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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

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Foreword

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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).

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For an explanation on 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 the following URL: 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*.

Introduction

Workers in the petroleum and natural gas industries face a number of stressors from the physical and psychosocial environment when working in the Arctic. These include prolonged periods of darkness (polar winter) and light (polar summer), remoteness, noise and vibration, low humidity and cold climate. The combination of different working environment factors can affect people's health and safety. Cold-climate locations, low temperatures and wind can directly affect both equipment (e.g. operability, reliability and integrity) and people (e.g. frostbite, hypothermia and performance decrement). In turn, affected equipment can affect the health and safety of personnel, and poor personnel performance can likewise have a detrimental effect on equipment. It is important to consider and assess all these relationships in order to have confidence in production and health, safety and environmental (HSE) risks at facilities in cold climates. This is illustrated in Figure 1. Based on the outcome of the assessment, approaches for cold-climate risk management should address all aspects of winterization, from prevention through facility design and specification through to working procedures. In addition to this, personal protective equipment (including clothing) may be necessary.

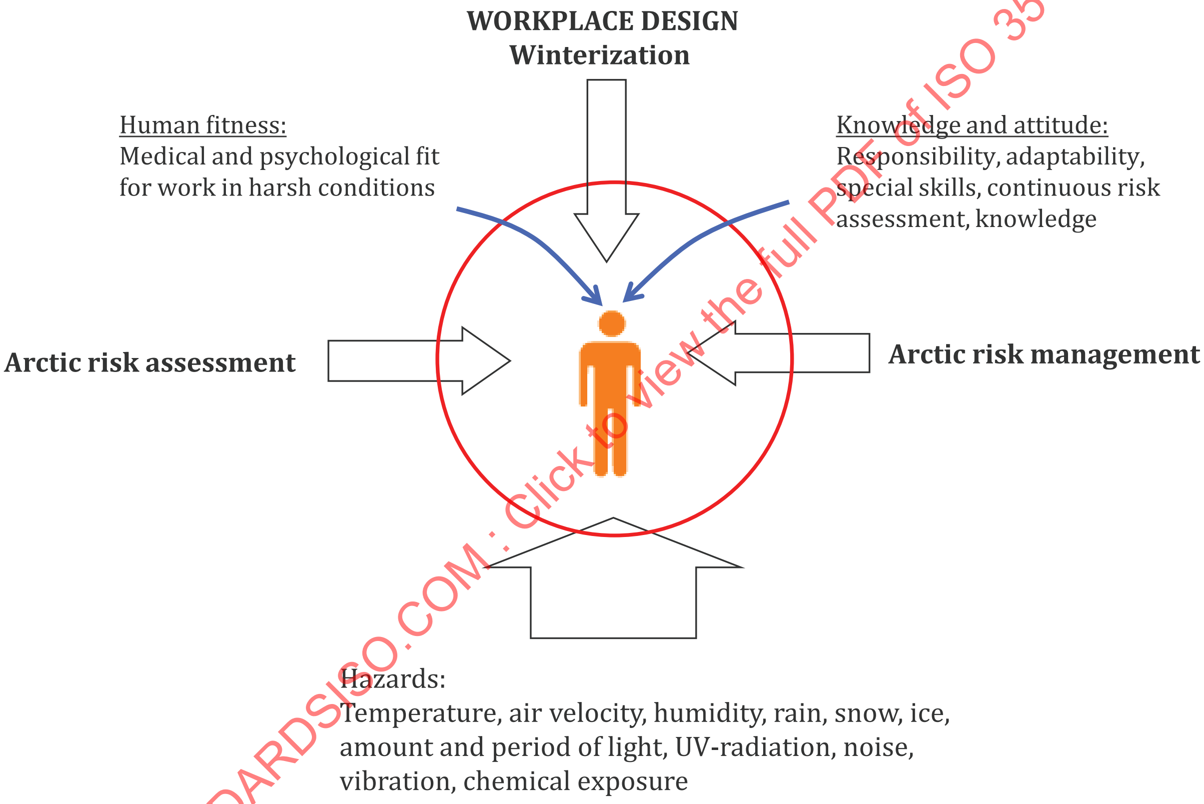


Figure 1 — Hazards and preventive measures to protect people in Arctic environment

Petroleum and natural gas industries — Arctic operations — Working environment

1 Scope

This document describes the working environment that can be expected when operating oil and gas facilities in Arctic environments/climate. This document provides principles and generic guidelines for the design and operation of fixed and floating oil and gas facilities both onshore and offshore.

The aim of this document is to ensure optimal health, safety, human performance and decision-making conditions for people working on oil and gas facilities in Arctic conditions.

This document applies to the design and operation of new facilities and structures, and to modification of existing facilities for operation in the Arctic environment. This also includes offshore and onshore exploration and accommodation units for such activities.

This document is divided into three main parts.

— The first part (Clause 5) describes the general principles and guidelines for risk management.

— The second part (Clause 6) describes the general working environment (working environment hazards found in many workplaces and provides some threshold limit values (TLVs) and design references that can be especially challenging in Arctic conditions.

— The third part (Clause 7 to Clause 9) addresses the climatic conditions expected in the Arctic. Clause 8 describes working environment design and technical solutions, while Clause 9 describes working environment operational requirements for prevention and management of cold-related problems.

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 Guide 73, *Risk management — Vocabulary*

ISO 5349-1, *Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration — Part 1: General requirements*

ISO 5349-2, *Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration — Part 2: Practical guidance for measurement at the workplace*

ISO 11064-6, *Ergonomic design of control centres — Part 6: Environmental requirements for control centres*

ISO 11079:2007, *Ergonomics of the thermal environment — Determination and interpretation of cold stress when using required clothing insulation (IREQ) and local cooling effects*

ISO 19901-1, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 1: Metocean design and operating considerations*

ISO 19906:2010, *Petroleum and natural gas industries — Arctic offshore structures*

ISO 31000, *Risk management — Principles and guidelines*

IMO MSC/Circ. 982, Guidelines on ergonomic criteria for bridge equipment and layout

EN 12464-1, *Light and lighting — Lighting of work places — Part 1: Indoor work places*

EN 12464-2, *Light and lighting — Lighting of work places — Part 2: Outdoor work places*

EN 12665, *Light and lighting — Basic terms and criteria for specifying lighting requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO Guide 73 and the following apply

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

— ISO Online browsing platform: available at http://www.iso.org/obp

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

3.1
anti-icing
measures to prevent ice from forming on surfaces, *structures* (3.15) or equipment

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

3.2
Arctic
area characterized by low ambient temperatures and the presence or possibility of sea ice, icebergs, icing conditions, persistent snow cover, and/or permafrost

Note 1 to entry: Area does not only include the Arctic, but also other areas that meet this characterization.

3.3
comfort
state of physical ease and freedom from pain or constraint

3.4
company
owner, operator, or license or duty holder of the authorized work

3.5
cold-climate conditions
potential presence of combinations of low air temperatures, low seawater temperatures, wind, snow, ice, freezing fog, etc.

3.6
de-icing
measures to remove snow and ice accumulations from surfaces, *structures* (3.15) or equipment

Note 1 to entry: The intent of de-icing is to make the surfaces, structures or equipment functionally available within a reasonable period of time.

3.7
facility
plant, rig, or *platform* (3.12), fixed or floating, stationary or mobile, on- or offshore, for use in oil and gas exploration, production or support.

3.8
functional requirement
requirement that provides the fundamental rationale behind a particular rule and which needs to be satisfied

3.9
hazard
source of potential harm

Note 1 to entry: Hazard can be a risk source.

3.10
heat tracing
method used to raise or maintain the temperature of pipes and surfaces

Note 1 to entry: Heat tracing is based on the principle that objects of unequal temperatures in a thermal system tend toward thermal equilibrium. Heat tracing cables consist of a heating element (a resistor) in either series or parallel configuration which produces heat when voltage is applied to it.

3.11
open work area
work area (3.18) with no substantial obstacles to the open air and completely exposed to ambient conditions

3.12
platform
complete assembly of structural and non-structural systems for the purpose of development and production of petroleum and natural gas fields

Note 1 to entry: The platform includes *structure* (3.15) and non-structural systems such as topsides equipment, piping and accommodation.

Note 2 to entry: The platform does not include soils.

3.13
safety system
system, including required utilities, which is intended to prevent, detect/warn of an accidental event/abnormal conditions, and/or to mitigate its effects

3.14
semi-open work area
work area (3.18) that is weather-protected (e.g. with weather louvers) and partially exposed to the open air

3.15
structure
organized combination of connected components and subsystems designed to withstand actions and provide adequate rigidity and stability

EXAMPLE 1 Examples of components include columns, beams, stiffened plates, tubular members and joints, mooring lines and tendons, foundation anchors and piles, but not the soil.

EXAMPLE 2 Examples of subsystems include structural integrity management (SIM) systems, stationkeeping thrusters and their control and power systems.

3.16
vendor
one who sells and/or delivers equipment and/or engineering services

3.17
weather protection
measures taken to prepare *work areas* (3.18) on the *facility* (3.7) for harsh weather (rain, sea-spray, wind, cold, snow)

EXAMPLE Wind walls, roof, partial or total enclosure.

