft, if part of the evacuation plan (see Reference [14]). Ice detection to identify any particularly hazardous ice conditions that can pose particular challenges to evacuation (e.g. evacuation craft launch). Several factors related to the ice affect the reliability and performance of different evacuation systems.

Survivability both in the water and on the ice surface should be taken into account for the evacuation systems. Several factors affect the type of EER system that can be used in different ice conditions, including:

- Ice concentration: this can have an impact on the evacuation and rescue systems used. Some systems can benefit in different ways from low, medium or higher ice concentrations and certain systems can perform better in some ice concentrations than in others (see References [15], [16] and [17]).
- Ice drift speed: highly dynamic ice conditions can be the most challenging. For example, rapidly moving floes can interfere with the launch of evacuation craft. On the other hand, high drift speeds can aid in the rapid movement of survivors away from the installation. This drift might not necessarily remove people from a place of danger, e.g. if the ice drift is in the same direction as the wind. The ability to accurately predict ice drift is an important factor in planning and executing an effective SAR operation in arctic and cold regions (see Reference [18]).
- Ice thickness: new, thin ice generally presents fewer problems, but also precludes any consideration of direct evacuation of installation personnel onto the ice surface. Thick ice generally presents many challenging issues for small evacuation craft as well as powerful SIMVs. Thick ice has a higher freeboard, which could make access to the ice surface more challenging, particular to evacuees in the sea. On the other hand, in some cases, thick ice can be used to support an evacuation craft or to provide an ice-supported TR.
- Ice type: some arctic and cold regions have a mix of FYI, second-year ice and multi-year ice. Old ice floes can be considerably stronger and thicker than FYI, and can affect the integrity of evacuation craft as well as the stationkeeping capability of icebreaking vessels. On the other hand, such floes can also be used as a stable platform for survivors.
- Floe size: the dimensions of the ice floes are important. Large thick ice floes (hundreds of metres in diameter) can offer places of refuge, while dynamic small ice floes in combination with high sea states and swell can threaten the stability and structural integrity of small non-ice reinforced evacuation craft.
- Ice roughness: the roughness of the ice (e.g. broken ice, ice rubble field/stamukhi, leads/cracks) can create problems with over-ice mobility (see Reference [14]). This can be critical if it is required that survivors evacuate through ice rubble to reach an SBV to be rescued. Thick, rough ice can also prevent an SBV from approaching a platform for direct survivor recovery. Rough pack ice can provide additional problems for stationkeeping of SBVs.
- Ice pressure: internal pressure in the ice sheet can significantly affect the ability of an evacuation craft to move away from the platform or make any headway or for an SIMV to reach it. Severe pressure can result in overturning and potential destruction of a small evacuation craft by crushing.

- Ice-wave conditions: in low ice concentrations, waves or swell can cause additional complications in launching an evacuation craft into the sea. Small floes can also compromise the integrity of evacuation craft, e.g. the wave energy combined with small ice fragments can create potentially high local impact loads (see Reference [19]).
 - Ice deformation caused by the ice cover impacting the substructure: the extent of ice deformation varies with the geometry of the substructure near the waterline, the thickness of the ice cover and the ice drift speed. This could affect the ability to launch an evacuation craft from a cantilever or via a deployment arm either past the ice damage zone or onto an ice floe (see Reference [18]).
- k) Spring melt: this condition can introduce a number of evacuation issues depending on the type of evacuation system chosen. Mobility on the ice is severely curtailed by melt pools and open holes, and the ice surface can become too hazardous to consider direct evacuation as an option.
- l) Icebergs/ice islands positioned between the evacuees and the rescue vessel, possibly impacting the rescue vessel response time and resulting in longer time to rescue.
- m) Coastal and inshore considerations affecting the ability of the evacuation craft to transit to shore (if part of the EER plan) or the ability of marine rescue craft to assist in an offshore emergency. Arctic phenomena, e.g. variations in ice conditions, ice-wave combinations, currents, should be identified. Physical environmental conditions existing during the arctic open water period should also be taken into account in the design and operation of the EER system.
- n) Anticipated combinations of impacts caused by several environmental parameters (if part of the design basis) should be identified and taken into account, e.g. impact of sea ice and waves in a marginal ice zone. Meteorological data should be obtained from weather stations where conditions are the most representative in relation to particular physical environmental parameters or which are located close to the installation.

A.7.3 Physical environmental conditions — Operations

Competent decision-making through regular EER assessment can, in some situations and some regions, partly depend on access to accurate and timely meteorological, metocean and ice data. Infrastructure for the acquisition of arctic real time operating environmental data should be accounted for. Environmental information systems should clearly state the collation and issue date, such as delays in acquisition and processing times in 'near-real' time satellite ice observations.

Where ice management and an ice management plan form an integral part of the EER plan (e.g. using an SIMV for direct transfer of evacuation craft to the vessel deck, or to maintain a clear route to the evacuation craft launch zone by pro-actively clearing away broken ice and grounded/ungrounded ice rubble), the vessel's ice management capabilities should be considered as part of the EER plan (see ISO 35104).

A.8 Escape, evacuation and rescue hazard identification and risk analysis — Design and operations

A.8.1 General hazard identification and risk analysis

EER is a system consisting of equipment and procedures designed to mitigate the effects of major incident hazards to personnel. Timewise, the system operation begins with the earliest indication, such as an alarm, of a potential hazard or a real incident situation, and ends when the hazard has been removed or when all personnel have been rescued and reach a safe haven. The physical system component includes each and every piece of EER equipment, personnel route, access or egress location and personnel location in relation to the facility configuration and operation. The procedural system component includes each and every personnel activity, procedure and decision from the time of the hazard onset, until all personnel reach a safe haven.

The reliability of physical components is a function of their condition (maintained and functional), facility state, environmental conditions (e.g. cold ambient air temperature, atmospheric and marine icing, snow) and incident effect (e.g. fire, explosion, un-ignited gas release). The reliability of evacuee activity and resultant procedure performance is a function of evacuee psychological condition (fear, stress, training) and physical capabilities, environmental effects and incident effects, as well as the designated evacuation system chosen (e.g. helicopters, evacuation craft).

The risk analysis process identifies hazards, assesses the frequencies and consequences and identifies adequate preventive, detection, control and mitigation measures for each and every credible incident scenario under each applicable environmental, operational, temporal (day or night) and manning condition.

There are essentially two categories of risk analysis:

- the periodical operation risk analysis, which considers all risks to personnel including transportation to and from the installation; and
- the individual EER scenario risk analysis, which considers only the risks associated with each EER scenario.

Normally, conduct of the EER HAZID and risk analyses follows the general installation EER, so that hazard zones and available escape and evacuation locations can be available for the EER HAZID and QRA. The EER scenario is considered successful if there are zero casualties resulting from the EER process (as evaluated by QRA) and is considered to have failed if there are one or more casualties.

The 'beyond hazard zone' is a location off the installation at which there is no hazard from the initiating event (e.g. no toxic gas, flame, explosion overpressure).

The EER scenario risk analyses are performed to provide the risk for each combination of incident, environmental, operational, temporal (day or night) and manning condition and to ensure this risk does not exceed the governing SRTC. The scenario risk analyses are used primarily to optimize the type and configuration of EER systems and procedures for the installation over different phases of its life cycle. For example, the initial years of the operation cycle can be dedicated to production drilling operations, to be replaced largely by production operations with different operational configurations, so that significantly different scenario conditions would prevail in the different phases thus requiring a new/updated EER analysis.

The periodically and scenario risk analyses are carried out at key stages during the design to assist in the optimization of the EER system configuration as well at regular intervals during the operating cycle. [Figure A.3](#) provides a general example of the steps and sequence involved and the relationships throughout the design process.

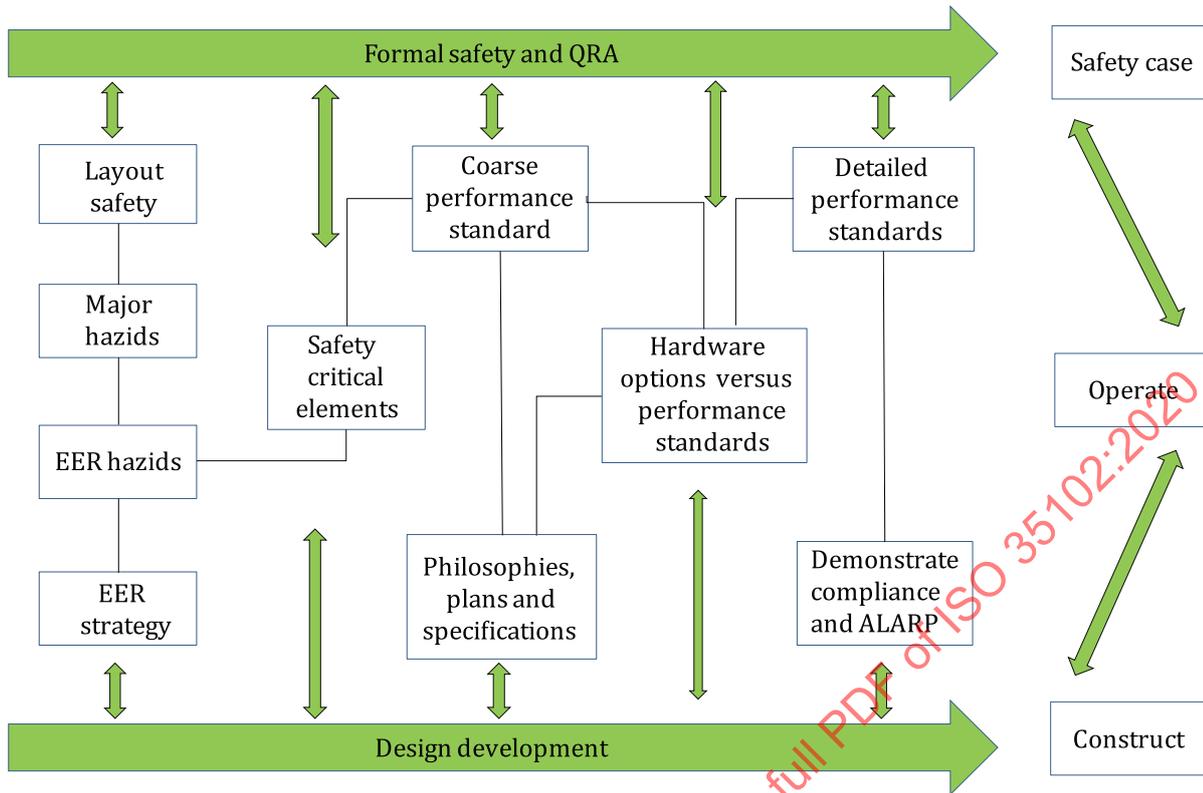


Figure A.3 — Process to achieve a performance-based EER system

The SRTC defines installation, operation and location-specific criteria of success or failure for any EER scenario against which hardware and procedural options should be evaluated for conformity during design and throughout the service life cycle of the installation.

The EER design should:

- be an integral process within and throughout the installation concept design and detailed design phases;
- minimize personal risk during EER and reduce the likelihood of economic losses and lost schedule opportunities.

The SRTC are verifiable attributes or benchmarks that provide qualitative levels and quantitative measures of performance to be achieved. It is important to recognize that compliance with prescriptive regulations is not necessarily sufficient to ensure conformance with SRTC performance standards.

A written procedure for inspections, maintenance and tests of the EER system should specify the nature and frequency of these activities. Where appropriate, this written procedure should provide for inspection and testing prior to the equipment being used in operations or after equipment modification or repairs. The written procedure and said activities should take into account challenges posed by the arctic environment.

Provisions for LSA can vary among installations as a function of their arctic climate exposure. The purpose of examining a particular type of LSA is to:

- assess its suitability from the outset and its use in conjunction with other LSAs or its continued suitability;
- assess its condition;
- assess its suitability for use in the Arctic;

- determine any necessary remedial measures.

It is necessary to demonstrate that the most appropriate system components, procedures and support services have been selected to in accordance with the operation EER system SRTC and ARTC in the arctic physical environment.

Timely implementation of any EER system recommendations from the HAZID and risk analyses, within the appropriate phase and the demonstration thereof, is an important factor that is often underestimated and that requires special attention in arctic and cold region applications.

A.8.2 EER hazard identification

Representatives from the key disciplines involved in EER, including the ER management and response teams, should participate in HAZID studies. Where applicable, this includes operations, marine, aviation, evacuation and response specialists, ice advisors, etc. Wherever an interface exists, relevant representatives should be engaged.

The assessment process should consider new technology and results of research into new and innovative methods of evacuation that can be more reliable and appropriate for arctic and cold regions than some of the conventional equipment currently available.

Two sets of HAZID studies should be conducted:

- Incident scenario HAZID applied to each credible accident scenario including fire, explosion, toxic gas, installation structural or buoyancy failure, under all applicable environmental (sea state, ice, seismic) and operational conditions. These studies identify and characterize the incident scenarios and associated conditions which pose a hazard to personnel, thus becoming candidates for EER scenario HAZID studies so that they can be further analyzed in the EER QRA.
- EER scenario HAZIDs for applicable EER system configurations for each of the incident scenarios which were considered to pose a hazard to personnel. The output of the scenario HAZID studies forms a basis for the EER scenario risk analysis described in [A.8.3](#).

The EER assessment process should consider new technology and research into new and innovative methods of evacuation that can be more reliable and appropriate for arctic and cold regions than conventional equipment currently available.

A.8.3 EER risk analysis

A.8.3.1 EER risk analysis considerations

Quantitative risk analyses (QRA) and qualitative risk analyses are useful tools to:

- identify which of the major incident hazards contribute most to the EER risk;
- establish specific EER system components that have a safety-critical function to perform during particular emergency scenarios;
- estimate the contribution of a proposed risk-reduction measure;
- quantify and/or qualify the risk to set SRTC and to determine conformity of any EER scenario risk with the established SRTC.