3.18
work area
area of the *facility* (3.7) where personnel normally stay or move in connection with work, excluding void hull areas

3.19
workplace
space within a *work area* (3.18) allocated to one or more persons to complete work tasks related to operations, production, inspection or maintenance

3.20
work system
combination of people and work equipment, acting together in the work process, at the workplace, in the work environment, and under the conditions imposed by the work task

3.21
working environment
totality of all physical, chemical, biological and psychological factors at work that can affect the employees' health and well-being

3.22
winterization
measures taken in the design and preparation of a *facility* (3.7) for 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

ACGIH	American Conference of Governmental Industrial Hygienists
ALARP	as low as reasonably practicable
CFD	computational fluid dynamic
EER	escape, evacuation and rescue
FEED	front-end engineering design
HAV	hand-arm vibration
HSE	health, safety and environment
IREQ	required clothing insulation
JHA	job hazard analysis (equivalent to job safety analysis)
JTA	job task analysis
PPE	personal protective equipment
SAR	search and rescue
TLV	threshold limit value
WCT	wind chill temperature

5 Risk management

5.1 General

The working environment shall be managed so that the working environment risks are controlled. These risks shall be managed according to the principles in ISO 31000.

Risk assessment shall include risk identification, risk analysis and risk evaluation. Mitigating measures shall be applied to eliminate or reduce the identified risks.

5.2 Management of working environment risks in the design process

Figure 2 shows the typical project phases in a design process that are also applicable to managing of working environment risks.

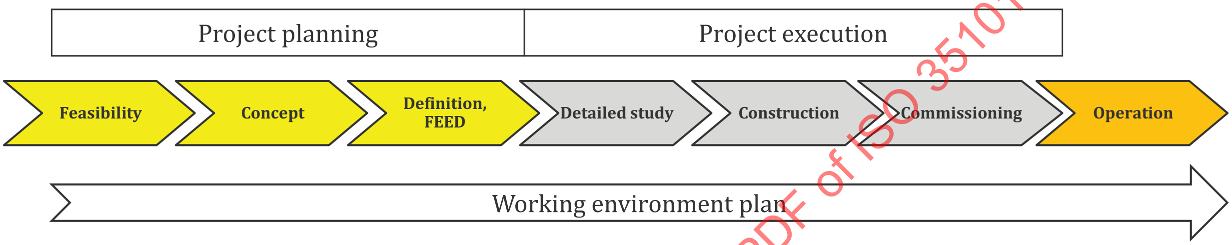


Figure 2 — Typical project phases in a design process

The operating circumstances (geographical site, environment, type of facility, manning, operating philosophy, etc.) shall be established in the concept and be updated throughout the design process.

A list of generic working environment hazards and risks connected is presented in Clause 6. The list is not complete and should be used only as a guide for risk identification.

All working environment risks shall be identified and assessed and form the basis for prioritized risk reducing actions. This process shall start in the concept phase and give input to the design basis. The process shall be updated throughout the planning and execution.

It is recommended to use a workshop method with participants from line management, technical disciplines, HSE experts and with employee involvement.

Relevant elements for risk management of the working environment include:

a) the geographical position, climate, type of facility;

b) existing information (literature, experience transfer from similar projects);

c) the manning level, operational conditions, operation and maintenance strategies;

d) personnel competence, health, etc.;

e) calculation of local wind chill, snow and ice conditions.

5.3 Mitigating measures — Risk reduction principles

5.3.1 Hierarchy of controls

The risk treatment shall describe solutions to eliminate, reduce and control the working environment risks. The method to control the risk should be considered in the order presented in Figure 3.

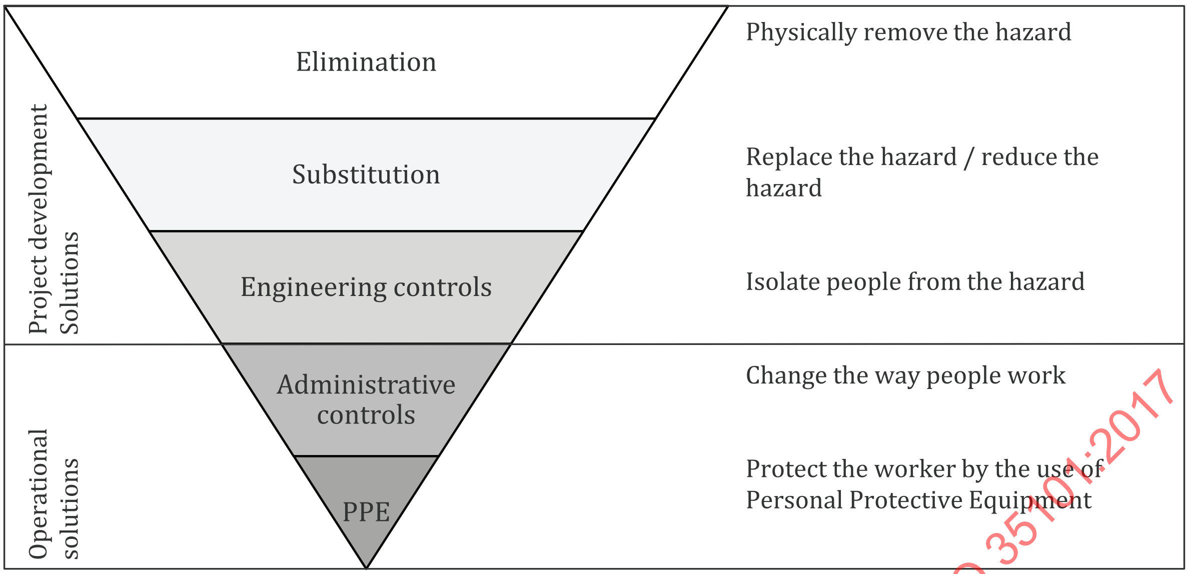


Figure 3 — Hierarchy of controls to mitigate working environment risks

5.3.2 ALARP

The working environment risk shall be kept as low as reasonably practicable (ALARP). For a risk to be ALARP, it shall be possible to demonstrate that the cost involved in reducing the risk further would be grossly disproportionate to the benefit gained.

5.4 Special assessment in Arctic environment

5.4.1 Input to design specification

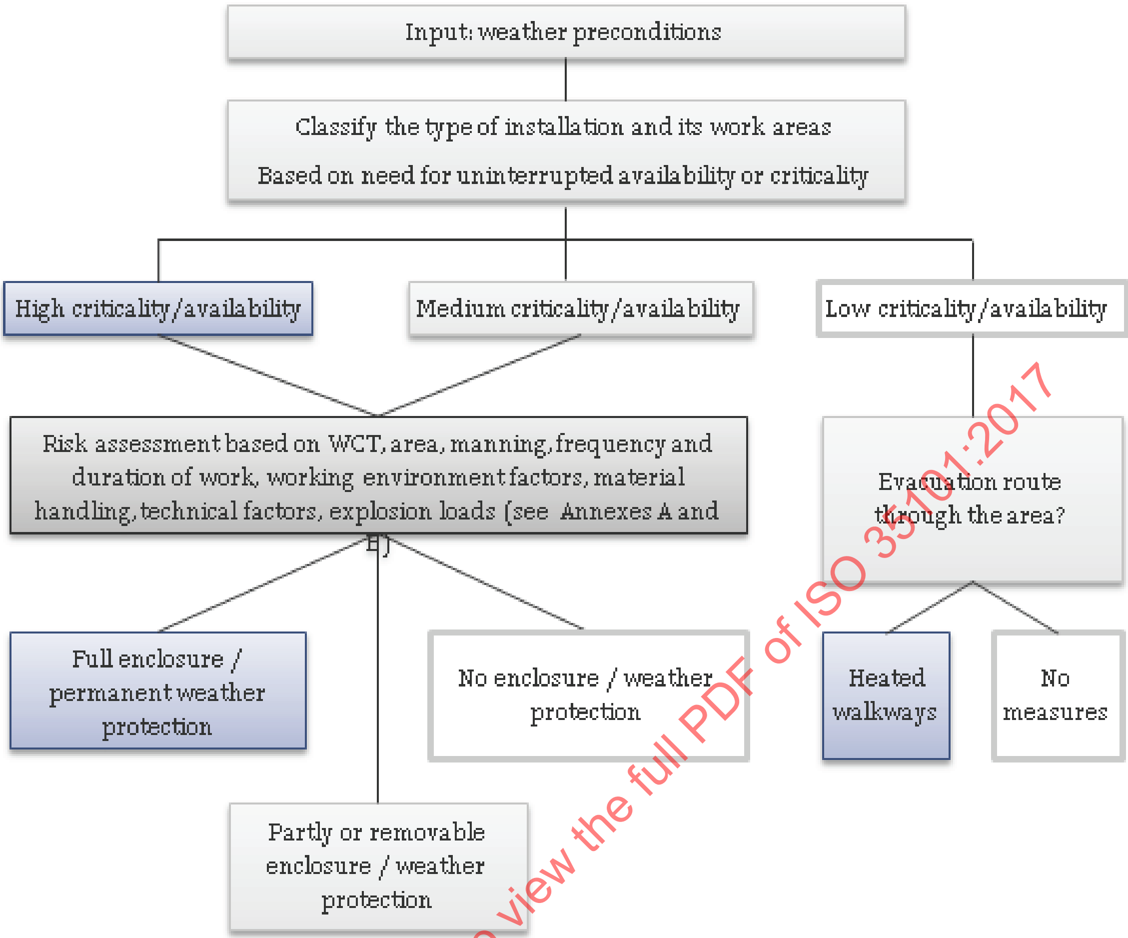
The process to secure a safe and healthy workplace in the Arctic starts by assessing the concept, the area of operation, the climate preconditions and the operation philosophy.

Figure 4 illustrates the assessments, possible solutions and the importance of making quality assessments to decide the right type of risk reducing measure in the design, especially the need for weather protection.

Design solutions and operational measures in combination give the protection level. The level of design solution should be according to risk assessment and ALARP analysis. See Clauses 5 and 8.

Operational solutions: Operations/work task performed in outdoor areas that are not adequately weather protected shall be risk assessed and treated as described in Clause 9.

NOTE Availability (i.e. high, medium, low) means how important it is that the outdoor area can be entered and used as a workplace independent of the weather conditions.



Design solutions and operational measures in combination give the protection level. The level of design solution should be according to risk assessment and ALARP analysis. See Clauses 5 and 8.

Operational solutions: Operations / work task performed in outdoor areas that are not adequately weather protected shall be risk assessed and treated as described in Clause 9.

Figure 4 — Flowchart illustrating the steps to analyse and prioritize the need for weather protection in the design process

This document addresses these issues in more details by describing:

a) the general work environment hazards in Clause 6;

b) the assessment of need for weather protection and other design requirements in Clause 8 and Annex B;

c) the risk assessment of operation, operational restrictions, clothing, guidelines for work and health requirements in Clause 9;

d) the education, training and supervision needs in Clause 10.

The operational consequences of cold risks due to unsolved design solutions shall be analysed. Clause 9 provides detailed methods and Annex A gives additional information about working environment studies and deliverables in project development.

5.4.2 Risk assessments in operation — Operational solutions

Design solutions, such as winterization, heating, enclosures and weather panels, have limitations due to risk of gas build-up, explosion, weight, space available and energy consumption.

The purpose of these assessments is to identify the risks that are not solved in design and thus shall be mitigated by means of operational restrictions or recommendations. For more detailed analyses, see ISO 11079, ISO 12894, ISO 13732-3, ISO 15743. See also Clause 9.

6 Management of working environment hazards in Arctic operations

6.1 General

This clause describes the generic working environment hazards found in many workplaces, and provides threshold limit values (TLV) and design references for those that can be especially challenging in Arctic conditions. Figure 5 gives an overview of the generic working environment hazards/factors that affect health and safety at work. As shown in Figure 5, the thermal factors play an important role, not only related to thermal comfort but also by interacting with other factors important to the total working environment and human performance.

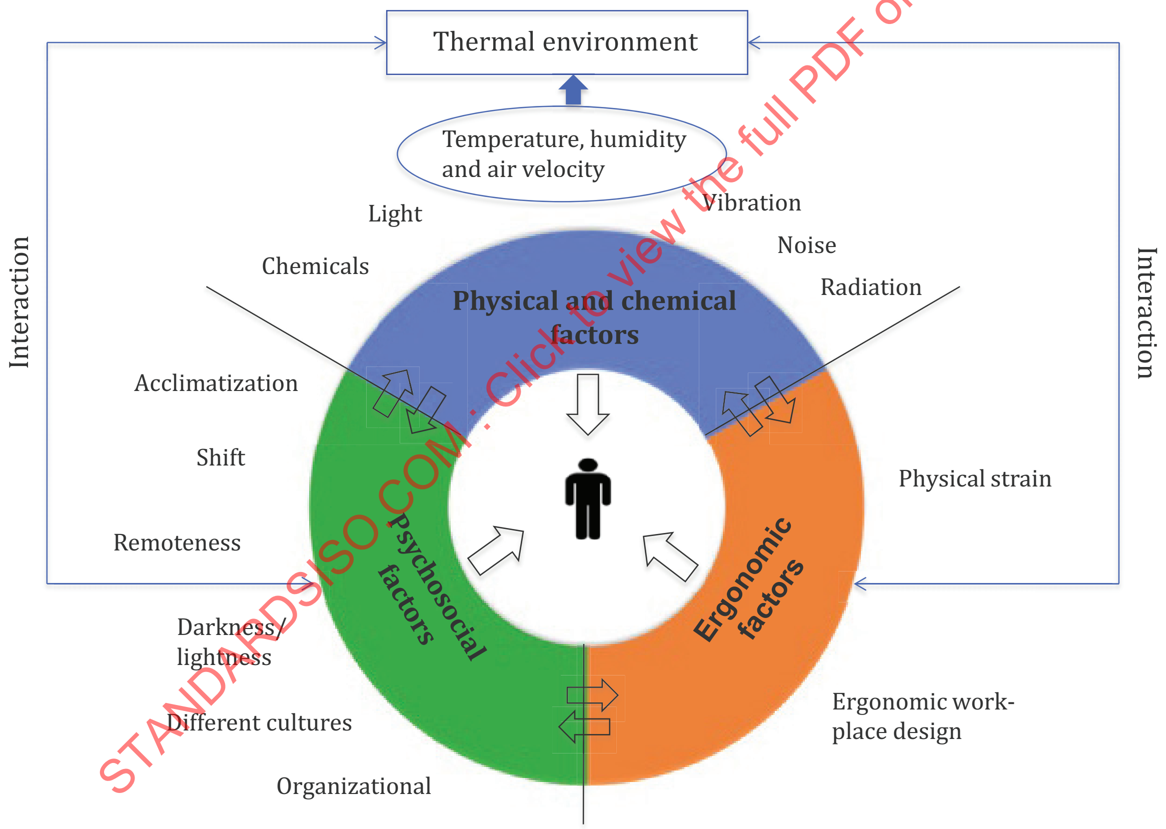


Figure 5 — Summary of factors of the industrial environment and their interaction with each other

6.2 Information on climate conditions

Climate conditions are described in detail in Clauses 7 to 9.

Clause 8 describes the working environment, technical and design solutions (including metocean data, winterization, de-icing, falling ice, accommodation, etc.) while Clause 9 describes operational requirements for prevention and management of cold-related problems (health and fitness, slips and falls, clothing and PPE, cold risk assessment and management, etc.).

General guidelines on metocean information are given in ISO 19900 and specific requirements in ISO 19901-1. The wind chill temperature (WCT) index is presented in Table 1 (see 9.5.3).

6.3 Illumination

During the Arctic winter season, daylight hours decrease with increasing latitude, and in addition, visibility can be reduced during bad weather conditions. Selecting appropriate design solutions are crucial to secure good operating conditions in this environment.

Provision shall be made to ensure ambient lighting of the outdoor working areas. Special attention should be given to area lighting for tasks that are normally performed during daytime and also on winter days with a combination of darkness, cold and bad weather.

During engineering, the quality of illumination should be analysed for both internal and external working and living spaces. The illumination should be analysed for various weather conditions and should take into account the unique seasonal illumination requirements during the prolonged periods of darkness (polar winter) and light (polar summer), as well as the effects of low-angle sunlight, visibility and contrast.

Work area light intensity shall be adequate for the general purpose of the location and type of activity in accordance with EN 12665.

To ensure that a specific lighting level, expressed as maintained luminance, is reached for a reasonable period of time, an appropriate maintenance factor should be applied.

For dedicated workplaces that require at least daily access or are critical from a safety point of view, EN 12464-1 and EN 12464-2 shall be applied in the specification of indoor and outdoor workplace lighting, respectively.

The illumination shall be analysed especially in the control room, control cabins and other rooms where sight-intensive work takes place, where display screen equipment is used on a regular basis and where the work requires good visibility during various weather conditions. Reflection and flickering of lights shall be eliminated. Lighting for control rooms shall be in accordance with ISO 11064-6. For the illumination on the bridge of mobile units, IMO MSC/Circ. 982 shall be applied.

Different levels of illuminance require different light colours, if the lighting is to be comfortable. Warm colours should be used in cabins and recreation areas where the lighting levels are below 500 lx. High colour temperature, whiter light, should be used in areas with high lighting levels.

6.4 Visibility

6.4.1 General

Visibility is especially challenging on onshore plants, where distances make it more difficult to orientate during poor visibility conditions (e.g. fog, snow, white-out, 24 h without daylight). On these plants, a system to detect people and guide them in their orientation shall be established.

The following solutions are suggested:

a) use of additional systems to locate people, identify locations, help people to orientate themselves in the surroundings (e.g. GPS tracker);

b) means of detection;

c) supervisor’s awareness of where people are;

d) infrared cameras to detect people and wildlife;

e) means of identification and orientation during daylight, bright sunshine;

f) sources of illumination to orientate;

g) buddy system;

h) communication systems.

6.4.2 Preventing glare

Provision shall be made to avoid direct glare from sunshine, from artificial light sources and from reflecting surfaces. Special consideration shall be given to the prolonged periods when the sun is low on the horizon and the resulting problems caused by both direct glare and glare reflected from structures, sea or ice surfaces.