The results of the QRA for a particular set of EER system components are compared with the results using different components for the same installation incident events. The results of a QRA can be coupled with a cost benefit analysis, the implied cost for averting a fatality and the frequency of TR impairment to determine whether the cost of a proposed risk-reduction measure (e.g. by applying new technology or additional evacuation methods) is justified. The outcome of a QRA process provides input to the SRTC evaluation and conformance tests.

These analyses contribute to the ALARP and performance demonstration that considers a range of fundamentally different options and documents the process of the analysis. ALARP strikes a balance between risk reduction and the cost of the resultant benefit. The performance based SRTC demonstrates that for each hazard scenario, the risks of EER can be controlled to the tolerable region.

Techniques that can be used to support decision-making and to demonstrate adherence to ALARP and SRTC include:

- QRA;
- qualitative risk analysis;
- emergency system survivability analysis;
- psychological human performance reliability variability under drill, precautionary and life-threatening emergency conditions;
- physical human performance decline with prevailing conditions including fog, wind, snow, night visibility, cold temperatures, sea state, incident effects such as toxic gas and other impediments;
- consequence modelling/analysis (e.g. smoke and gas ingress and dispersion calculations, gas plume dispersion in hazard zone analysis, fire and explosion effects analysis);
- event-tree methodologies (i.e. probabilistic logic networks for systematically deducing the probabilities of different outcomes from the occurrence of a given undesired event);
- Monte Carlo simulation of the QRA to quantify uncertainties and expected values.

A comprehensive EER risk analysis method developed utilizing the aforementioned techniques and considerations is outlined in Annex B.1.

A.8.3.2 Additional EER risk analysis methods

Numerous risk analyses are typically performed in the development of the EER plan. These include, but are not limited to, the following:

- TR impairment study (to define design impairment time needed to complete evacuation, especially in light of anticipated ice conditions);
- fire and blast analyses (impact on TR design and location of escape and evacuation hardware);
- escape-way study (integrity assessment to help provide assurance that routes will be available in accordance with design/plan);
- evacuation route study (similar to escape-way study);
- rescue vessel (SIMV, if used as part of the EER plan) performance study (to help ensure vessel is able to support as intended and rescue evacuees within anticipated survival time);
- SSIV analysis (to determine whether the SSIV can be brought on-board given access challenges imposed by an ice cover);
- evacuation means risk analyses (to help ensure appropriate number and placement/location of evacuation means);
- Monte Carlo simulation for the principal EER risk analyses described above, as well as selected supporting risk analyses in order to obtain a quantitative evaluation of the variability of key outputs such as the success rate.

The overall EER analysis should utilize the results of the supporting analyses for quantitative inputs.

A.9 Continuous assessment

A.9.1 Continuous assessment — Design

Continuous assessments help to ensure that regardless of changes that can occur, conformance with the EER performance standards is maintained.

a) Feasibility and concept engineering phase

During the feasibility and concept engineering phase, the EER continuous improvement and assessment preparedness work should focus on the following:

- establishing the EER philosophy;
- determining whether any of the proposed EER concepts result in non-traditional emergency preparedness solutions to account for the arctic physical environment;
- identifying any arctic emergency preparedness aspects that can result in higher costs to achieve an acceptable solution;
- identifying any potential additional procurement lead time required to modify and/or develop EER hardware suited for arctic applications;
- comparing and ranking potential EER system concepts and optimizing chosen concepts.

b) FEED phase

This is when layout drawings, P&IDs for process and essential safety systems are issued. The main purpose of a FEED EER analysis is to:

- identify technical requirements to arctic EER design in the FEED phase;
- provide EER arctic-specific input to the FEED design;
- identify EER aspects which require detailed analysis;
- identify design or operational assumptions related to remote location and arctic physical environment conditions;
- provide recommendations to the design of arctic-capable solutions;
- establish performance requirements of the EER system in the arctic environment.

c) Detailed design and preparation for operations

A detailed EER assessment should be developed when the final design has been issued. The main purpose is to:

- update the EER analysis to account for any changes to the detailed design;
- verify arctic EER system performance requirements from the FEED phase;
- provide arctic EER system input toward the development of arctic operational procedure;
- give arctic EER system input towards development of the ERP.

d) Physical environment

Part of the EER system control is the development of an appropriate ice, metocean and environment forecasting process. The forecasting process is used to assess external influences on the EER system performance to help ensure that the EER design parameters are within the EER operating envelope.

The installation design should facilitate testing the EER system through a systematic programme of emergency scenario drills with specific pre-planned learning objectives carried out in a realistic manner.

e) **Risk assessment**

Risk is the second external parameter impacting the EER assessment. A risk analysis should be initiated during the early part of the engineering design phase by the identification of the major installation process risks, as well as those related to arctic operation and the design of EER system.

Part of this risk assessment process is to identify mitigation measures that can be needed to achieve an ALARP condition. To maintain this ALARP condition and to form part of the EER process, guiding controls should be developed and put in place.

f) **Hardware integrity**

Once the facility hardware, including the EER system, has been designed and constructed and is ready to be placed into operation, the design integrity requires that it will be safeguarded to remain within the envisaged integrity envelope, regardless of the external environmental conditions.

g) **Personnel competence**

After EER personnel competence requirements have been defined, including the HSE-critical tasks, a training and development programme should be implemented. Part of this training programme is the competency assessment of people before their assignment to the installation, specifically those having HSE-critical responsibilities, such as the OIM.

h) **Procedures and controls**

A plan should be developed for EER system procedures and controls, as developed in the design phase, to be regularly reviewed for fitness and conformance using regular audits. These procedures typically include the assignment of EER system integrity accountability to an individual, establishment of an EER chain of command and the listing of HSE EER-critical tasks. These are normally included in the installation HSE case.

A.9.2 Continuous assessment — Operations

To validate the EER state of readiness, a simple “Yes (☑) No (☒)” approach can be used to reflect the assessment and the state of readiness of these EER elements, as shown in [Table A.1](#).

Table A.1 — Illustration of the continuous assessment and improvement process for EER systems

Continuous assessment & improvement processes			
	EER state		
Environment (ice and metocean forecasting)	☑	or	☒
Risk analysis and mitigation (manual of permitted operations, EER matrix)	☑	or	☒
Hardware integrity (design, maintenance, winterization)	☑	or	☒
Personnel competence (training, drill, POB management)	☑	or	☒
Procedures and controls (communication, alarms, chain of command)	☑	or	☒

The OIM should receive continuous ice, metocean and environmental forecasts, along with an assessment of any external influences on the EER system, to aid in EER decision-making, command and controls. If these forecasts and/or improvement processes are not available, the OIM may decide

to restrict operations to reduce risk until such time the forecasting and/or improvement processes are available.

a) **Physical environment**

Ice, metocean and environmental forecasting should be a continuous process that includes providing regular updates on relevant parameters to the OIM, who is ultimately accountable for EER decision-making, command and controls.

Testing of the EER system should be carried out for all credible emergency scenarios to help ensure adequate capability.

b) **Risk assessment**

Similar to the various design phases, risk assessment is a recurring assurance process that should be carried out throughout the operational phase. Risk management is probably the most critical recurring process for assuring the integrity of the EER system.

In other words, risk assessment is not a one-off process in design, but a recurring assurance process as part of the EER decision-making that contributes to or defines the state of preparedness. For example, in a scenario where there is a particularly large build-up of ice rubble (grounded or floating) at the substructure that could hamper the launching of evacuation craft, a decision to penetrate a reservoir for the first time might need to be deferred until the environmental conditions are more favourable.

To maintain this ALARP condition and to form part of the EER process, guiding controls to maintain the ALARP condition can take the form of, for example, the development of a manual of permitted operations, preferably complemented by EER system selection criteria, in order to help ensure continuous assessment by the OIM in the EER decision-making process.

c) **Hardware integrity**

The types and quantities of LSA spare parts inventories should be assessed, given the arctic environment and remoteness. Hardware installation can be complicated by environmental conditions associated with the Arctic. Winterization of hardware should also be assessed to help ensure it is available for use as planned.

The EER system design should be complemented with the required routines for preventive maintenance. In the operations phase, timely execution of these preventive maintenance routines on the EER system, to be classified as safety-critical, is mandatory.

d) **Personnel competence**

Medical/physical qualifications should be considered for personnel assigned to remote arctic offshore facilities commensurate with their operational and EER responsibilities.

A safety logbook or similar record-keeping tool should be established to record this HSE training and assessment.

To remain competent, regular EER emergency scenario drills and exercises are required and should be executed year-round while still minimizing the risk to personnel. The performance of the individual and the team should be within a predefined performance envelope. Mitigating measures should be defined for individuals and teams to perform as expected.

Guidance on developing, implementing and maintaining training and competence assurance programmes can be found in ISO 15544. Such programmes should also account for the arctic physical environment and added risk associated with it.

e) **Procedures and controls**

Guidance on the command structure within the EER system can be found in ISO 15544. The command structure should also account for the impact of the arctic environment.

A plan should be developed for EER system procedures and controls (similar to that developed in the design phase, but for operations), to be regularly reviewed for fitness and conformance using audits. These procedures typically include the assignment of EER system integrity accountability to an individual, establishment of an EER chain of command and the listing of HSE-critical EER tasks. These are normally included in the installation HSE case.

Regular emergency scenario exercises are critical in training and establishing the necessary state of readiness or preparedness of the facility and its personnel.

Part of the EER HSE management system is the POB locator system (e.g. a T-card or more advanced electronic tracking system). When properly implemented, the EER HSE management system helps ensure that adequate POB controls, including mustering, are in place and that personnel with the required qualifications are on board (e.g. sufficient evacuation-craft coxswains).

A.10 Escape, evacuation and rescue system capabilities

A.10.1 EER system capabilities — Design

The range of credible combinations of environmental conditions expected at the installation, including air and sea temperatures, winds, waves, currents, marine ice, icebergs, ice accretion and visibility, should be taken into account. The shape of the substructure can have a profound impact on the ice/open water environment near the installation and thus on evacuation and rescue capability (see Reference [18]).

Consideration should be given to the credible hazards and their resulting consequences, in terms of damage or impairment to the installation and the number of personnel injured by the initiating event, the susceptibility of the installation to the initial hazard or subsequent escalation and the overall probability of being able to successfully carry out EER.

The design of the installation, including its substructure, and its integrity for process operations takes into account those elements that can impact the EER system and how this compromises selection of the optimum EER components such as the following:

- the ERP as part of the safety management system specifying the management of EER in response to a credible incident;
- the ERP including the command structure, the means of communication as well as all arrangements among and between response teams planned to be involved in responding to the incident;
- decisions regarding EER based on analysis of the entire ER system;
- planning for the EER system development as a critical part of the process for reducing risk to ALARP levels;
- management of the EER system for providing the full life-cycle of the installation, from planning through operation and decommissioning, including provisions for managing changes to the installation and its operation;
- whether or not the installation is normally manned, the expected peak and average manning levels, shift schedule, personnel locations and crew changes and visitation frequency and details if not normally manned;
- major incident scenarios and their effect on the EER system as identified in the installation risk assessment, including fire, explosion, toxic emissions, major structural failure, ship or iceberg collision and other loss of essential support facilities;
- possible hazards to personnel in the credible incident scenarios considered, accounting for hazards at all potential personnel locations;
- measures to prevent the impairment of the EER system;

- location and integrity of embarkation areas and/or TR(s), routes to these and alternative MSs and the route from these to protected/unimpaired evacuation points;
- time required for installation personnel to escape from their workplace to the TR and to move from the TR to evacuation points under the credible emergency scenarios, taking into account the range of weather and environmental conditions and bulky clothing;
- time required for installation personnel to evacuate;
- contingency plans, including the use of alternative MS(s) and evacuation methods;
- methods employed and times required to transfer from the primary, secondary or tertiary means of evacuation and to deliver the personnel to a safe haven;
- immersion suits and other PPE required, as well as their numbers and locations on the installation;

Immersion suits and other PPE required should be appropriately located and specified to provide maximum protection against scenario hazards and environmental conditions. It should be considered that certain immersion suits are designed with boots that might not be conducive for walking across ice and snow, and with non-removable gloves that pose challenges to dexterity (see Reference [20]).

- schedule and procedure for EER equipment maintenance, inspection, testing and operational drills to assure familiarity, reliability and availability in accordance with performance requirements;
- design of equipment to facilitate easy operation in cold conditions, with the aim of avoiding small or complex equipment;
- schedule and procedure for personnel EER training, drills and major EER exercises commensurate with HSE-critical roles, including those personnel on/off the installation (e.g. SBV, helicopter) as well as those in transit to/from the installation;
- effect of stressors on human performance in EER;
- coordination with external ER support and communication during the EER process.

Once the SCE has been identified, it is necessary to define its critical function in terms of a performance-based standard. A performance-based standard can be applied to persons and procedures as well as hardware systems and items of equipment.

A.10.2 EER system capabilities — Operations

Based on the performance standard, assurance tasks can be defined in the maintenance system to help ensure that the required performance is confirmed.

A.11 Emergency response organization

A.11.1 Emergency response organization — Design

The ERP should take into account lead time associated with replacement of ER personnel from shore due to remoteness and the arctic environment.

The station bill should describe the emergency alarms, the chain of command, location of the TR(s) alternative MSs, appropriate leadership for every MS, and the duties of every individual in each incident scenario. The impact of the arctic environment and remoteness of installation personnel and ER capabilities should be taken into account when developing the station bill.

A.11.2 EER system capabilities — Operations

The assumptions that form the basis for design and operation should be monitored and assessed in the operational phase and the ERO updated as necessary in response to changing conditions/factors.