The following solutions are suggested:

a) sun-shields;

b) low-reflecting surfaces;

c) sun glasses, goggles with polarizing filters.

6.5 Physiological and psychosocial effects (human performance)

For some individuals, working in remote Artic environments can cause adverse effects on human performance (psychological, sociological and physiological).

Psychological effects can lead to, for example:

— disorientation;

— impaired vision;

— impaired mental function, reduced memory;

— decreased alertness/situation awareness.

Sociological effects can lead to, for example:

— disengagement;

— perceived safety;

— social isolation.

Physiological effects can lead to, for example:

— impaired performance, especially manual performance, due to cooling;

— impaired tactile sensitivity due to cooling;

— increased physical strain due to decreased performance and use of heavy garments;

— need for longer recovery.

As input to the living quarter design, a study of psychosocial, sociological and physiological challenges and design preconditions shall be carried out.

6.6 Noise and vibration

6.6.1 General

During concept definition and optimization/front-end engineering design (FEED), the major sources of noise and vibration shall be identified.

On facilities that are planned for use in areas with Arctic climate, noise and vibration caused by external Arctic environmental conditions and by ice-breaking and active/passive ice management activities, shall be considered in the concept definition and optimization/FEED.

6.6.2 Noise

The maximum noise levels, expressed as total dB(A), in the different areas of the facility, shall be defined based on national regulations.

NOTE NORSOK S-002 provides an informative list of area maximum noise levels.

During engineering, the activity shall ensure that significant noise sources are identified and their influences evaluated. This also applies to external noise sources such as ice.

All work in noise-affected areas should be planned taking into account the noise exposure and the type of hearing protection used.

All use of PPE should take into account reduced protection effects due to the challenging combination of cold weather protection and ear protection.

6.6.3 Vibration

ISO 2631-2 and ISO 6954 for leisure, manned and unmanned areas, and EN 14253 for seated and standing operators can be used as guidelines for measuring, reporting and evaluating whole-body vibration.

6.6.4 Hand–arm vibration

Exposure to hand-arm vibration (HAV), particularly from hand-held tools, is a risk factor related to peripheral vascular disease and Raynaud's disease (white finger). Cold environment is a known cofactor increasing the risk for developing the disease. Exposure is particularly relevant during maintenance periods. Even if most maintenance is performed in the summer, the Arctic summer climate conditions are still defined as a cold working environment.

HAV tools shall meet the requirements stated in ISO 5349-1 and ISO 5349-2.

During the engineering phase, significant vibration sources shall be identified and their influences evaluated.

Use of HAV tools should be kept to a minimum when working in a cold climate.

Substitution of methods and tools shall be considered (e.g. robotics), and low-vibration equipment should be used. Working requirements should be established for vibration tools used in the cold. Workers shall be monitored routinely for signs of disease related to HAV.

6.7 Hazardous chemicals

There shall be a chemical management system in place. See OHSAS 18001 or ISO 14001, TLVs and references made to ACGIH TLVs and biological exposure indices (BEIs).

Arctic facilities may have more enclosed, semi-enclosed or sheltered working areas than other facilities, in order to protect workers from the cold. The possible effects of consequent reduced ventilation on increased vapour, particle or gas exposure and chemical health risks shall be assessed.

During project development, a chemical health risk assessment shall be performed to identify, evaluate and control such risks to an acceptable level. The analysis shall consider the operational need for using substitute chemicals suited to Arctic environmental conditions, and the potential health risks to humans of using these substitute chemicals.

To reduce exposure risk, appropriate ventilation is needed in enclosed/sheltered working areas. Sampling in enclosed systems is the preferred solution.

Carbon monoxide poisoning from exhaust can be an additional risk factor in cold environment.

6.8 UV radiation

Arctic regions can experience increased solar UV-B radiation associated with stratospheric ozone depletion. Workers should be provided with appropriate sunglasses and sunscreen to protect eyes and skin during daytime when exposed to sunlight.

Guidelines for UV protection can be found in ACGIH TLVs and BEIs.

6.9 Wildlife

Facilities and living quarters should be designed to prevent interaction with wildlife.

There should be an adequate system of management and training of workers to prevent interaction with wildlife. The ultimate consequence, such as attack, shall be avoided. Training and supervision should include knowledge on how to avoid contact with wild animals and if it occurs, how to behave in order to prevent an attack.

7 Environmental and cold climate preconditions

7.1 General

The company (employer) is responsible for selecting appropriate physical environmental design parameters and operating conditions. Physical environmental parameters shall be determined in accordance with ISO 19901-1 and ISO 19906. General guidelines on metocean information are given in ISO 19900.

The company should take regulatory requirements into account, where they exist. These requirements can include a minimum duration of site-specific data (according to country regulations), the type of data and a definition of extreme design parameters.

The company shall conduct a realistic assessment of the physical environmental parameters affecting the proposed structure or operation. This assessment shall be used in preparing the facility's design and operation with respect to working environment.

Fundamental to the risk management strategy is the philosophy of assessing the expected environmental conditions at the specific geographic location where a facility will be placed or an operation will be conducted. This approach has the advantage of tailoring risk management efforts.

Defining generalized environmental climate zones, however, can be an efficient means of promoting certain risk-management efforts, such as for the design and provision of cold-weather clothing.

7.2 Metocean data

The following types of meteorological, oceanographic and ice data shall be used as basis for winterization design (see also ISO 19906):

a) wind speed:

— annual mean;

— seasonal variation for one year (5-year history);

— maximal and minimum values;

— predominant wind direction;

— number of days exceeding 90 % of maximum speed;

b) temperature:

— annual mean;

— minimum value;

— mean daily lowest temperature (MDLT);

— maximum value;

— seasonal variation for one year (three coldest months; 5-year history);

c) humidity;

d) ice;

e) Arctic night/day: daylight hours in summer/winter.

NOTE Details are given in ISO 35106.

The data should be based on at least 5-year history and new calculations shall be made, if the data are more than 2 years old.

7.3 Assessment of the need for permanent weather protection

The need for permanent weather protection shall be evaluated for all outdoor workplaces. Assessments of the temperature, wind and precipitation parameters affecting the working environment and safety shall be performed. These assessments shall be used to optimize the facility's design and operation with regard to working environment and safety issues. The analyses shall first be performed as input to concept selection and shall be updated, if design/layout changes affect workers' exposure to cold stress. The analysis shall always include assessment of work frequency, duration, criticality, snow and falling ice, precipitation and other relevant issues, including explosion risk.

The method itself consists of three sequential steps, including an initial planning stage.

a) Step 1: Analyse the outdoor activities.

b) Step 2: Quantify factors and risk score.

c) Step 3: Prioritize and decide.

It is recommended that the steps be performed in a workshop setting. A detailed description of the suggested methodology is presented in Annex B.

7.4 Area wind chill temperature (WCT) — CFD simulations

WCT calculations shall be used as input to risk assessment (Step 2).

The formulae and methods described in ISO 11079 shall be used to calculate the WCT and used as input to risk assessment of outdoor operations.

Based on historical wind and temperature data, the geographical (local) WCT shall be calculated at 10 m above sea level or actual ground level. The local wind velocity shall be inputted to computational fluid dynamic (CFD) simulations. CFD shall be calculated based on the facility geometry at 1,5 m above deck level.

The operational consequences of cold risks not solved by design solutions shall be analysed (see detailed methods in Clause 9 and the WCT index in Table 1).

8 Working environment design philosophy and technical solutions

8.1 General

Arctic environmental conditions have a strong influence on the working environment of operations and maintenance. To meet the working environment challenges of the Arctic environment, specific requirements shall be set for design, construction, operation and maintenance of systems, area and equipment that can influence the overall safety level.

The general design philosophy shall be that the working environment quality on facilities in the Arctic shall be maintained at least at the same level as for other facilities not exposed to Arctic environmental conditions. To meet the working environment challenges of the Arctic environment, specific requirements are set for system and equipment design, construction and operations that influence the overall safety level.

All systems, equipment and areas of a facility where the Arctic environment can impair safety, functionality or operability should be evaluated with respect to working environment. A systematic process for evaluation and selection of solutions is required to ensure the risk level is as low as reasonably practicable. The evaluation process should be risk-reduction driven.

Preference shall be given to selecting permanent technical solutions rather than temporary operational or procedural solutions. It is important to select solutions that increase safety and working environment quality without introducing adverse side effects.

The main objective is to provide adequate protection for personnel to ensure their health, safety, performance and decision-making under the expected Arctic environmental conditions.

The main principle in providing such protection is to enclose or shield working areas from the elements. Areas that are not fully or partially protected, and where snow and ice can accumulate, should be provided with anti-icing or de-icing arrangements, as appropriate.

On facilities that are planned for use in areas with Arctic climate, outdoor operations shall be identified and reduced to a minimum.