A clear and unambiguous plan should be developed to describe interfaces between the installation ERO and external organizations and resources. This plan should be agreed among the organizations involved. The plan can include the following:

- marine resources (e.g. icebreakers and other rescue/ER vessels);
- aeronautical resources (e.g. SAR operations, medevac or transport helicopters);
- support facilities (e.g. hospitals and accommodation facilities for injured and evacuated/rescued personnel);
- locations where rescue resources and personnel can be temporarily accommodated during times when metocean or ice conditions warrant it.

A.12 Competency assurance

A.12.1 Competency assurance — Design

Competency assurance should be extended to include all support personnel, including those not normally based on the installation (e.g. supporting SBV and/or SIMV, aircraft and shore-based personnel) whose actions are relied upon during EER ER, and including those whose support might only be required at certain times of the year (e.g. when ice is present).

A.12.2 Competency assurance — Operations

The ERO for EER should be adaptable, taking into account human behaviour under stress and that key personnel could be unavailable or injured in the incident. This can be particularly appropriate to arctic climates where extended periods of darkness prevail and there is an increased risk of slipping on ice, and of cold injuries and fatigue due to the arctic physical environment. Flexibility in the EER ERO should therefore be included in classroom and practical training and drills to help ensure that those required to substitute for key personnel are competent to do so.

The EER ERO should take into account the arctic physical environment, e.g. personnel might periodically need to be relieved to warm up and/or take shelter from the elements.

Personnel training to simulate evacuation to and traversing of the sea ice cover should be considered, if part of the EER plan.

A person should have only one duty in an emergency. If a person has more than one emergency responsibility, care should be taken to help ensure that assigned roles are compatible and do not introduce unrealistic expectations for the actions that might need to be undertaken by one individual (e.g. combining medical and radio operator roles or multiple roles that require the individual to have a prolonged exposure to the arctic environment in a slowly escalating incident) (see Reference [21]).

Arrangements for supernumeraries and other special groups working on arctic offshore installations should include general training in emergencies, cold-climate survival, installation-specific induction training, and training based on the ERP. Information, instruction and training should be refreshed periodically as necessary.

Competency assurance in the use of LSAs and PPE in arctic settings is required, especially with reference to cold weather clothing appropriate for the lowest temperatures likely to be encountered, and the effects that wearing bulky clothing and mittens can have on the operation of equipment, ease of movement around the installation and in evacuation craft. PPE competency assurance is often assessed through emergency scenario drills where PPE is used as part of the training exercise. Where deficiencies are identified, a corrective action plan should be developed (see References [22], [23] and [24]).

People with key roles in the EER organization should have an appropriate understanding of the following:

- underlying theory of EER for offshore installations;

- differences in EER tactics during the open water season and periods when ice is present, including shoulder seasons;
- EER and incident analyses;
- available EER technology and environmental technology;
- environmental data;
- arctic survival requirements;
- methods and control systems for technical maintenance;
- methods and media for information communication;
- organizational theory and management;
- human behaviour in stressful situations.

It is important for effective EER that the organization acts in a manner that is suited for the purpose, logical and systematic. Those with roles in EER should be capable of dealing professionally with the situation irrespective of the:

- time of day;
- season of the year (i.e. open water or ice season);
- duration of required effort, such as during a slowly escalating incident or when evacuation is delayed due to onerous ice conditions;
- shift duty rosters;
- phase of the activities;
- size of crew on the installation;
- composition of personnel.

Personnel working on an installation should at least have basic training in EER, basic first aid, use of LSAs, fire-fighting and arctic survival. In addition, as part of the installation induction process, all new personnel should be introduced to the following installation-specific factors:

- a) escape and evacuation routes, any designated muster areas and ER equipment;
- b) main hazards, including those arising from the cold-climate conditions and incidents that can arise, and those which are installation-specific;
- c) EER procedures and action plan (the station bill);
- d) ERO.

Personnel with key roles in EER should be given more advanced instruction in EER to ensure that they are able to:

- deal with their EER duties in a rational and professional manner;
- develop a clear plan for managing the emergency;
- make good use of the available EER equipment;
- execute operational control of the EER resources;
- assess the adequacy of individual or group performance in practices, drills and emergency events;
- handle persons subjected to stress (incident and/or cold-induced stress);

- deal with and communicate information;
- assess the best option for evacuation, bearing in mind the environmental and ice conditions around the platform and physical limitations of the evacuation means;
- understand any limitations that the ice conditions can impose on the SIMV/SBV/rescue vessel's ability to reach the rescue point or to approach the installation.

Competence can be acquired through training, practice and drills, but requires a plan to be developed to build up competence for those who are new to a role, have limited offshore arctic experience or who do not have a demonstrable level of competence. Training means acquisition of new knowledge and skills, e.g. through courses, attitude campaigns and safety meetings.

Practice means verification and maintenance of knowledge and skills to enable handling of individual parts of the total EER system. Practice can involve refresher courses, familiarization with the use and operation of EER equipment and with the emergency control centres onshore. The use of electronic simulation techniques can be considered acceptable, as long as relevant for the operation and of sufficient fidelity and accuracy in representing the actual incident scenario.

Drills help ensure verification and maintenance of knowledge and skills through simulation of an EER effort. A plan for drills should be drawn up for all units of the EER organization, which takes into account:

- the scenarios which can require EER;
- the shift duty roster;
- types of operations which can be in progress when an emergency arises (e.g. upfront penetrating the reservoir, it would be good to have a blowout drill the week before);
- the level of activity on the installation;
- any organizational changes;
- time of year;
- inability of the SIMV/rescue vessel (if applicable to the EER plan) to approach the installation due to ice conditions;
- the impact of arctic environment conditions on drill participant safety.

PPE competency assurance is often assessed through emergency scenario drills where PPE is used as part of the training exercise. This is particularly important for arctic PPE which is usually bulky, restricts movement, can require assistance to don and can take longer to don than non-arctic PPE.

A.13 Communications and alarms

A.13.1 Communications and alarms — Design

The audible and visual emergency alarms should be standardized where practicable throughout the operating region.

Methods of communicating installation status should be standardized where practical.

The provision for protecting outdoor communications and alarm system components from the arctic environment (e.g. enclosures, heat-tracing) should be considered.

Audible alarms should be supplemented with visual signals such as flashing beacons in high noise areas.

Information on ice conditions, wave direction/height and wind speed/direction near the installation should be available in the TR to assist the OIM in making an informed decision on whether and/or how to evacuate the installation.

Back-up communications systems can include hand-held radios and satellite radio systems. The impact of cold temperature on battery performance/longevity needs to be taken into account. If hand-held radios are used for communications, they should be fully charged and available for use at every embarkation area.

Back-up alarm systems can be achieved by duplicating, e.g. adding a redundant system with independent amplifiers, loudspeakers, flashing beacons and cables.

A.13.2 Communications and alarms — Operations

The impact that routine maintenance inspections and service of communications and alarms safety systems (particularly those carried out in the presence of cold temperatures and high winds, which could be more time-consuming) can have on escape/evacuation routes should be considered. Route blockages should be communicated to installation personnel. Temporary alternative route signage should be placed during these activities.

The impact that routine communications and alarms maintenance inspections have on the functionality of TR integrity as well as access to LSAs (particularly those exposed to the arctic environment) should be considered. In cases where components of the communications and alarm systems are temporarily placed out of service, measures should be implemented to duplicate their function (e.g. safety watch during repair) or higher-risk work activities suspended until communications and alarm system functionality has been restored.

The ability to effect repairs on communications and alarms equipment exposed to the arctic environment should be considered.

A.14 Personal protective equipment (PPE)

A.14.1 PPE — Design

PPE arrangements, including the numbers, types (various sizes generally preferred versus 'one size fits all') and storage locations, should be determined as part of the EER plan. The quantity of PPE should include those placed in the accommodation module/muster area, TR, etc. for the maximum POB compliment, including spares deployed at strategic locations on the installation for personnel that cannot make it back to the accommodation module in an emergency.

The impact of cold weather, snow, icing, etc. should be considered when determining PPE quantities on-board and identifying outdoor storage locations.

The following minimum device types, subject to the EER analysis, should be provided for personnel in sufficient numbers:

- immersion suits, where stipulated by the EER plan (specific regulations might also apply);
- lifejacket (harness type through the legs that does not dislodge if the wearer falls/jumps from a height) with sufficient buoyancy taking into account that the user can be wearing heavy clothing;
- smoke hoods (small maintenance-free bag) and/or escape air packs; the selection of the most appropriate type of respirator for escape from a contaminated atmosphere depends on the nature of the hazard and the ability of installation personnel to leave the contaminated area;
- flashlight.

Where required, immersion suit design should consider the requirement for a CA-EBS to facilitate escape from a submerged helicopter, a wave-splash shield to extend survival time, strobe light, GPS-enabled PLB and whistle to aid SAR operations.

If helicopters are used in the EER plan, transit or immersion suits designed to prevent progressive body cooling are best for use during personnel transfers to and from the installation, unless deemed unnecessary by the EER analysis. The amount of suit buoyancy required should also be considered

when selecting a helicopter transit suit (egress versus survival), as too much buoyancy can make it difficult to evacuate a submerged helicopter.

Helicopter transit suits that are designed to have less buoyancy and are fitted with a buoyancy chamber that can be either activated or inflated once clear of the helicopter are commercially available.

The selection of PPE should take into account performance in freezing water and/or low air temperatures for the maximum anticipated rescue time.

Deployment locations should include the living quarters and other strategic areas.

The impact of cold temperature on PPE performance should be taken into account, e.g. reduced battery lifetimes at low temperatures for portable gas detectors and individual radio systems, and efficiency of tightness of the seal for escape masks and immersion suit hoods due to possible cracking or rigidity of synthetic rubber at low temperatures.

Immersion suits having enhanced performance for the arctic environment should be considered, including an integral boot conducive to walking across the ice (if part of the EER plan). Immersion suit design should also consider whether wave-splash shields are required, given this capability can also be used to lessen the impact of wind on the user's otherwise exposed face.

In addition to immersion suits, the need for arctic clothing in grab bags (e.g. arctic parka, windproof insulated trousers, arctic hat/face mask, insulated gloves, boots) suitable for the arctic environment should be considered for use when transferring to the ice cover.

A.14.2 PPE — Operations

If weapons or hazing devices are required due to wildlife risks, the location, control and permitting should be carefully considered. Designated qualified installation personnel should have easy access to weapons or hazing devices when required, but at the same time, the equipment should not be exposed to environmental or hazardous conditions that could negatively impact functionality. Weapons should not normally be readily available to all personnel, but rather only those who are trained/qualified to use them.

Personnel should be familiar with the donning and wearing of immersion suits in advance of any incident, so that they know the correct size of suit required and the limitations of manual dexterity when wearing arctic PPE. Removing the hand protection of an immersion suit for a task that requires manual dexterity not achievable through the immersion suit can rapidly lead to cold weather injury/loss of functionality of the extremities.

The wearing of an immersion suit aids personnel in maintaining an adequate core body temperature. Particularly in an enclosed evacuation craft or life raft, perspiration moisture can build up in the insulating layers inside the immersion suit potentially causing a loss of insulating capabilities. Over time, this moisture build-up can result in cold weather injury, unless it can be effectively mitigated (see References [27], [28] and [29]).

Cold temperatures can make certain types of immersion suits stiff and difficult to don. Hence provisions to maintain all immersion suits with suitable pliability should be considered.

A.15 Man overboard recovery

A.15.1 MOB recovery — Design

Depending on the marine and ice environments, MOB recovery can include an SBV (equipped with a fast rescue craft), a fast rescue craft aboard the installation, a marine evacuation craft or other suitable means as established by the EER analysis.

MOB recovery can be achieved by the installation's own resources, another nearby installation, an ER vessel or shore-based resources, provided the response time is adequate.

Guidance on the maximum times to rescue are specified in Appendix G of Reference [25].

The installation should generally be equipped with individual personnel overboard aids, ready for immediate deployment at strategic locations where a MOB incident could potentially occur. The numbers of aids with water-activated lights as well as smoke and retrieving lines should be established as part of the EER analysis.

Where required, design of MOB recovery aids and deployment locations should account for the effects of sea spray icing, atmospheric ice and snow.

A.15.2 MOB recovery — Operations

It is good practice that when an SBV takes over an SBV duties, the vessel carries out an MOB drill to demonstrate crew readiness to assume the SBV role.

The safety of participants involved in the MOB drills (e.g. during hazardous activities such as recovery of persons floating in the ocean/partial ice cover) needs to be assured. Dummies may be used for the MOB drills. If applicable to the EER plan (e.g. where there could be open water or periodically a partial ice cover around the installation and the probability of a MOB incident dictates it), MOB drills should also be performed in the presence of an ice cover.

An analysis should be carried out to confirm the satisfactory efficiency and capacity of the MOB recovery times. Target times should be evaluated from the perspectives of both single and multiple casualties (e.g. helicopter crash) and MOB casualty incident scenarios, if applicable.

Realistic drills using single or multiple dummies should be conducted at various times of the year to confirm that the target rescue times can be met. If a new vessel becomes responsible for MOB rescue, the vessel crew should be tested prior to taking over the duty to help ensure that they can meet the agreed standard.

If the ice (e.g. high ice concentration, active ice rubble field generation), sea state (e.g. periods of high currents) or weather conditions (e.g. dense fog) are such that a rescue boat would not be able to rescue a MOB within the target time, the installation (and support vessel if so equipped) should suspend any work where personnel can be at risk of falling into the sea/onto the ice cover.

If recovery is to be effected using a helicopter, then it should be equipped with a winch and a properly trained and competent winch operator.

Providing PLBs on all transfer and immersion suits, along with a suitable receiver on the rescue vessel (and other locations as identified in the EER analysis, e.g. an SIMV/SBV), should be considered. This is particularly important during winter darkness where the ability to visually maintain contact with the person is compromised.

Providing a means to recover personnel from the sea to the MOB rescue craft/vessel (e.g. Jason's Cradle) should be considered, given that hypothermia sets in quickly and thus any MOB casualties will have limited ability to help themselves.

If approaching a person in the water in ice conditions using a marine craft, care should be exercised to help ensure that the approach of the craft does not cause ice to move adversely and crush the person awaiting rescue.

A.16 Escape

A.16.1 Escape — Design

A.16.1.1 General escape — Design

The goal of escape is to ensure that, in an emergency, personnel move to a place of relative safety on the installation (normally the TR), consistent with the specified performance-based standards.

A.16.1.2 Escape routes — Design

Design of escape routes should consider:

- that the defined escape routes remain available at all times for personnel to reach the TR or their MS;
- the movement of stretchers, rescue and firefighting teams;
- the suitability for personnel wearing bulky PPE to descend quickly from remote locations to the main escape routes.

The escape routes should be straight and horizontal to the extent possible, with minimal number of stairs and if possible, with flow of personnel in one direction in an emergency. Ladders should not be used along main escape routes. External route floors should be free of trip hazards as far as possible and self-draining or provided with other means to reduce ice build-up. A means should be available to remove ice and snow from escape routes when the design cannot preclude its accumulation.

The dimensions of escape routes should be adequate for the number of people who might be required to use them and demonstrated to provide adequate flow of people through the use of escape modelling software.

The exits should be situated as far apart as practical. Internal room arrangements are evaluated for possible blocking of exits following an incident as well as external blockage, to help ensure that at least one exit remains available.

Airlock and watertight doors, when remotely operated, should be equipped with a suitable alarm that activates prior to remote door-closing.

Escape route design should be assessed using appropriate escape modelling software and design modifications made to alleviate areas of high congestion or where movement of personnel is deemed to be slow.

The surface coating of decks, walkways, platforms, stairs, ladder rungs, etc. can be adversely affected by environmental and operational conditions, including:

- extreme low temperature and temperature fluctuations above and below freezing;
- atmospheric icing (freezing rain and freezing fog);
- marine icing (sea spray);
- ice and snow accumulation;
- impact caused by ice removal measures;
- presence of wash water and melt water;
- presence of mud, hydrocarbons, oil contaminants and other substances which can leak during normal operation or during an emergency.

Round bar rungs should not be used in external locations. Ladder rungs should be constructed of square bar with a corner/edge pointed upwards, so that accumulated ice can be broken by the weight of the user. A non-slip coating capable of taking into account the aforementioned conditions should also be incorporated in the design, or other means evaluated to achieve a comparable level of performance.

Enclosures can be temporary or permanent, taking into account fire and explosion risks as well as the practicality of installation. Meteorological conditions, such as level of precipitation (snow and rain), marine and atmospheric icing in the area should be considered when deciding on the level of permanent and temporary enclosures relied upon during EER. For potentially hazardous areas containing flammable and toxic substances, the potential risk caused by an enclosure should be balanced by other risk-reduction measures. Special attention should be given to enclosed areas when carrying out the fire and explosion risk analysis to help ensure that risk-level design blast loads are not exceeded. Enclosure

of any potentially hazardous areas where hydrocarbons or other significant amounts of flammable substances are present should include appropriate measures to reduce the risk of fire and explosion in accordance with criteria and as far as reasonably practical.

Electrically or battery-powered signs are not required to be equipped with active anti-ice protection, if the heat emitted by them is sufficient to melt accumulated snow and ice.

A.16.1.3 TR — Design

Due to the ice conditions and other arctic physical environmental challenges, evacuation can at times be delayed, necessitating that the TR impairment time be longer than in non-arctic regions. Additionally, arctic region muster area/TR space requirements might need to be larger to accommodate donning of immersion suits. Guidance on how some non-arctic (e.g. North Sea) installations dealt with these issues is provided for consideration (see list items b), d) and e) below) as a starting point for others to develop their own Arctic region and installation-specific criteria.

The TR design should take the following into account:

- a) Ensuring capacity sufficient to accommodate the maximum permissible number of POB for the entire period in which it is expected to be occupied. When determining the POB, the number of visitors that can be on board, helicopter crews and rotation personnel arriving by helicopter that were stranded, attendant vessel personnel that can be rotating by helicopter or another vessel, etc. should be considered. Space allocation should take into account the bulky arctic clothing and/or immersion suits that personnel might be wearing or need to don.
- b) When mustering in groups of 20 or more, an area of 1,5 m² (16,0 ft²) per person should be provided. This is based upon 50 % seated and 50 % standing and allowing for cross-flows of personnel. When mustering in groups of fewer than 20, area requirements can be reduced to about 0,8 m² (8,6 ft²) per person. This is based upon 25 % seated and 75 % standing, without significant cross-flows of personnel. These area values are for clear areas, including loose furniture.
- c) Air supply to the TR:
 - taken from multiple locations;
 - each intake being individually closed upon local smoke or gas detection and protected from environmental effects;
 - compressed air in sufficient quantities and storage modes to assure breathing-air supply for the requisite period in fully isolated mode.
- d) Based on oxygen depletion and carbon dioxide (CO₂) build-up, the minimum volume of an enclosed TR should be 1,4 m³ (50 ft³) of air per person per hour of TR endurance. Heat stress, oxygen depletion and CO₂ build-up also affect the space requirement for an enclosed TR. The minimum internal oxygen level should be at least 17 % (vol) for at least 60 minutes whereas the maximum CO₂ level should not exceed 20 000 ppm (i.e. 2 % vol).
- e) When analysis of incident scenarios for an enclosed TR indicates that significant smoke and gas ingress might occur, a protection measure can be to seal the TR. When a breathable external air supply is lost, an adequate internal air supply should be available for the remainder of the endurance period. Oxygen consumption and CO₂ production are linked to energy expenditure.
- f) Automatic regulation of air composition and internal climate control system.
- g) TR exits to be fitted with air locks to avoid ingress of gases, smoke and vapours.
- h) Medical facilities in the TR as determined by the EER plan.
- i) ERO and alarms documented on a station bill deployed at strategic locations throughout the installation.

- j) Potential for requiring longer TR impairment time associated with delays in being able to effect evacuation due to unfavourable ice conditions (e.g. active ice rubble generation beneath the launch zone of evacuation craft, more time for the SBV to clear a path to the evacuation craft due to ice conditions).

It is not required that a TR will be fully operable and accessible under all incident scenarios, provided contingency plans are in place to help ensure the safety of personnel by clearly designated alternative muster points.

Primary TR

- The space needed to accommodate the anticipated number of personnel in the TR should be assessed taking into account that personnel will be standing, seated and will likely need space to don PPE, including immersion suits. The minimum volume of air required for an enclosed TR for the full TR impairment time should be determined.
- Safe levels of oxygen and carbon dioxide should be maintained in enclosed TRs and noxious gases prevented from entering the TR throughout the time personnel are inside.
- If the main installation control point is part of the primary TR, a separate but adjacent space designated as the ECP should be considered, which can then provide the ER management team with a more suitable environment for making complex decisions under stress.
- For enclosed TRs, the prevention of smoke and/or gas ingress is of paramount importance in maintaining integrity. The minimum acceptable air change rate should be stated as part of the TR performance-based standard.
- The location of entrances and exits to a TR should promote a single-directional flow of personnel during an incident, where possible, excluding cross-flow and counter-flow of personnel. All TR external doors should resist smoke and gas penetration. All TR external doors should be kept free of ice, snow and frost.
- The TR should have facilities to monitor ice and sea conditions in the vicinity of the launch point for evacuation craft and a secondary means of evacuation to assist the OIM in making an informed decision on whether to delay evacuation or on the timing of evacuation (e.g. in response to drifting ice or active ice rubble field generation).

Secondary TR

- A secondary TR (if deemed necessary by the EER analysis) should provide a means of two-way communication with the primary TR for the relaying of information regarding the whereabouts, condition and numbers of personnel unable to reach the primary TR and to receive information regarding evacuation. There should be a means of monitoring conditions, such as fire, smoke and gases on the designated evacuation route, which might be visually determined.
- Emergency power, lighting and any other facility which is necessary to maintain the integrity of the secondary TR to help ensure life and structural support should be provided.

A.16.1.4 MS — Design

When dimensioning MSs, accommodating injured personnel on stretchers should be considered as well as additional personnel arriving by helicopter (in the event the helicopter cannot depart due to the incident or a mechanical issue), personnel on the installation from an SBV awaiting helicopter or another vessel transfer to shore, supernumeraries that can be on the installation, etc.

MS dimensioning should take into account that personnel will be wearing bulky clothing and/or immersion suits or might have to don their immersion suit at the embarkation point location in the event of a rapid escalating incident or impairment of the TR.

MS dimensioning should recognize that additional installation personnel might be on hand in the event they were unable to assemble at their designated MS due to the environment and/or incident, or assembled at the wrong MS.

Alternative embarkation areas should provide protection from the effects of the incident and the arctic environment for a time sufficient to allow control of an emergency or until a decision is made to abandon the installation.

A.16.2 Escape — Operations

A.16.2.1 General escape — Operations

To maintain crew competency, installation personnel should carry out emergency scenario drills on a regular basis using emergency and EER equipment as part of the exercise. The drills programme should assess the capabilities of all POB, including back-to-backs.

The drills programme also should account for the challenges associated with performing drills in cold weather and dealing with the fact that some lifesaving equipment cannot be available for use when needed in an incident (e.g. due to accessibility restrictions resulting from the incident) and the reality that there might be a greater variety of lifesaving evacuation equipment or options on arctic/cold weather installations than available on those operating in open seas.

The arctic physical environment can impact the types and frequency of emergency scenario drills that can be carried out. For example, it can be impractical to charge the fire system when temperatures are below freezing, if the system cannot be adequately drained after the drill. In this case, fire-fighting skills should be simulated so as not to cause unnecessary icing on decks and structures.

Escape drills should include practicing with blocked routes.

To maintain proficiency, the full suite of emergency scenario drills should be carried out for each crew rotation.

Drills should periodically include personnel donning immersion suits to evaluate competency and should at times include embarkation of evacuation craft when participants are dressed in survival gear. Safety strops or other means to prevent accidental launch should be used.

Function tests for the operational escape management system should include the communication system, escape route lighting and escape path routing verification.

A.16.2.2 Escape routes — Operations

The posting of watches by competent personnel can be considered to provide a temporary alternative route(s) when certain safety systems are temporarily unavailable.

A.16.2.3 TR — Operations

A TR's primary objectives are to help ensure:

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

The location(s) for the TR relative to the evacuation craft (if so equipped) are installation/ice environment/emergency scenario-specific and should be part of the original installation's design and orientation.

Periodic assessments, particularly after snowstorms and icing events, should be carried out to help ensure that the TR can still be hermetically sealed from other areas and the outside environment.

A.16.2.4 MS — Operations

The frequency of MS inspections and maintenance to remove ice and snow accumulations should take into account snowstorms and icing events.

A.17 Evacuation

A.17.1 Evacuation — Design

The goal of evacuation is to ensure that personnel leave the installation to a place of rescue outside the hazard zone consistent with the developed performance-based standards.

A.17.1.1 General evacuation — Design

There are normally considered to be four categorizations of evacuation means, namely: preferred, primary, secondary and tertiary. The hierarchy of evacuation system utilization is as follows:

- a) The 'preferred means of evacuation' is normally the method of choice for evacuating personnel, based on the lowest risk and on the familiarity, frequency and use, availability and suitability for prevailing conditions. The preferred means is the method used for the normal crew changes. During a precautionary evacuation, the preferred means is normally used.
- b) The 'primary means of evacuation' is a means of evacuation that is normally available on the platform. Its operation can be carried out in a controlled manner under the direction of the person in charge. It is the first choice of evacuation from the installation in an emergency situation. The primary means of evacuation usually provides the most protection and/or lowest risk to evacuees of all the evacuation methods available in an emergency situation.
- c) The 'secondary means of evacuation' is a means of evacuation that allows personnel-controlled access to a rescue platform without having to enter the sea and can be carried out independently of external support. The secondary means of evacuation does not provide as much protection from hazards and the elements as does the primary means, but it can avoid immersion in the sea/ice.
- d) The 'tertiary means of evacuation' is a means of evacuation that relies heavily on individuals' own actions and is used when the primary and secondary means are not available and thus it has inherently higher risks. The tertiary means of evacuation is typically used by individuals that are fleeing and cannot reach the primary or secondary evacuation systems because of the incident, rather than by groups following procedures. The tertiary means of evacuation is normally more basic and can include personal descent devices, scramble nets and/or ladders onto ice.

Two principal evacuation system configurations are relevant.

- Direct evacuation systems, such as bridges, motion-compensated gangways or chutes and evacuation craft directly to an SBV, constitute a direct evacuation system. Once evacuated by means of such a system, evacuees are deemed to be in a place of rescue or safety equivalent to rescue.
- Indirect evacuation systems by which evacuees move from the installation to a location outside the hazard zone if they are able to do so. Then as the rescue effort commences, evacuees survive until they are transferred to the place of rescue. For example, leaving the installation in a TEMPSC launched to the sea or onto an ice cover, exiting the hazard zone in the TEMPSC (evacuation complete), surviving in the TEMPSC until an SBV is alongside, and transferring to an SBV (rescue complete) constitutes characteristics of an indirect evacuation system.

The evacuation plan might change depending on the season owing to the capability of the various means of evacuation in open water and when ice is present.

The matrix shown in [Table A.2](#) provides an example of how an OIM operating in an arctic or cold region can have more than one evacuation option available and gives an indication of the decision process involved.