8.2 Design process and design requirements for Arctic conditions

To implement optimal risk reduction in design, it is important to have an overview of metocean data and risks as early as possible. The data/risk assessments shall be used to suggest design solutions to mitigate the risks. From a working environment view, the main focus is to reduce as much as possible the human work outside shielded areas in seasons when the wind chill requirements are exceeded. It is also important to construct in a way that makes it easy to carry out operations wearing the necessary clothing and PPE.

Therefore, the work tasks and work load shall be taken into account in the design of the facility. Inadequate design can cause operational limitations, e.g. work time limitations. It is important to carry out risk assessments in the correct and early phases of project development, in order to reduce the cost and increase the possibility of later design changes without incurring too much cost and effort.

Winterization is primarily focused on the adverse effects and control of snow, freezing sea spray and atmospheric icing on a facility, as well as material properties in cold temperature.

As suggested in DNV-OS-A201, the design shall, as a minimum, address the following:

a) identification of measures for addressing the technical provisions presented in this clause, including the specific anti-icing, anti-freezing and/or de-icing measures chosen for each applicable functional requirement;

b) the intended time-scale required/manpower available for any de-icing activities (e.g. of the helicopter deck) that require completion within a particular time period;

c) physical proximity necessary for any de-icing measures selected, taking into account the related operational safety issues (e.g. working at heights, working over water);

d) identification of any operational temperature limitations and restraints imposed on the industrial activities.

8.3 Enclosures for weather protection

Enclosures may be temporary or permanent, taking into account fire and explosion risks, as well as practicality of the facility. For potentially hazardous areas containing flammable and toxic substances, the potential risk caused by enclosures shall be counteracted by other risk-reduction measures.

Enclosure of manned areas with WCT below −24 °C (risk classes 0 and1) shall be provided based on operational needs for comfort of staff, provided that this has no significant adverse effect on safety risk.

Meteorological conditions such as level of precipitation (snow and rain) in the area shall be taken into consideration when deciding on the level of permanent and temporary enclosures.

Low sun, in combination with snow/ice, can cause problems with glare that should also be considered (see 6.4.2).

Utility modules and non-hazardous process utility areas may be fully enclosed, ventilated and heated as appropriate for equipment functionality and the working environment.

Special attention shall be given to enclosed areas when carrying out the fire and explosion risk assessment, to ensure that risk levels and design accidental loads are not exceeded.

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

Alternative wall designs for semi-open modules include

a) partly covered explosion-relief panels,

b) panels that can open and close remotely,

c) perforated explosion-relief panels, and

d) explosion relief louvers.

Temporary windshields for critical maintenance operations shall be used during severe climatic conditions.

Wall design shall ensure that icing does not reduce their explosion-relief characteristics. Systems shall be in place for easy facility and removal of temporary shelters.

8.4 Anti-icing, anti-freezing and de-icing

Work area surfaces and access ways subject to snow, ice or frost accretion shall be provided with anti-icing or de-icing arrangements as follows.

Anti-icing arrangements shall be provided for exposed:

— escape routes;

— escape exits, including doors;

— emergency muster locations;

— access ways to lifeboats, life rafts, rescue boats and their associated launching and embarkation systems;

— stairways and their railings, where stairways comprise part of an escape route;

— helicopter deck, for offshore facilities;

— helicopter deck for ships, if classified as a primary element of the vessel's escape, evacuation and rescue (EER) plan, or if the ship has primary EER or search and rescue (SAR) support duties for an offshore facility;

— decks, access ways and stairways that are exposed to snow, ice or frost accretion and required for frequent daily use;

— drainage systems, including scuppers, drains and down-piping on all decks and access ways exposed to snow, ice or frost accretion.

Anti-icing arrangements shall have sufficient capacity to keep the area or equipment free of ice, snow or frost down to the facility's minimum design operating temperature.

De-icing arrangements shall be provided for:

— decks exposed to snow, ice or frost accretion that are not in frequent daily use;

— access ways, stairways and gangways that are not in frequent daily use;

— railings;

— helicopter deck for ships, if not classified as a primary element of the vessel's EER plan, and if the ship does not have EER or SAR support duties.

De-icing arrangements shall be sufficient to remove accreted ice, snow or frost within a reasonable period of time (normally 4 h to 6 h). In arrangements with electric heating cables or heating pipes with fluids or steam as a heating medium, special attention shall be paid to the heat transfer from the cables or piping to the structure to be heated. The spacing of cables or pipes shall be appropriate for efficient heating. The fastening of cables or pipes shall be such that the heat is readily dissipated to the structure. In arrangements applying heating by fluids in pipes, additional capacity of steam plants or thermal oil heaters shall be calculated. Heat tracing should be of the self-limiting type.

All de-icing activities shall be supported with a specific job task analysis (JTA). The JTA is to address the case-specific issues related to wind chill for personnel carrying out the de-icing, and the associated dropped object hazards.

8.5 Anti-icing and anti-freezing measures

If anti-icing and anti-freezing measures are required for exposed areas, systems and equipment, the following example solutions are generally suitable.

a) Equipment and areas that require anti-icing measures are to be situated in protected locations as far as possible, so that sea spray and weather cannot reach them. This can be accomplished by using fully enclosed spaces, semi-enclosures, recesses with removable "curtains" in front, or similar. Use of a shielded location is normally the simplest and most reliable solution for anti-icing wherever possible.

b) Heating of spaces, depending on the type of equipment located therein.

c) Hard removable covers can also be applicable for some types of equipment. Cover by canvas can be acceptable for some types of equipment, such as fire monitors. A supply of heated air can be an alternative, if the equipment in question is enclosed under a cover, hard cover or canvas.

d) Use of electric heating blankets or heat tracing can be a solution for protection of equipment on open decks or unheated spaces.

e) Use of anti-freeze additives or low-temperature fluids in liquid systems, alone or in combination with supplementary heating of either the piping or the circulating fluid.

8.6 De-icing measures

If removal of ice prior to use of the equipment is acceptable, de-icing can be carried out by fixed heating arrangements or by use of portable equipment, or a suitable combination thereof.

Portable equipment may consist of

a) hoses for steam blowing,

b) hoses for flushing with heated water,

c) mallets (wooden, rubber or plastic),

d) snow blowers,

e) shovels, and

f) hydraulically operated power tools.

8.7 Work areas and access ways protection

All work areas shall have a layout that provides for safe and easy access for operation, inspection, readings and maintenance, also by a person wearing bulky cold weather gear. The layout design shall take Arctic environmental conditions into account by minimizing exposure to spray, wind, cold and the accumulation of ice and snow. This shall be done by enclosing or shielding work areas and access ways from the elements, wherever practicable.

The functional requirement for work areas and access ways is that the gangway system shall operate normally in cold-climate conditions.

The prescriptive requirements are given below.

a) Personnel should be able to use the gangway normally at temperatures down to ambient air temperature, or to a less severe temperature if the temperature of gangway disconnect is specified in the owner‘s winterization operations philosophy/design basis document and included in the winterization operations manual.

b) The gangway and boom rests shall be able to withstand icing loads in the operating and stowed (parked) conditions, and shall be constructed from suitable materials based on an ambient air temperature.

c) The gangway shall be capable of being de-iced without damage, particularly with respect to the control and safety systems.

d) The operating limitations of the gangway (for ice loading and for operating temperatures) shall be specified by the gangway manufacturer and included in the winterization operations manual.

e) The appropriate de-icing methods and accessibility requirements for personnel to carry out de-icing shall be specified, with equipment susceptible to mechanical damage or water ingress from de-icing activities to be specially addressed.

f) Job task analysis (JTA) shall be carried out for the de-icing activities (e.g. working at heights, working over water).

g) The “emergency automatic disconnect” feature shall remain operational in cold-climate conditions and shall be protected by anti-icing or anti-freezing measures as appropriate.

h) Escape ways and muster areas shall be kept free of snow and ice at all times.

8.8 Falling ice protection

Neither personnel shall be at risk of injury nor a system which is important for safety shall be put at risk of damage caused by ice falling from elevated structures, including (but not limited to) cranes, derricks, flare booms, masts and overhanging structures, etc.

The layout design shall minimize the danger to personnel from the fall of ice that can accumulate on structures (such as cranes and derricks). This can be done by arranging work areas away from structures likely to accumulate ice, installing anti-icing systems on structures to prevent ice accumulation, or protecting work areas with roofing that can withstand impact from falling ice.

Measures to protect people, safety-critical and sensitive equipment shall be implemented. Escape ways, access ways and work areas shall not be exposed to risks of ice falling from structures above.

Alternative solutions shall be evaluated that may include:

a) avoiding structures where hazardous build-up of ice is likely above escape ways/walkways and work areas;

b) using heat tracing of structures;

c) using local protection.

In areas that cannot easily be protected, regular removal of forming ice should be carried out.

Special considerations shall be given to the crane booms, scaffoldings and exhaust air outlets.

8.9 Anti-slip systems

Slippery floor surfaces shall be avoided in work areas and access ways. Non-slip systems shall be installed in exposed stairways and stepladders, including the uppermost step at deck/platform level.

In enclosed areas with external bulkheads or deckheads which are not insulated condensation can form and drip/run onto the deck, creating a slippery surface requiring a non-slip system.

8.10 Cold surfaces protection

It should be possible to operate outdoor handles, machines, switches and other equipment wearing winter gloves. Equipment that has to be operated without gloves shall be insulated to avoid contact freezing.