Event: A well kick occurs giving time for **precautionary** evacuation of 80 non-essential personnel. 22 essential personnel remain to control the well but fail. They escape and muster in the TR, where the OIM has made the decision to abandon the installation using one or more **primary** or **preferred** methods (if available and suitable for use in hazard conditions), **secondary** means and even **tertiary** evacuation methods where one or more persons are unable to reach the TR.

Table A.2 — Example of evacuation method decision hierarchy — OIM evacuation decision matrix

Choice	Precautionary	Emergency		
	Preferred	Primary	Secondary	Tertiary
1st ^a	Method A	Method B	Method C	Method D
2nd ^a	Method B	Method C	Method D	Method E
3rd ^a	N/A ^b	Method D	Method E	Method F

^a In the event that the first choice is not available (or inappropriate given prevailing hazards), the OIM selects the next available and reliable option, and so on, until full complement of non-essential and essential personnel are evacuated.

^b There might not be other available options that provide the required level of reliability during precautionary down-manning.

Embarkation areas and evacuation craft system access should be designed to allow rapid boarding of personnel including those injured and requiring assistance while preventing ingress of hydrocarbon and other toxic gases. The interior design of the craft should enable efficient personnel boarding, seating and tending to injured personnel including stretcher cases.

A.17.1.2 General evacuation helicopters

The use of helicopters in the EER evacuation plan can be for transferring personnel to an adjacent platform, SBV or intermediate shore facility with a helipad and emergency equipment, etc., rather than to the shore base to minimize flying time and increase the speed of evacuation.

Helicopters should be selected taking into account:

- a) payload range;
- b) payload mass;
- c) take-off weather minimum;
- d) landing weather minimum;
- e) transportation capacity for injured evacuees;
- f) location of places of safety en route;
- g) availability and specification of navigational aids;
- h) availability of intermediate refuelling facilities which can extend range or time on site;
- i) navigation conditions along the flight route (e.g. long nights, low sun, reduced number of ground-based navigation aids, monotonous terrain, magnetic anomalies);
- j) de-icing protection.

A helicopter incident en route between shore and the offshore facility can initiate an SAR operation and should also be considered. The most effective rescue method can be employing an SAR helicopter if there is heavy ice or shallow water.

A.17.1.3 Evacuation method — Design

The following considerations/challenges should be taken into account in evacuation system design:

- a) Where deemed necessary, the evacuation means should be designed to minimize the effect of impact with the structure, other vessels and the ice cover, through inherent built-in strength or through the use of fenders if it will not adversely affect ice navigation. The design of launch arrangements should help ensure adequate function considering sea spray, atmospheric icing, cold temperatures, snow and ice rubble field build-up around the platform.
- b) Evacuation systems in sufficient quantities and locations, capable of being deployed and operated in the physical environment of the arctic or cold region should be provided. The use of materials capable of performing as intended in the lowest anticipated temperature should be considered in the design. Design consideration should also be given to access and boarding, winterization, icing (before and after launch), visibility (e.g. through evacuation craft steering-position windows), etc. Available evacuation systems have limitations with respect to operating in various ice environments. For example, conventional TEMPSCs are unable to make headway in ice concentrations greater than about 5/10. Marine evacuation systems should be selected or developed further to operate in all ice environments for which their use is planned. Hulls should have sufficient strength to resist loads imposed by broken or slush ice, if the EER plan calls for launching the craft in an ice cover without assistance from an SIMV.
- c) In regions where ambient temperatures can negatively impact starting, appropriate winterization measures, including the use of low temperature lubricants and fuels, should be taken. The design should also evaluate the requirement for engine heaters, battery trickle chargers, etc. Outer metallic surfaces, which evacuees can touch, should be suitably insulated, where possible, to prevent frostbite caused by touching them.
- d) Fuel capacity should be assessed in accordance with performance-based standards based on transit and survival requirements according to maximum time for rescue, i.e. normal duration of storms in the region, distance/time from shore-based rescue services, etc.
- e) Thermal insulating materials and construction should be selected with regard to the following parameters:
 - water absorption;
 - moisture behaviour under frost/thaw conditions;
 - compatibility with other construction materials;
 - durability;
 - low density and thermal conductivity;
 - sufficient mechanical strength.
- f) In most cases, the space required in an evacuation boarding area and evacuation craft should exceed 100 % of the maximum complement to account for injured personnel, non-functionality and/or unavailability of one or more evacuation methods due to an unexpected hazard scenario. The space should be sufficient to accommodate personnel wearing PPE and account for the potentially longer times that evacuees can be expected to spend on-board the evacuation craft before rescue.
- g) Evacuation methods should be designed in accordance with established human engineering principles and their ergonomic adequacy, i.e. bulky PPE, for expected personnel configurations. Performance in cold water and arctic temperatures with reduced manual dexterity should be considered.
- h) The design of evacuation methods should consider the requirement for a self-contained air support system and fire-protection. If marine-based, their design should be self-righting and capable of survival when subjected to pressures transmitted through a converging ice field.

- i) The evacuation method should include additional food rations to allow for the greater calorie burn in cold conditions. Water supplies should be protected from freezing to maintain the integrity of their containers or the type of water storage container/storage method (e.g. expandable or not filled to capacity) selected that is not damaged by freezing.
- j) Ventilation in a full evacuation craft is important, as increased temperatures can cause discomfort and encourage evacuees to discard bulky PPE to their future detriment. CO₂ build-up within the evacuation craft can require regular ventilation.
- k) The evacuation method should be provided with the equipment necessary for facilitating SAR success, including communications and navigation equipment that takes into account the special challenges associated with working in high latitudes in remote areas.
- l) Lighting of the marine evacuation craft boarding area should be uninterrupted during an emergency. This includes the sea or ice surface entry zone beneath the craft.
- m) Secondary evacuation methods should allow personnel-controlled access to the rescue platform without having to first enter the sea or ice cover.
- n) Tertiary evacuation means should be located and stored such that they are protected from the same event/escalation scenario that can impair a secondary means of evacuation.
- o) Tertiary evacuation means can include fixed stairs and ladders, rope ladders and personal abseiling devices where their deployment and use are unlikely to be impaired by environmental conditions. Using these methods normally exposes the evacuee to the elements.
- p) Tertiary evacuation means should accommodate personnel wearing the expected PPE required for cold weather and/or cold water.
- q) If part of the evacuation plan, multiple tertiary means (as stipulated by the EER analysis) to facilitate direct access to the ice or the sea should be strategically located to enable the evacuation of personnel who have no other means of leaving the installation.

A.17.2 Evacuation — Operations

A.17.2.1 General evacuation — Operations

The evacuation route aboard the installation is the route from the TR or MS to the means of evacuation. After abandoning the installation, the evacuation route will lead beyond the hazard zone if the evacuation craft/means is able to get there. In some EER strategies under some instances (e.g. ice conditions) evacuation can rely on the rescue vessel/means to approach the evacuation craft, rather than the evacuation craft transiting to the rescue craft (see Reference [15]).

Training in the use of evacuation equipment might need to be carried out both onshore and through emergency scenario drills aboard the offshore installation.

Where appropriate in stable ice conditions (e.g. landfast ice, a grounded ice rubble field), establishing a rendezvous point or points off the installation on the ice that provides additional medical, food, fuel, communications equipment, etc. should be considered. This is particularly pertinent in case the emergency scenarios include a highly toxic environment on the installation during an emergency (e.g. H₂S gas release).

Evacuation routes across the ice (if used as part of the evacuation plan) should consider hazards posed by the ice cover and exposure of personnel to the incident and to the physical environment.

A.17.2.2 Evacuation method — Operations

Where prior warning of a potential incident is available, a precautionary evacuation of non-essential personnel should be considered to reduce personnel exposure to the hazard. The operator should

assess whether risks to evacuees during a precautionary evacuation are any greater than if they were to remain on the installation.

The removal of personnel at this time is also referred to as precautionary de-manning. The most reliable means of evacuation available should be used during a precautionary evacuation. It is expected that this will typically be the 'preferred' means of evacuation.

The risk analyses necessary to demonstrate the appropriate selection of precautionary evacuation method should include, but not be limited to, the following criteria:

- a) time estimated for a potential incident to lead to an emergency evacuation;
- b) time available to mobilize the evacuation method;
- c) time to effect the evacuation;
- d) determination of non-essential personnel to be evacuated;
- e) travel distances to rescue platforms or safe havens;
- f) environmental conditions (weather, ice, ocean) prevailing and forecast, during the evacuation and rescue period;
- g) means available for embarkation and transfer of personnel;
- h) human factors, including personnel training;
- i) ability to transport evacuees beyond the maximum potential hazard zone.

The preferred or precautionary means of evacuation is usually undertaken using the means of transportation employed for crew changes, typically helicopters and vessels. Additional capability might be needed for helicopters operating in the arctic offshore. For example, it is compulsory in Norway that all helicopters operating north of 60° N latitude have de-icing capability.

When there is an imminent danger to the installation personnel, an emergency evacuation should be carried out.

The risk analyses necessary to demonstrate the appropriate selection of emergency evacuation method(s) are likely to include, but are not limited to, consideration of the following criteria:

- preparations to evacuate while inside the TR or at the MS, including assessment of personnel condition, incident hazards, prevailing and forecast environmental conditions (including ice cover) and proximity and availability of a rescue platform and/or safe haven;
- awareness of developing/changing hazard zone consequences during the evacuation process;
- protection of the installation evacuation route from the TR to the primary evacuation system(s);
- suitability of the evacuation method and its conformance with performance-based standards (functionality, availability, reliability, survivability and interdependencies with other systems);
- personnel distribution and locations at the time of the incident;
- mobilization time;
- escape time, vertical and horizontal ladders, stairs and level walkways allowing for effects of low temperatures, icing, stability, dexterity, clothing, etc.;
- embarkation times and sequencing relative to the location of personnel and the provision of assistance to injured personnel;
- behaviour of personnel in the range of scenarios relative to the capacity of available systems;
- human factors under stress, including level of emergency training;

- rapid build-up of CO₂ inside the evacuation means unless there is adequate ventilation;
- stretcher access, casualties, access to medical support after leaving the TR during evacuation and for transfer to a rescue platform;
- effects of motion sickness and stress on performance (see Reference [26]);
- capability of evacuation method in prevailing low temperatures, ice environments and/or metocean conditions;
- transit visibility, collision risks at night, etc.;
- launch and departure route from installation to rendezvous points with rescue platform(s).

To maintain crew competency, the POB should carry out emergency scenario drills on a regular basis utilizing emergency and EER equipment as part of the exercise. The drills programme should assess the capabilities of all POB, including back-to-backs.

The drills programme should take into account the challenges associated with performing drills in cold weather and the possible non-availability of some LSAs periodically (e.g. due to the presence of the ice cover) and the fact that there might be a greater variety of lifesaving evacuation equipment on arctic/cold weather installations than those installations operating in open seas.

The practicalities of launching evacuation craft at the prescribed intervals in SOLAS might not be possible due to the ice cover. Therefore, the operator should help ensure the testing and verification of evacuation system readiness to help ensure system availability when required. Alternatively, national authorities can be requested to issue an exemption for alternative methods of ensuring the evacuation craft functionality and readiness.

A.18 Rescue

A.18.1 Rescue — Design

The goal of rescue is to retrieve evacuees to a safe haven.

Rescue is the process whereby evacuees who have abandoned the installation (and the direct hazards posed by the incident) and are in an evacuation system (e.g. inside an evacuation craft, on the ice cover, in the sea), survive until a safe haven is available and complete the transfer to that safe haven (see Reference [30]).

In the case of direct evacuation, evacuees are deemed rescued when the direct evacuation is complete; hence no rescue is applicable. Thus, rescue only applies in the case of indirect evacuation systems, such as marine evacuation craft or other temporary methods of survival off the installation and then transfer to a safe haven.

If possible, marine evacuation craft should be able to launch in open water and when ice is present though not all marine evacuation craft have dual open water and ice capabilities. Suitability of the rescue system/method should take into account the safety of rescue personnel and evacuees, time efficiency (i.e. ability to achieve the set recovery goals within the anticipated survival time), complexity of the rescue system design which is impacted by the required workload and personnel competency and the challenges imposed by the arctic physical environment.

The rescue system should be designed for the maximum POB which can include day visitors and personnel in transit (e.g. from the SBV, SIMV or arriving from the SBV/SIMV and awaiting shuttle to shore, installation personnel that have completed their tour and are awaiting transportation back to shore, personnel being shuttled to/from another installation).

The design of the rescue system should include the following:

- a) Ensuring that all personnel have a high probability of reaching a safe place within a reasonable amount of time (i.e. within their survival time) under the prevailing circumstances and arctic physical environmental conditions.
- b) Developing a statement of requirements for designing rescue means to reduce and extend capabilities in the area of operation to the most extreme design weather limits, both for open water and in the presence of an ice cover.
- c) Summarizing the state of the art related to the rescue of personnel for the particular evacuation craft or other means of evacuation anticipated. Identifying the relevant regulations, standards and design guidance associated with their utility for the rescue system design process.
- d) Developing a risk register that, when combined with a statement of requirements, is used as a guide in the rescue system design.
- e) Developing a compatibility matrix between the evacuation and rescue systems.
- f) Utilizing a structured approach for designing innovative rescue means (e.g. stage/gate approach common to product development and innovation).
- g) Survival: the range of anticipated environmental conditions, including seawater and air temperature, the effects of ice abrasion, etc. should be taken into account. The time for the SBV or SIMV (if part of the rescue plan) to transit through the ice to round up survivors should be assessed. Keeping survivors protected from the elements, fed, watered, etc. should be considered. Times for recovery of survivors by an icebreaker should take into account the challenges to vessel positioning imposed by the ice cover (e.g. ice ridges, pressured ice). Vessel manoeuvring in the presence of an ice cover can be violent and time-consuming so a rescue craft or rescue basket/crane swung from the vessel to the evacuee might be the preferable method rather than manoeuvring close to the survivors.
- h) Shelters: strategies incorporating shelters deployed on a stable ice cover should be considered where appropriate as part of the EER analysis.
- i) Design integrity: both hardware and personnel components should be taken into account.
- j) Personnel recovery: it is necessary to provide means of transfer from the primary and secondary evacuation methods to the rescue platform (safe haven) that does not require personnel to enter the sea or always move onto the ice cover.
- k) Communications: primary and secondary evacuation systems should have the capability to communicate with the rescue platform during the survival and recovery process.
- l) Lifting appliances for evacuee recovery: conditions and methods for recovery of evacuees from primary evacuation systems, secondary evacuation systems and/or in the sea or from an ice cover through the use of lifting appliances should be assessed in the EER analysis and implemented accordingly.
- m) Tertiary evacuation system interface: where deemed necessary by the EER analysis, the tertiary evacuation mode should have the provision of launching/lowering to the open sea or directly to an ice cover for later recovery by the primary or secondary means of evacuation or the rescue system.
- n) Medical treatment requirements: the required level of medical treatment from the rescue platform should take into account the travel time to a medical facility (which is capable of treating the types of injuries that could be expected), the capability of the medical facility for handling multiple casualties, etc.
- o) Vessel rescue platform: when vessels are used as part of the rescue plan, the vessel's bridge should be designed to enable the vessel's master to continuously monitor rescue operations.

- p) Materials: material properties in cold temperatures and in ice should be taken into account to help ensure that components maintain their functionality.
- q) Propulsion system: the rescue mission and range of natural and incident-impacted environmental conditions expected should be taken into account to help ensure that the vessel (or other means of rescue) has sufficient power and manoeuvrability to carry out its intended role.

Additional design guidance on rescue vessel times and systems is provided in Reference [25].

A.18.2 Rescue — Operations

To avoid undue risk to installation personnel, dummies may be used in rescue training drills. In particular, rescue drills simulating a helicopter crash close to the platform should be performed using a realistic number of dummy occupants.

Measures that will be in place for rescue operations, whether or not they are under the installation's direct command and control, should be described in the safety management system.

The installation operator together with the rescue resources are responsible for maintaining and upgrading the procedures for command, control and communication.

The time for the SIMV, support icebreaker (or other rescue means) to transit through the ice to round up survivors should be simulated with the support vessel(s) and compared to the design basis to determine whether any other measures are required to keep survivors protected from the elements, fed, watered, etc.

In cases where the installation relies on external resources for rescue, these external resources should be evaluated in conjunction with the installation to provide assurance that EER is a fully functioning, integrated system. This might include helicopter operations outside of normal operating hours, e.g. at night, or performing rescue training operations in vicinity of the SBV/SIMV during the night and when ice is present.

Annex B (informative)

Examples of Arctic EER risk analysis and operational EER systems

B.1 Example EER risk analysis

B.1.1 General

As referred to in [A.8.3](#), this annex provides an EER risk analysis example using the PEERS. The model is useful for assessing the SRTC and the contribution of EER to ALARP. Towards this end, the risk assessed for each scenario is compared to the SRTC threshold. In the case of ARTC, the scenario risk assessed is combined with the annual probability of occurrence of the incident necessitating the scenario and then added to the array of risks used in the ALARP evaluation.

PEERS was initially developed for the Transport Development Centre (TDC) of Transport Canada during the period 1999 to 2006 as the RPT (see References [\[31\]](#), [\[32\]](#), [\[33\]](#), [\[34\]](#) and [\[35\]](#)). The RPT was used in the setting of quantitative performance based targets in the TDC performance-based standards developed in 2003 (see Reference [\[8\]](#)). Subsequently, the RPT was further expanded in capability and scope in Reference [\[36\]](#) and renamed the probabilistic escape evacuation and rescue simulator (PEERS). The PEERS model provides the probability of success (and failure) and its contribution from all principal EER components, including the effects of personnel performance, equipment reliability, environmental and accident conditions for a specific installation, and EER system configuration for any specified EER scenario. An outline of the important steps and examples of the results of the PEERS model are given in this subclause, with details available in References [\[36\]](#), [\[50\]](#) and [\[51\]](#).

The principal steps of EER modelling are illustrated in the block diagram in [Figure B.1](#) (adapted from Reference [\[36\]](#)). Uncertainty modelling results using Monte Carlo simulation are not included herein. Essentially, after assimilation of data (step 1) and assessment of the key accident scenarios (step 2), the modelling of the escape process (step 3) is conducted. The escape process entails movement of personnel from their location at the time of the alarm to a TR or muster point. The evacuation process (step 4) entails movement from the TR to an evacuation craft or other device and its launch and movement to a safe distance from the installation or vessel. Step 5 involves rescue which consists of survival until a rescue platform is available and subsequent transfer of evacuees to that rescue platform. It takes into consideration the environmental conditions, available rescue modes such as helicopters, SBVs, other ship traffic or nearby land or installation locations. In the final step (step 6), the results of the three individual component models are integrated to give an overall EER reliability or success probability rating for the EER scenario.

The method described in this subclause is intended as an example of ways to quantify the reliability of specific EER scenarios in order to assess conformity with the SRTC. Alternative methods which generate quantitative reliabilities can also be used.

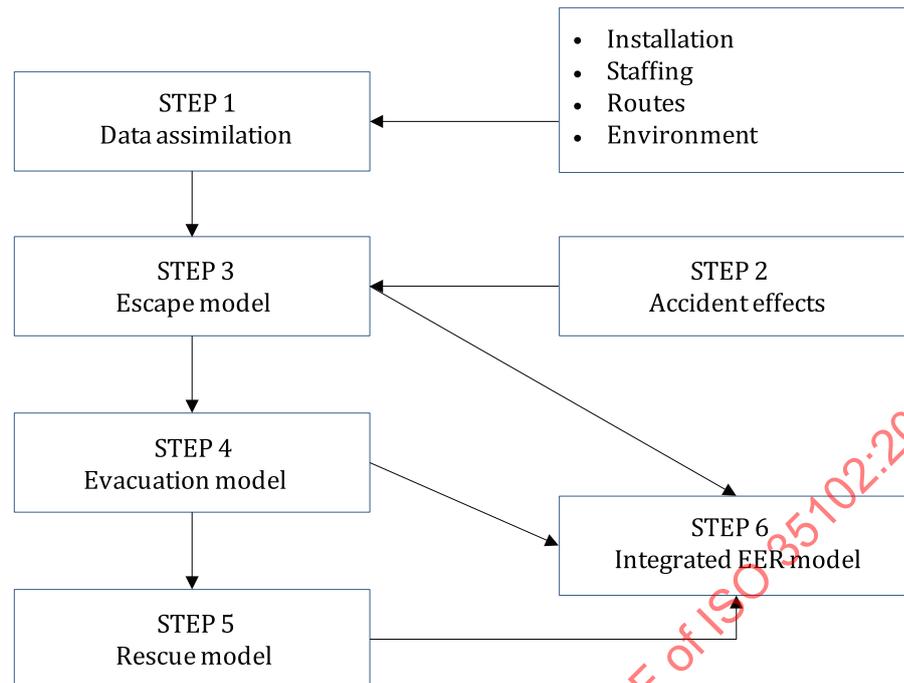


Figure B.1 — Principal steps of an EER scenario risk analysis

It is important to develop a model that is as realistic as possible using verified or expertly generated data. In the case of PEERS, the model has been calibrated with real EER data collected in dedicated real-time exercises carried out by real offshore personnel on a dedicated installation with the observation (video, timing, visual) of dedicated qualified personnel, including engineers, scientists, and representatives of the model developers (see References [31], [32], [36]). Such a model calibration can only be carried out for the EER drill situation rather than precautionary or emergency evacuations. However, when the model has realistic activities and times including delays from bottlenecks and botched procedures giving results corresponding to a real drill performance, it gives a solid base on which to expand its scope to model precautionary and emergency EER scenarios. One of the most important variables in adapting the drill model to emergency conditions is the consideration of human performance under life-threatening stress conditions.

In assessing the performance of evacuees in emergencies, it is essential to consider the effect of stress on their performance. Essentially, clearly documented results from analysis and experiments (see References [9], [31], [39] and [40]), indicate that human performance changes significantly with psychological threat level (see Figure B.2). Two principal aspects of human performance characterize these changes, namely cognitive function and perceptual capability as documented in Reference [41]. These two capabilities improve with mild stress, say on changing from a drill to a precautionary evacuation and deteriorate drastically as life-threatening conditions prevail, as could be the case in an uncontrolled sour gas blowout offshore. In the risk model described in this subclause, such effects are explicitly quantified in variations in the error rate and time to complete tasks which comprise each EER activity (see References [32], [36] and [37]). However, in a more cursory evaluation, one can simply assume conservatively that EER performance in a life-threatening emergency will be 5 to 10 times worse, i.e. have a 5 to 10 times lower success rate, than in the corresponding drill which was documented.

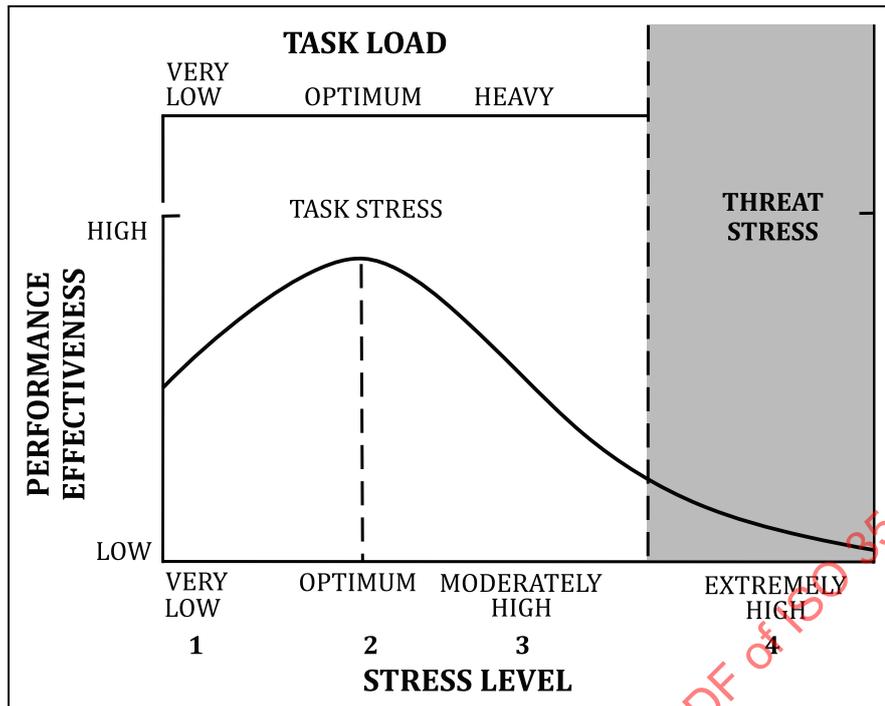


Figure B.2 — Variation in human performance reliability with stress level (see References [9] and [39])

Realistic environmental conditions, including sea-state and ice conditions, are also a vital consideration to include in a realistic model. For arctic locations, a range of sea-state and ice characteristic combinations should be considered. Table B.1 gives a matrix of possible combinations of ice and sea-state conditions used extensively in the PEERS model. The shaded areas are combinations of the environmental conditions not expected to occur at the location under study. Such matrix is location-specific and can differ among locations.

Table B.1 — Generic arctic environmental condition matrix

Ice	Seastate			
	Calm	Moderate	Severe	Extreme
Open water	1	2	3	4
Open pack ice ≤5/10	5	6	7	
Open pack ice 5/10 – 8/10	8	9		
Very close pack ice 8/10 – 10/10	10			
Solid thick ice sheet undeformed	11			
Solid thick ice sheet deformed	12			

The full range of overall (global) input variables (excluding environmental conditions except fog), which are parameters that apply to all components of the EER system, is presented in Table B.2 and further described in Reference [36].

Table B.2 — EER QRA generic global inputs

EER global inputs				
Study number				
Purpose				
Description				
AccidentRUNr1A	Accident location Process		Accident severity Large	
FOG	None	Medium	Heavy	
Escape time limit Min		POB		EER time limit Min

B.1.2 Risk analysis for escape

The layout and location of a specific offshore installation plays a major role in influencing the results of an escape analysis.

Aspects for consideration include, but are not limited to:

- availability of protected/unaffected alternative routes to TR or MS;
- escape route impairment from e.g. ice, blowing snow, reduced visibility, heat from fires, toxic gas and smoke, explosion (blocked escape ways due to incident);
- mobilization and escape times (from workplace to TR or MS);
- escape times vs escape-way design;
- travel time, vertical and horizontal ladders, stairs, level walkways allowing for effects of low temperatures including icing, stability, dexterity, stiffening of bulky clothing, trip hazards, etc.;
- width of escape routes relative to personnel locations and possible bottlenecks due in part to personnel wearing bulky arctic clothing thus causing congestion;
- time to muster all personnel including an allowance for assistance to and transport of injured persons;
- level of personnel training/experience and frequency of exercises;
- TR structure integrity and boundary protection including resistance of walls to fire and blast, structural integrity and HVAC;
- impact of a dynamic ice cover on the ability to evacuate and therefore on the TR impairment time;
- appropriate life-support for mustered personnel in the TR for full TR impairment time;
- availability and locations of PPE;
- human factors including physiological and psychological effects on error rate and the ability to perform functions under stress;
- ERO (1st line, 2nd line and 3rd line) actions and responsibilities; process controls, hazard status monitoring, communication;
- communication with the command and control centre and support services;
- command and control, availability of necessary organizational ER structure when required.