ISO 13732-3 provides a predictive model, which includes the effects of material thermal properties and surface temperature thresholds for finger and hand contact with cold surfaces, enabling establishment of limit values for contact with different cold surfaces. It is recommended to use ISO 13732-3 whenever there is risk of contact cooling with cold materials. This should be done as part of a cold risk assessment.

8.11 Safety equipment

Safety equipment, such as safety showers, first aid kits, eyewash bottles and manual firefighting equipment shall be placed in wind-protected areas. Equipment which is exposed to freezing conditions requires heat tracing and heated storage compartments. Safety showers and eyewash stations shall be protected from freezing and shall be located such that users are protected from exposure to freezing temperatures.

The locations of safety showers and eyewash stations shall be identified through an evaluation, taking into account the chemicals handled, possible spillages, and risk to personnel of burns or exposure. Protection of both the shower or eyewash station and the user from exposure to freezing temperatures shall also be considered. If safety showers and eyewash stations are located in areas subject to freezing temperatures, they shall be in a heated enclosure and water lines to the showers/stations shall be traceheated with thermostatically controlled low voltage electric heating systems (see ISO 19906:2010, 15.2.9.5).

8.12 Heat tracing and insulation

Heat tracing and insulation shall be assessed for use to ensure availability of essential safety, process and utility systems and protection against hazardous ice build-up. This is especially applicable to stairs, handrails and floors.

8.13 Hospital

The hospital (medical facility) at or on the facility shall have adequate equipment and capacity to stabilize the patient, treat traumatic injuries and acute illnesses, taking into account risks related to the Arctic climate, the time for safe evacuation to hospital onshore and the availability of evacuation systems. Staffing of the hospital shall be based on national requirements in the operating area. Equipment for telemedicine should be available at the hospital.

NOTE Recommended practice for remote Arctic operations is provided in the IRHC publication “Remote Healthcare Guidance Document for Energy and Associated Maritime Activities”.

8.14 Living quarters

When operating in remote areas, shift exchange can be postponed because of weather conditions and outside recreation can be difficult for periods. It is therefore especially important that the living quarters be designed to keep people physiologically and psychologically fit for longer periods.

General requirements for the design of living quarters are as follows:

a) living quarters and manned areas shall be kept at a temperature and humidity that ensures the health and safety of the personnel;

b) accommodation spaces and manned control stations shall be dimensioned to ensure they can be kept at a temperature of at least +20 °C (see NORSOK S-002);

c) food and water storage capacity shall be sufficient to cope with late arrival of supply boats due to weather restrictions.

8.15 Cabins

Due to the total stress factor for operating in Arctic conditions, rest periods for the workers shall be ensured.

Cabins shall be designed so that workers can enjoy normal undisturbed sleep.

Lightproof blinds should be provided in all cabins to ensure darkness.

9 Operational requirements for prevention and management of cold-related problems

9.1 General

The operating environment is normally identified in the initial design basis that establishes the physical metocean and meteorological conditions at the site (see Clause 7). Information from this design basis is critical to further assessments and design for winterization.

With respect to Arctic operations and occupational HSE, further assessment(s) are required to specifically consider

a) the effects of low-temperature environment on workers required to operate, inspect, maintain and repair equipment, and

b) how to avoid shutdown or reduction of production/operation due to the reduced human performance caused by the hazards discussed in this document.

This clause describes the operational requirements to ensure acceptable working conditions and thus stable production.

9.2 Buddy control system

Work in cold climate implies a risk of local and whole body cooling. A buddy control system, i.e. working in pairs rather than individually, should be implemented to avoid risks of frostbite and impaired manual performance going undetected.

Partners should watch for early warning signs of excessive cold stress in the other person, including disorientation, white spots on extremities, cold hands or discomfort.

9.3 Background

Arctic operations expose workers to cold, windy and wet conditions. Working in a cold environment can cause adverse effects on human performance and health, such as thermal discomfort, increased strain, decreased performance and cold-related diseases and injuries. Cold can also interfere with other factors in the workplace, modifying or aggravating the risk of common hazards and increasing the risk of cold-associated injuries.

Due to the impact of cold on human health and performance, as well as on work productivity, quality and safety, a comprehensive strategy of risk assessment and management practices and methods is needed for work in cold environments.

Several International Standards have been developed to provide methods (instruments and indices) for determining cold stress, as well as methods and practices for assessing and managing occupational health and performance risks in cold work, for example, ISO 11079, ISO 12894, ISO 13732-3 and ISO 15743. Their application is at the discretion of those responsible for occupational health and/or safety.

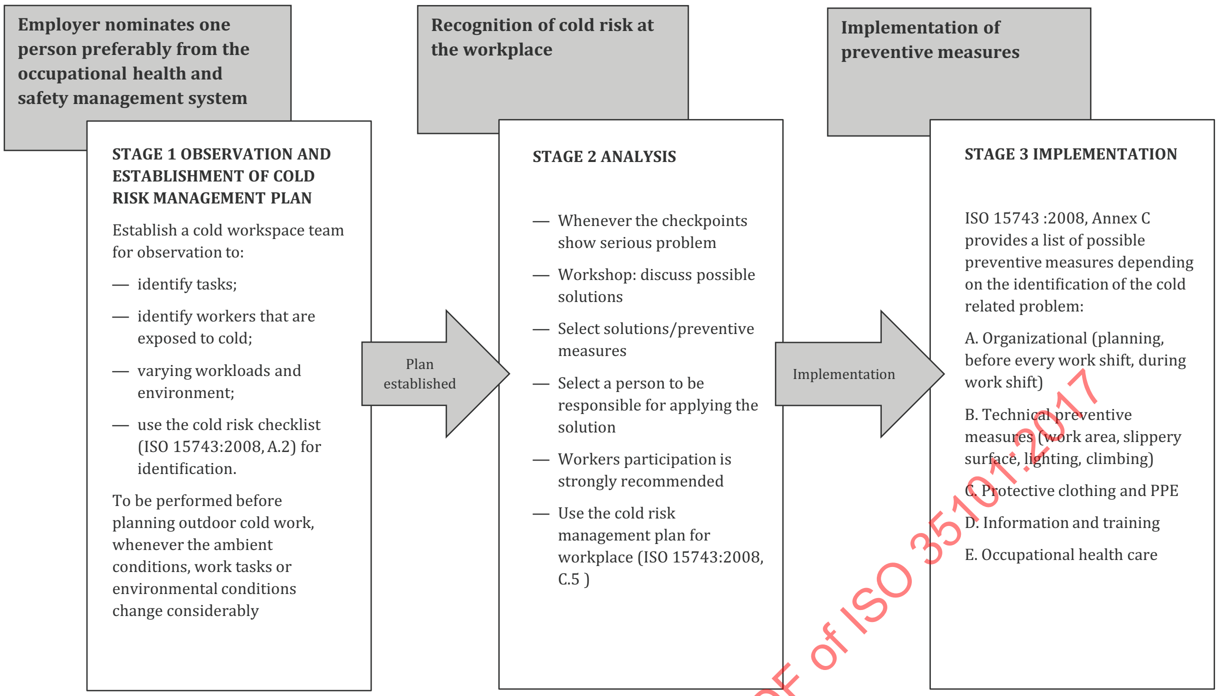
9.4 Cold risk management system

Outdoor operations in areas exposed to cold weather risks cannot always be avoided. In these cases, a plan is needed to handle risk. This sub clause provides requirements and guidelines for operational cold risk management and assessment.

The company (employer) shall determine whether cold-related risks are significant and shall control significant risks by means of elimination, isolation (where elimination is not possible or practicable) or minimization (where isolation is not possible or practicable).

A cold risk management system shall be implemented as part of the general risk management and occupational health and safety plans of the company and adapted to the existing risk management models, rules and regulations. The plan should include both cold risk assessment and a health risk management system. The management plan should include instructions for use, examples of known risks, cold and health risk checklist, information about protective clothing, training and supervision.

A stepwise model for developing a cold risk management plan is shown in Figure 6. This includes both organizational and technical measures taken in the workplace.



NOTE Adapted from ISO 15743.

Figure 6 — Model for a cold risk management plan

It is recommended to establish a cold-workplace team that is responsible for the design and implementation stages and for continuous follow-up of cold-related issues.

The management system should consider human factors, such as experience, training, work on night-time operations (year-round in some cases).

For new operations, temporarily reduced performance should be considered, in the expectation that performance will improve.

Goals should be established and seasonal evaluations of performance should be carried out.

9.5 Cold risk assessment

9.5.1 General

All human interventions which are carried out in open areas or unheated spaces and which are related to the safety systems (including regular maintenance, inspection and testing activities) shall be documented by assessing and interpreting the risk of physiological constraints or discomfort while working in a cold environment.

This subclause does not describe a single procedure, but rather a strategy in three stages that can be applied successively to gain insight into working conditions, and thus be able to draw the most appropriate conclusions about the risks involved and to identify preventive measures. This subclause follows the methodology described in existing International Standards for cold work.