Consider the example of a comprehensive risk analysis for escape. First, a simple three-dimensional drawing or electronic representation of the escape routes is initially used to provide an understanding

of their spatial distribution as illustrated in [Figure B.3](#). Characteristic escape parameters are then used to assess the unit rates of progress which can be expected for different numbers of personnel along escape routes. Escape route configurations should be considered in conjunction with incident zones of impact which can be superimposed on escape routes. Routes should be selected to avoid accident effects such as structural blockage, fire, toxic gas or smoke.

Clearly, personnel not immediately affected by the incident will avoid escape routes within the hazard zone and can be restricted to alternative routes, possibly interconnected vertically as shown in the isometric view in [Figure B.3](#).

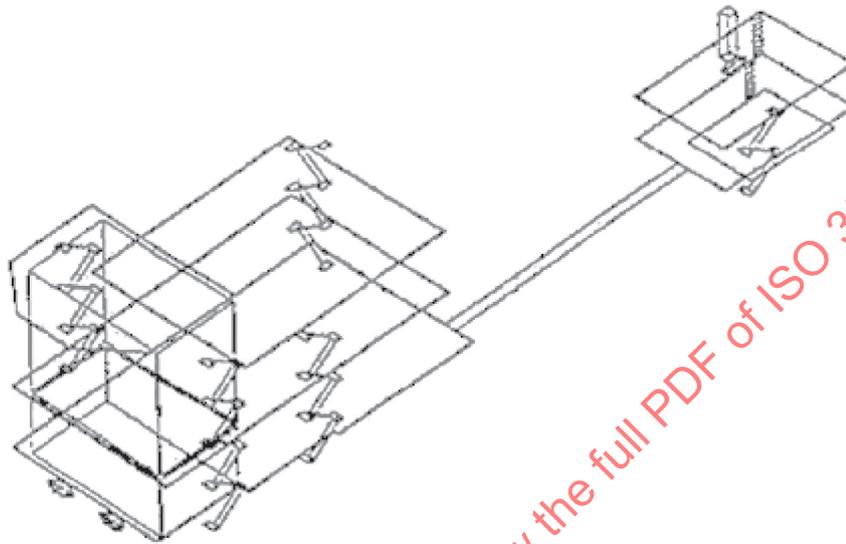
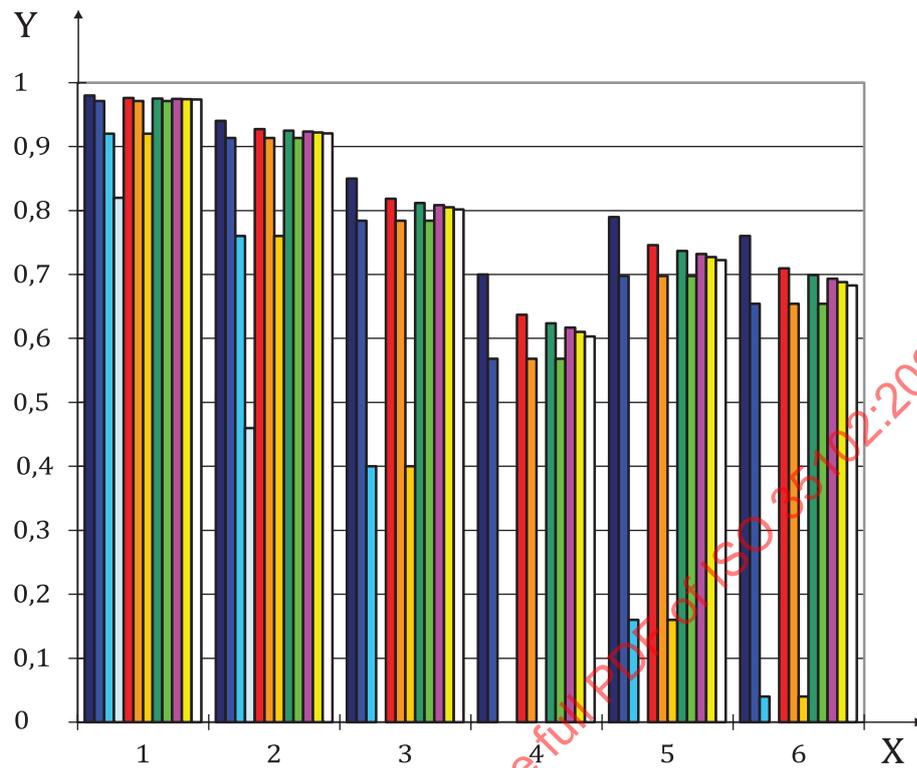


Figure B.3 — Escape route isometric

Logical application of the unit parameters based on the drill indexing to an appropriate configuration of escape routes, considering the initial locations of personnel throughout the installation, can then be used as a basis for computation of expected times and arrival success to the TR, as summarized by histograms for each of six routes shown in [Figure B.4](#).

The averaged escape success rate for each environmental condition can then be shown as the histogram in [Figure B.5](#). These averages have been computed as the average values of success for each of six routes in each of 12 conditions. Clearly, some routes might be preferred while others (route 4) would not be used depending on the incident and environmental conditions as a further refinement to the calculation.



Key

X route

Y success rate

■ open water — calm

■ open water — moderate

■ open water — severe

■ open water — extreme

■ ice ≤5/10 — calm

■ ice ≤5/10 — moderate

■ ice ≤5/10 — severe

■ ice 5/10-8/10 — calm

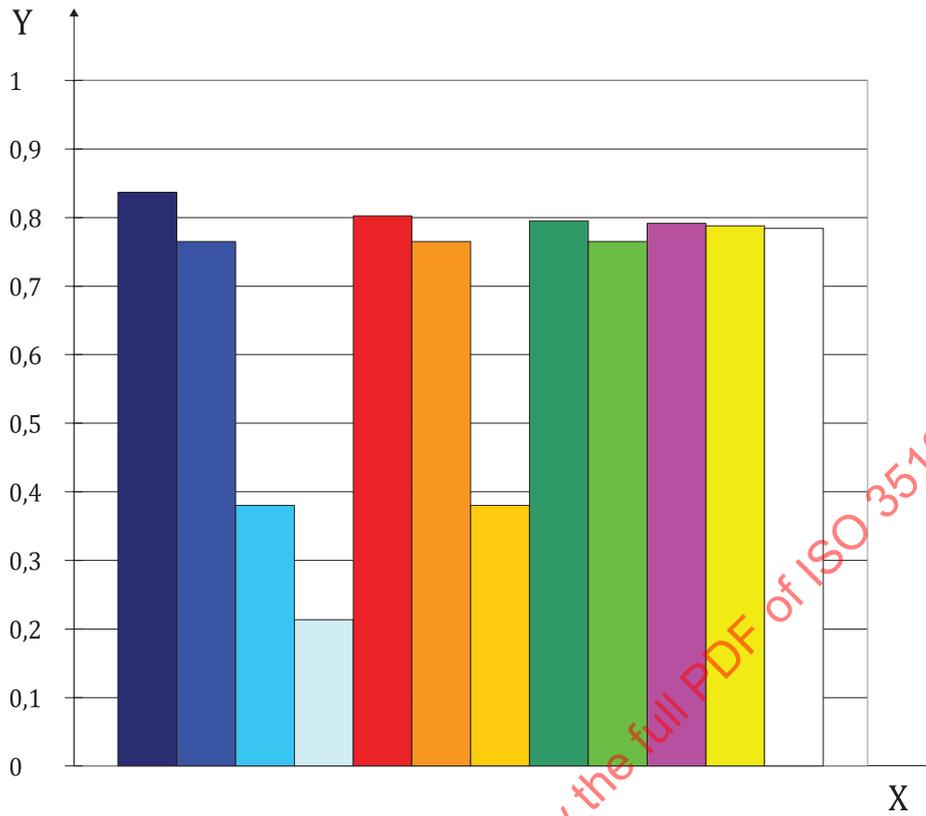
■ ice 5/10-8/10 — moderate

■ ice 8/10 < 9/10 — calm

■ solid sheet undeformed — calm

■ solid sheet deformed — calm

Figure B.4 — Escape route success graph



- Key**
- X route
 - Y success rate
 - open water — severe
 - open water — extreme
 - ice ≤5/10 — calm
 - ice ≤5/10 — moderate
 - ice ≤5/10 — severe
 - ice 5/10-8/10 — calm
 - ice 5/10-8/10 — moderate
 - ice 8/10 < 9/10 — calm
 - solid sheet undeformed — calm
 - solid sheet deformed — calm

Figure B.5 — Average escape success graph

Finally, consideration should be given to EER capacity and integrity. The time limit parameter for escape and TR residence is used to evaluate risk for specified major incident conditions.

B.1.3 Risk analysis for evacuation

B.1.3.1 General

Evacuation methods and processes should be selected as a function of the risk level. The capability of the system to satisfy performance-based standards should be analyzed for evacuation drills, precautionary evacuations (i.e. evacuation of non-essential personnel, down-manning) and emergency evacuations/abandonment of installation. Precautionary evacuations occur based on the warning of a potential incident with time for precautionary evacuation. Loss of incident control that threatens personnel safety usually results in an emergency evacuation. The decrease in human performance that can be expected with the increased stress in an emergency evacuation should be considered.

Generally, emergency scenario evacuation drills are only carried out in relatively benign environmental conditions to protect the drill participants. This means that conducting drills involving full evacuation/abandonment of the installation (e.g. to the sea via evacuation craft) should be avoided, except under favourable conditions. Precautionary evacuations might need to be carried out in somewhat more severe environmental conditions, if the precautionary evacuation process is deemed less hazardous in the conditions than remaining on the installation or executing an emergency evacuation. Emergency evacuations should be conducted whenever warranted regardless of environmental conditions.

B.1.3.2 Types of evacuation

B.1.3.2.1 Precautionary evacuation

Where prior warning of a potential incident is available, precautionary evacuation of non-essential personnel should be considered to reduce/remove exposure to the hazard. The operator should demonstrate that risks to evacuees during a precautionary evacuation are no greater than if they were to remain on the installation. The removal of personnel at this time is also referred to as precautionary down-manning. The most reliable means of evacuation available should be used during a precautionary evacuation. It is expected that this be the preferred means of evacuation.

The risk analyses necessary to demonstrate the appropriate selection of precautionary evacuation method should include, but not be limited to the following criteria:

- a) time estimated for a potential incident to lead to an emergency evacuation;
- b) means available for embarkation and transfer of personnel (e.g. helicopter, SBV, personnel basket);
- c) time available to mobilize the evacuation method;
- d) time to carry out the evacuation from the installation;
- e) determination of non-essential personnel to be evacuated (i.e. down-manning process);
- f) travel distances to safe havens (e.g. SBV, flight to shore or another installation);
- g) environmental conditions (e.g. weather, ice, waves, temperature) both prevailing and forecast, during the evacuation and rescue period;
- h) human factors, including personnel training and effect of emergency stress on performance;
- i) ability to transport evacuees beyond the maximum potential hazard zone (i.e. the distance to the edge of the fatality zone as determined by the QRA consequence analysis).

In conducting the risk analysis for a precautionary evacuation, it is important to consider the environmental conditions under which the evacuation would be carried out.

B.1.3.2.2 Emergency evacuation

When there is an imminent danger to the installation personnel, an emergency evacuation will be conducted.

The risk analyses necessary to demonstrate the appropriate selection of emergency evacuation methods are likely to include, but are not limited to, consideration of the following criteria:

- preparations to evacuate while inside the TR, including assessment of personnel condition, incident scenario, prevailing and forecast environmental conditions including the ice cover (which can limit/exclude use of evacuation craft) and proximity and availability of a rescue platform and/or safe haven;
- POB counting and search for personnel on the installation;
- facilities on a PSV for picking up evacuation craft/lifeboats/rafts from the sea (also to be addressed during the rescue);
- possible site-specific weather, sea state, ice and icing conditions (operability of evacuation means in cold climate and ice-infested areas);
- awareness of possible changing hazard zone (such as the spread of a toxic gas cloud) during the evacuation;
- physical means of protection of the installation evacuation route from the TR to the primary means of evacuation and other available evacuation system(s);
- suitability of evacuation method and its conformance with performance-based standards (functionality, availability, reliability, survivability and interdependencies with other systems);
- embarkation times and sequencing relative to the location of personnel and the provision of assistance to, and evacuation of, injured personnel;
- distribution of personnel, their behaviour in the range of scenarios relative to the capacity of available systems;
- human factors under stress including consideration of level of emergency training;
- stretcher access, casualties, access to medical support after leaving the TR both during evacuation and for transfer to a rescue platform safe haven;
- effects of motion sickness on performance;
- capability of evacuation method in prevailing low temperatures and ice and sea-state conditions;
- evacuation craft transit visibility (air, sea), collision risks at night, etc.;
- launch and movement beyond the hazard zone.

Inputs for the evacuation model include the specification of each evacuation mode and its probability (%) of utilization in any given scenario. Because a detailed availability analysis is conducted, the number of evacuation means installed, the number of units needed to evacuate all POB and one unit's availability, expressed as a percentage of installation service time, are required inputs. [Table B.3](#) shows an example of evacuation inputs. For simplicity, 'N' different evacuation modes for the full range of open water and ice conditions are provided. Whereas two evacuation modes are shown for brevity here; a full range of primary, secondary and tertiary evacuation modes would normally be used.