ISO 15743 presents a strategy and practical tools for assessing and managing cold risk in the workplace. It supports good occupational health and safety, and is applicable to work in the Arctic, with the exception of work performed underwater. It includes:

a) models and methods for cold risk assessment and management;

b) a checklist for identifying cold-related problems at work;

c) a model, method and questionnaire intended for use by occupational healthcare professionals in identifying those individuals with symptoms that increase their cold sensitivity and, with the aid of such identification, offering optimal guidance and instructions for individual cold protection;

d) guidelines on how to apply thermal standards and other validated and more complex scientific methods when assessing cold-related risks.

Cold risk assessment in the workplace follows the principles of risk assessment, presented in three stages, and generally accepted principles of risk assessment (see Figure 6).

9.5.2 Identification of cold-related problems at work (Stage 1)

The checklist for identification of cold-related problems as described in ISO 15743 should be used to identify cold-related problems. The identification of cold-related problems shall be carried out for open and semi-open work areas to ensure the acceptability of health and safety to personnel. The analysis shall be based on a task analysis of relevant areas, identifying types of work carried out, frequency, duration and physical workload, and urgency with respect to safe and reliable operation.

If the analysis identifies that preventive actions are needed, a more detailed analysis shall be carried out. Evaluation and selection of corrective actions should be based on further identification of problems related to cold air, wind, contact with cold surfaces, water, moisture, cold-protective clothing and PPE, effects of cold on body extremities, and other cold-related problems.

This study can be included as a separate part of a working environment risk assessment or job hazard analysis (JHA). Tools and methods for more detailed analyses are described in 9.5.3 (Stage 2) and 9.5.4 (Stage 3), including determination of wind chill and risk categories (see 9.5.3), work, warm-up and recovery schedules and estimation of required clothing insulation (see 9.5.4).

9.5.3 Determination of wind cooling (wind chill exposure) (Stage 2)

Outdoor work at low ambient temperatures and in wind represents a risk of frostbite and degradation in human performance. The danger of frostbite to exposed skin can be evaluated using the wind chill temperature (WCT) (see Table 1). The formulae and methods contained in ISO 11079 provide a tool for calculating the WCT and classifying cold exposure risk.

Table 1 shows the cooling power of wind on bare skin, expressed as the WCT. Table 2 explains the use of the colour codes in Table 1, classification of risk categories, WCT, risk of frostbite and recommended limits for work.

Table 1 — Cooling power of wind on exposed bare skin, expressed as comparative WCT

Wind scale	Wind speed		Ambient temperature (°C)										
Beaufort (m·s⁻¹)	Km·h⁻¹	m·s⁻¹	0	−5	−10	−15	−20	−25	−30	−35	−40	−45	−50
Light breeze (1,6–3,3)	5	1,4	−2	−7	−13	−19	−24	−30	−36	−41	−47	−53	−58
	10	2,8	−3	−9	−15	−21	−27	−33	−39	−45	−51	−57	−63
Gentle breeze (3,4–5,4)	15	4,2	−4	−11	−17	−23	−29	−35	−41	−48	−54	−60	−66
	20	5,6	−5	−12	−18	−24	−31	−37	−43	−49	−56	−62	−68
Moderate breeze (5,5–7,9)	25	6,9	−6	−12	−19	−25	−32	−38	−45	−51	−57	−64	−70
	30	8,3	−7	−13	−20	−26	−33	−39	−46	−52	−59	−65	−72
Fresh breeze (8,0–10,7)	35	9,7	−7	−14	−20	−27	−33	−40	−47	−53	−60	−66	−73
	40	11,1	−7	−14	−21	−27	−34	−41	−48	−54	−61	−68	−74
Strong breeze (10,8–13,8)	45	12,5	−8	−15	−21	−28	−35	−42	−48	−55	−62	−69	−75
	50	13,9	−8	−15	−22	−29	−35	−42	−49	−56	−63	−70	−76
Near gale (13,9–17,1)	55	15,3	−9	−15	−22	−29	−36	−43	−50	−57	−63	−70	−77
	60	16,7	−9	−16	−23	−30	−37	−43	−50	−57	−64	−71	−78
	65	18,1	−9	−16	−23	−30	−37	−44	−51	−58	−65	−72	−79
Gale to hurricane (>17,2)	70	19,4	−9	−16	−23	−30	−37	−44	−51	−59	−66	−73	−80
	75	20,8	−10	−17	−24	−31	−38	−45	−52	−59	−66	−73	−80
	80	22,2	−10	−17	−24	−31	−38	−45	−52	−60	−67	−74	−81

NOTE This table is modified from ISO 11079, including the Beaufort scale.

Table 2 — Classification of risk categories, WCT, risk of frostbite and recommended limits for work

Classification of risk	Wind chill temperature °C	Risk	Recommended limits for work
0	≥ −9	Low risk, <5 % chance of frostbite for most people	Normal work; emergency work; planned maintenance
1	−10 to −24	Low risk, < 5 % chance of frostbite for most people, uncomfortably cold	Normal work (reduced work periods); emergency work
2	−25 to −34	Moderate risk, increasing risk of frostbite for most people in 10 min to 30 min[a], very cold	Normal work (reduced work periods); emergency work
3	−35 to −59	High risk, risk of frostbite for most people in 2 min to 10 min[a], bitterly cold	Emergency work only
4	−60 and colder	Extreme risk, risk of frostbite for most people in 2 min or less[a], extremely cold	No work outside

[a] In sustained winds over 50 km/h (14 m/s), frostbite can occur sooner than indicated.

NOTE This table is adapted from ISO 11079.

All open decks and unheated spaces shall be assessed with regard to necessary human interventions, irrespective of function, taking account of the detrimental effects of cold temperatures/wind chill on human responses.

The WCT should be continuously monitored in open and semi-open areas for facilities where it is expected that WCTs below −10 °C occur and the duration of outdoor activity is expected to exceed 40 min. These areas should be identified in the design stage of the planning and risk assessment of cold exposure carried out. WCT simulations shall be made for the three coldest months of the year (see Clause 7).

A three-step assessment is as follows.

a) Step 1: Address WCT for every outdoor work area on the facility.

b) Step 2: Decide if a weather shield or enclosure should be recommended.

c) Step 3: Carry out risk assessment based on task analysis and WCT.

A permit to work in severe cold shall be obtained when deviation from the recommended work limits in Table 2 is necessary.

Where wind-chill reduction measures can affect confinement and congestion, e.g. through use of modularized enclosures, then additional measures to manage fire and explosion risk, fumes, chemical exposure and toxic atmospheres in manned areas may be required.

Use of good practice with respect to cold-weather clothing and PPE shall be assumed (see 9.6). However, it should not be assumed that personnel are continuously entirely protected, such that PPE cannot be routinely relied on to protect personnel when times to frostbite are short.

The expected staffing requirements to meet the cold weather operation requirements shall be checked to be acceptable with respect to platform crewing. For the initial assessment, it shall be assumed that increased frequency of personnel rotation between indoor and outdoor areas is not available as a measure to meet the wind-chill exposure limits, i.e. design and physical protection measures to limit cold exposure are preferred, provided that they do not have an adverse effect on safety.

9.5.4 Work, warm-up and recovery regimes (Stage 3)

Work, warm-up and recovery regimes can be estimated based on various input factors, including temperature, wind speed, work intensity and clothing.

ISO 11079 provides a method to estimate recommended time of outdoor exposure (duration) if the insulation value of the clothing and the metabolic heat production (IREQ model) are known. ISO 11079 can further be used for estimation of recovery times, defined as an estimate of how much time indoors is required to restore normal body heat balance after cold exposure. Recovery times are dependent on the ambient conditions of the recovery room, metabolic heat production during recovery and the insulation of available clothing.

Table 3 — Recommended maximum duration of exposure, work regimes and preventive measures based on WCT

WCT	Risk of frostbite	Maximum duration pr. cold exposure	Preventive measures
≥ −9 °C Normal work	0: Low risk <5 % chance of frostbite for most people	Unlimited	— Dress warmly — Stay dry — Be aware if manual operations with bare hands shall be performed outdoors
−10 °C to −24 °C Shorter work periods	1: Low risk <5 % chance of frostbite for most people Uncomfortably cold	120 min	— Dress in layers of warm clothing, with an outer layer that is wind-resistant — Wear a hat, mittens or insulated gloves, a scarf and insulated waterproof footwear — Stay dry — Keep active — Be alert if manual operations with bare hands shall be performed

a In sustained winds over 50 km/h, frostbite can occur sooner than indicated.