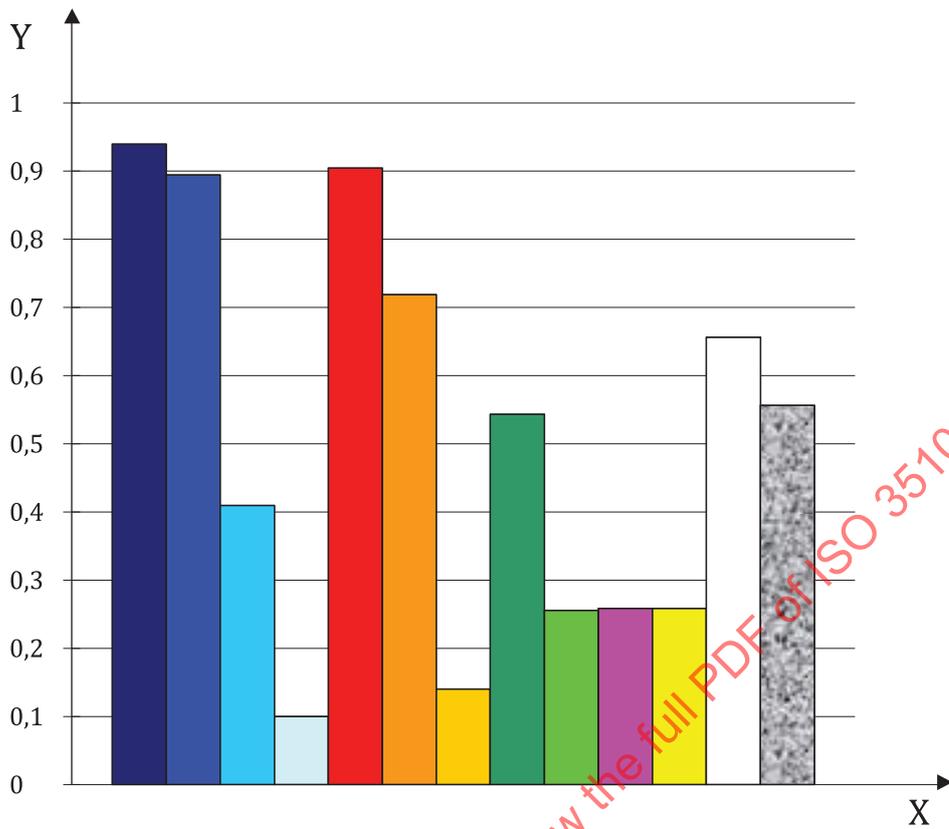
Table B.3 — Evacuation inputs

N	Evacuation mode	# Units installed	# Units re-quired	Avail-ability per unit -%	Off-set class	% of time used for each environmental condition											
						Open water - C	Open water - M	Open water - S	Open water - E	Ice <5/1 - C	Ice <5/10 - M	Ice <5/10 - S	Ice <8/10 - C	Ice <8/10 - M	Ice <9/10 - C	SS unde-formed - C	SS de-form-ed - C
1	Mode 1																
2	Mode 2																
N	Mode N																

In the evacuation analysis, a clear distinction should be made between mechanical failures and human performance failures to facilitate evacuation system evaluation and improvement. Mechanical failure is used in the broad sense to include all non-human performance, including machinery, structures, electronics, electrical circuits, communication systems and other non-human systems failures.

Next, the evacuation analysis is carried out. The final results are again presented in histogram form. Histograms give the combined success rate resulting from human and mechanical performance contributions (see [Figure B.6](#)). For a study of uncertainties, the base inputs are entered as distributions, and the results are probability densities and time distributions. The success rate in an emergency evacuation, meaning no fatalities or serious injuries, for severe and extreme sea-state conditions is very low; the resultant weighted average is on the order of 55 %. Anecdotal data on installation emergency evacuations suggest a relatively low success rate can be expected, particularly for severe or extreme conditions such as those associated with the Ocean Ranger and Piper Alpha disasters (see References [\[42\]](#) and [\[43\]](#)).

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- Key**
- X route
 - Y success rate
 - open water — severe
 - open water — extreme
 - ice ≤5/10 — calm
 - ice ≤5/10 — moderate
 - ice ≤5/10 — severe
 - ice 5/10–8/10 — calm
 - ice 5/10–8/10 — moderate
 - ice 8/10 < 9/10 — calm
 - solid sheet undeformed — calm
 - solid sheet deformed — calm
 - weather weighted average

Figure B.6 — Evacuation analysis results

B.1.4 Risk analysis for rescue

The rescue process commences when the evacuees have moved beyond the installation hazard zone. Rescue includes the survival and recovery of personnel directly from the sea and/or the ice surface, retrieval/transfer of survival system with persons on board either from the water (raft/lifeboat/evacuation craft), directly from the ice onto a vessel (e.g. SBV, PSV, SIMV, MOB), boat or installation/platform. Rescue operations are considered complete when evacuees have reached a designated safe haven.

The risk analyses to evaluate the reliability and performance of available rescue and recovery methods should include the following criteria:

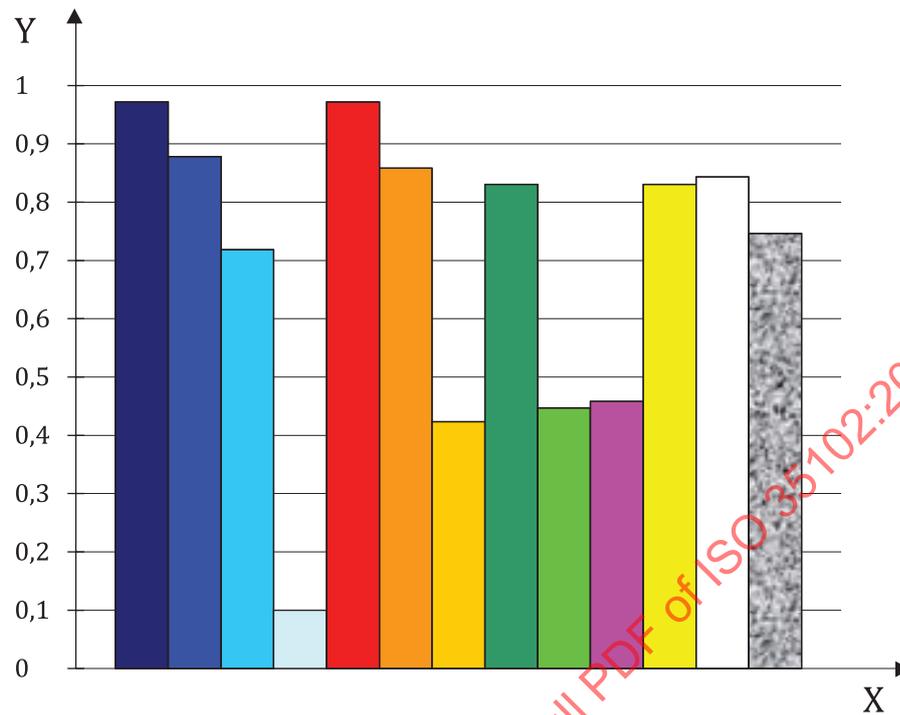
- a) environmental (e.g. weather, sea state, icing and ice conditions) limitations on performance of rescue and recovery craft/equipment and associated recovery aids (air and surface);
- b) abilities including levels of training of evacuees and rescue installation personnel;
- c) effect of emergency stress on physical and psychological performance;
- d) capacity and suitability of rescue platform (i.e. the ability to operate inside an incident hazard zone);
- e) time from evacuation outside hazard zone to completion of rescue;
- f) rescue system search times with associated limitations due to low visibility and weather conditions and impact of dynamic ice cover;
- g) reliability of communications links between evacuees and the rescue platform or search system, including the accuracy of locator methods;
- h) levels of medical support (triage facilities) on rescue platform;
- i) facilities for stretcher recovery to the rescue platform (e.g. personnel basket transfer from installation to SBV/PSV or pick up by helicopter);
- j) risk to rescue platform crews under prevailing ice and weather conditions (interdependencies with other systems);
- k) mortality/survivability curves versus PPE/rescue times for specific evacuation systems.

The rescue process is generally subdivided into the survival and the retrieval components. Human and mechanical performances are integrated here, although new data to assess these are expected. The survival and transfer success probabilities are then used in the intermodal event tree for the designated evacuation and rescue modes to evaluate rescue success probability. [Table B.4](#) shows an example rescue and integrated EER event tree for severe open-water weather, this time for three evacuation modes and five rescue modes, but based on the assumption that escape and evacuation are 100 % successful. [Figure B.7](#) is provided to illustrate success rates (considering all the evacuation modes used) for all applicable rescue modes under 12 environmental conditions and their weather-weighted success rate.

Table B.4 — Evacuation event tree calculation format

Escape	Evacuation			EE time success factor	Survival time [h]	Evacuation rescue — Severe weather					Relative success rate	
	Success rate	Mode	% of time			Success rate	Rescue mode	Time to availability [h]	Survival time factor	% of time		Success rate
	1	Heli										
	2	TEMPSC (Twin Davit)				1	SAR helicopter					
						2	SBV or SIMV					
						3	Passing vessel or SIMV					
						4	Land					
						N	Other					

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Key

X route
Y success rate

- open water — severe
- open water — extreme
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- ice ≤5/10 — moderate
- ice ≤5/10 — severe
- ice 5/10–8/10 — calm
- ice 5/10–8/10 — moderate
- ice 8/10 < 9/10 — calm
- solid sheet undeformed — calm
- solid sheet deformed — calm
- weather weighted average

Figure B.7 — Rescue success rate chart

B.1.5 Integrated risk analysis

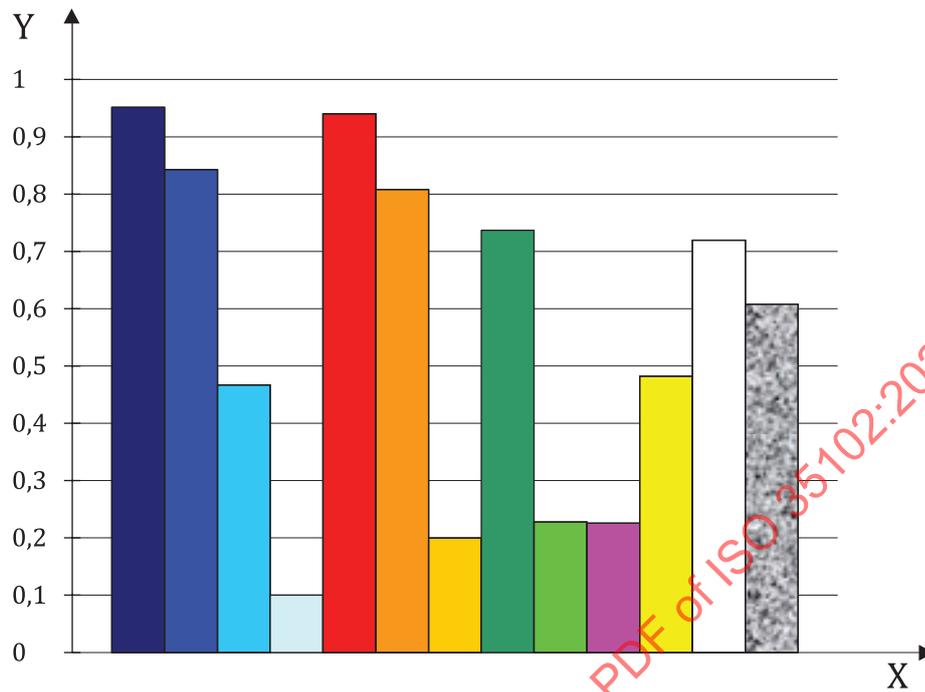
The integrated EER results give the total performance of the EER system including both human and mechanical performance in each of the environmental condition, for all three main components of the

EER. It is important to distinguish between the relatively low-stress drill or precautionary EER and the emergency EER situation.

[Figure B.8](#) shows an example of the integrated EER success rate histogram for the drill or precautionary EER in 12 environmental conditions, together with their weather-weighted average for the location under consideration. The success rate as indicated earlier, is the probability that there will be no fatalities or serious injuries. The weather-weighted average is a function of a specific geographic location as it depends on the relative proportion of each weather class. As the individual weather class results are independent of geographic location, one would expect that for the drill situation only the open water calm or ice <5/10 ice calm condition would apply as the OIM would likely not endanger the drill participants with more difficult sea or ice conditions unless the means of evacuation can accommodate the more challenging ice environment. Thus, the weather-weighted average for the drill would have an approximately 95 % success rate.

However, precautionary evacuation would likely not be carried out in less desirable conditions. Rather, if staying on board was considered too hazardous, the OIM would order an emergency evacuation. Thus, the precautionary evacuation weather-weighted average for conditions which the OIM considers acceptable would likely be somewhat lower than the drill value, depending on the conditions chosen for the precautionary evacuation, with a value between 60 % and 95 %. Note that the difference between the values in [Figure B.8](#) and [Figure B.9](#) are attributable mainly to the effect of emergency stress on personnel performance.

The example success rate for the combined EER components in an emergency EER as shown in [Figure B.9](#) is quite low with a weather-weighted average of approximately 40 %. The figure shows that there is almost no chance of success in extreme (hurricane) conditions (10 %), and much higher (>75 %) success rate in calm conditions. Unfortunately, often in an emergency there is no choice but to evacuate under the prevailing environmental conditions, although some control over choice of conditions in which to evacuate can be exercised with either timely precautionary evacuation or extension of residence time in the TR when feasible. In addition, this will also enable and support the emergency management to decide on the type of evacuation to be carried out. Additionally, if environmental conditions are forecast to exceed the design criteria of the EER system, high risk operations can be suspended to minimize the risk that EER will need to be carried out.



Key

X route

Y success rate

- open water — severe
- open water — extreme
- ice $\leq 5/10$ — calm
- ice $\leq 5/10$ — moderate
- ice $\leq 5/10$ — severe
- ice 5/10-8/10 — calm
- ice 5/10-8/10 — moderate
- ice 8/10 > 9/10 — calm
- solid sheet undeformed — calm
- solid sheet deformed — calm
- weather weighted average

Figure B.8 — Integrated drill or precautionary EER success rate