Table 3 *(continued)*

WCT	Risk of frostbite	Maximum duration pr. cold exposure	Preventive measures
−25 °C to −34 °C Shorter work periods and buddy control	2: Moderate risk Increasing risk of frostbite for most people in 10 min to 30 min Very cold	30 min[a]	— Dress in layers of warm clothing, with a wind-resistant outer layer — Minimize exposed skin (face mask and goggles) — Wear a hat, mittens or insulated gloves, a scarf, neck tube or face mask and insulated, waterproof footwear — Stay dry — Keep active — Take breaks and drink warm drinks — Check face and extremities for numbness or whiteness (buddy control)
−35 °C to−59 °C Emergency work in extreme wind chill conditions	3: High risk High risk of frostbite for most people in 2 min to 10 min Bitterly cold	10 min[a]	— Dress in layers of warm clothing, with wind-resistant outer layer — Cover all exposed skin (facemask and goggles) — Wear a hat, mittens or insulated gloves, a scarf, neck tube or face mask and insulated, waterproof footwear — Be ready to cut short or cancel outdoor activities — Keep active — Take breaks and drink warm drinks — Check face and extremities for numbness or whiteness (buddy control) — Perform risk assessment before each work task
−60 °C and colder	4: Extreme risk High risk of frostbite in most people in 2 min or less Extremely cold	2 min[a]	— No work outside

[a] In sustained winds over 50 km/h, frostbite can occur sooner than indicated.

9.6 Clothing and personal protection regimes

9.6.1 General

Appropriate clothing is a prerequisite for work in cold environments. Insufficient clothing insulation can cause unwanted cooling. At high activity, there is a risk for accumulation of sweat and increased discomfort. Special attention should be given to the compatibility of protective clothing and PPE (e.g. eye protection, respiratory protection, helmet, etc.). In general, clothing shall have good insulation properties, as well as good ventilation to eliminate moisture. Protective clothing and PPE shall ensure sufficient comfort and freedom of movement to support work performance. The most vulnerable areas are the face, hands and feet.

It is important to secure good compatibility between the different types of PPE to avoid reduced protective effect when PPE's are combined.

The following guidelines should be applied:

a) appropriate protective clothing and PPE for cold work should be selected as part of the workplace risk assessment;

b) clothing should provide comfort and protection of the worker, while facilitating outdoor work tasks;

c) clothing should consist of under, middle and outer layers and be adjustable for the level of required activity and environmental conditions (air temperature, precipitation);

d) the clothing outer layer should allow for heat dissipation through evaporation and transport of perspiration outwards through the clothing system.

Wind chill is commonly encountered in cold climates, but it is mainly the low temperatures which endanger body heat balance. Proper adjustment of clothing can often provide control and regulate body heat loss, to balance a change in the ambient climate. The IREQ method presented in ISO 11079 can be used to evaluate the clothing insulation required to maintain thermal balance of the body. The equation provided takes into account the most recent scientific findings concerning heat exchange at the surface of the skin, as well as the clothing.

See Table 3 for general guidelines on clothing at different WCTs.

A multi-layered clothing system is ideal for cold climates, with each layer serving a specific purpose:

— inner layer (underwear): provides moisture absorption and transport;

— middle layer (shirt, sweater): provides insulation and moisture transport;

— outer layer (windbreaker, Arctic clothing, rain gear): provides protection against the external environment and moisture transport.

9.6.2 Hand protection

In Arctic conditions the extremities, in particular fingers and toes, will gradually cool down and reach unacceptably low temperatures. Extremity cooling is prevented or reduced by wearing adequate clothing protection and insulated hand, head and footgear.

Optimal hand function is dependent on skin temperature, with deterioration in manual performance combined with pain sensation occurring at skin temperatures lower than 15 °C, deterioration of tactile sensation and numbness at skin temperatures lower than 8 °C and risk of frostbite at skin temperatures below 0 °C. The degree of hand and finger cooling depends on the local climatic conditions, local protection and heat input by blood circulation.

The latter factor is much dependent on the overall thermal balance. If the heat balance is negative, as for example when protective clothing does not match IREQ, extremity blood flow is reduced due to vasoconstriction. This can reduce heat input to very low levels.

Adequate hand protection shall be provided. This shall keep the hands of the wearer warm and at the same time enable him to perform the fine manipulations of the hand and fingers at a low ambient temperature.

Guidelines for selection of hand protection are given below.

a) Physiological criteria for determination of local cooling during “high strain” and “low strain” activity can be found in ISO 11079:2007, Annex B.

b) EN 511 is a general standard designed to be used to evaluate any glove which claims protection against cold environments. EN 511 includes two specific tests for assessing thermal insulation:

   — determination of thermal insulation of handwear, convective cold and contact cold;

   — other low temperature performance tests.

   Extremity cooling can also be evaluated by direct skin temperature measurements. Recommended criteria and temperature levels are given in ISO 11079:2007, Annex B.

The need for insulated hand protection shall be considered for all work not requiring fine manual dexterity in temperatures less than 15 °C (for sedentary work) and 5 °C (for active physical work).

In very cold temperatures of −15 °C or less, the use of mittens, including “lobster-claw” type, and of windproof over-mittens, should be considered.

If manual dexterity is required for more than 10 min to 20 min in temperatures of less than 15 °C, additional hand-warming measures should be provided. Metal tools and handles should be insulated if temperatures can fall below the freezing point. Insulated gloves are required in any conditions where workers can contact metallic surfaces at temperatures below −3 °C.

9.6.3 Foot protection

Footwear shall have good insulation and also have a good grip on icy surfaces, since injuries frequently are caused by slipping and falling.

Personnel shall be provided with insulated anti-slip footwear suitable for protecting the wearer under the relevant environmental conditions (cold, wind and water) and shall take into account the type of work to be performed, including climbing of ladders.

Anti-slip footwear shall be designed to provide stable footing on snow- and ice-covered surfaces. Anti-slip footwear shall be non-static and non-sparking so as not to present an explosion risk.

A list of boot-selection criteria is given below:

a) composite (metal-free) protective toecap and shank;

b) high ankle level;

c) wide foot;

d) good grip sole;

e) shoelaces in upper part (not across ankle), to reduce ventilation effect;

f) room for extra inner sole;

g) room for felt slipper;

h) room for thin inner sock;

i) room for thick socks;

j) loose/removable/washable inner heat-lining.

Guidelines for slip-resistance requirements (not ice and snow conditions) for safety footwear can be found in ISO 20345.

9.6.4 Face protection — Cold air protection

In Arctic conditions, the face is exposed to both airway cooling and risk of frostbite on bare skin. At WCTs below −15 °C respiratory cold air protection is recommended, especially at high activity levels with increased ventilation. At WCTs below −30 °C, respiratory protection is strongly recommended. A specialized face mask (asthmatic filter mask) is recommended to protect the respiratory tract. A balaclava is recommended for full-face coverage and a helmet liner when the WCT is −24 °C or lower.

Adequate face protection shall be provided which can both keep the face of the wearer warm and protect the respiratory tract from cold ambient air.

Guidelines for face protection can be found in ISO 11079:2007, Annex B.

9.6.5 Chemical respiratory protection

When selecting respiratory protection (PPE) against chemical exposure in cold environment, the following shall be considered:

a) check the mask for "leaks" when used with head protection, e.g. balaclava;

b) ensure that the chemical filter absorption efficiency is not impaired by the low temperature;

c) use a fan-assisted full-face mask for high airflow on the facial skin to reduce local WCT;

d) be aware that full-face masks tend to have low visibility due to condensation at temperatures below +5 °C;

e) take note that freezing of the facial skin can occur at the locations where the mask touches the skin.

9.7 Fitness for work in the Arctic environment

9.7.1 General

The company (employer) is primarily responsible for assessing the fitness of individuals for work in the Arctic (cold environment) in compliance with national legislation.

Different groups of people react differently to cold stress and remoteness, and experience with work in cold, and or remote, climate can vary. Awareness of this fact shall be implemented in training.

Cold-related conditions are defined as conditions which are either caused by cold or whose symptoms are aggravated during cold exposure. People with conditions such as asthma, diabetes and earlier frost injuries can experience a worsening of their diseases as a result of exposure to cold.

Remoteness is an additional factor, both for psychological reasons and because distance/time to proper medical facilities/hospital can be long. Healthcare support on the facility can be limited; the quality of this support shall be considered in relation to the fitness assessment.

The company is advised to adopt the cold-related health assessment process outlined in ISO 12894 and ISO 15743 to identify any possible medical predisposition of workers to harm from exposure to cold. The resulting assessment shall be taken into account in the company's decisions on accepting or rejecting an individual for work in the Arctic environment, where permitted by national legislation.

In all cases, it is essential that an individual risk assessment be undertaken to avoid needlessly excluding someone from work for which they are qualified.

9.7.2 Cold-related health risks

Cold-related health risks include respiratory, cardiovascular, peripheral circulatory, musculoskeletal and dermatologically related diseases, freezing and non-freezing injuries and hypothermia. A description of these diseases can be found in ISO 12894.

9.7.3 Cold-related health assessment

For work in sub-zero climates, a health assessment should be undertaken, both prior to work and routinely through the working period.

ISO 12894 and ISO 15743 provide relevant guidance for conducting a health assessment of individuals for working in cold environments. The cold-related health assessment outlined is a three-stage medical screening conducted by occupational health professionals. Each stage involves identification of cold-related health risks, both in the workplace, as well as regarding the health of the individual.

As a result of the assessment, the occupational health professionals recommend whether an individual should be accepted or rejected for work in a cold environment. Those accepted should receive particular advice, training and information in order to ensure their optimal health and performance during cold work.

9.7.4 Medical health examination associated with operation in the cold

All personnel required to work offshore shall be subject to a standard medical examination, for example as described in ISO 12894.

The examining doctor shall be aware of the location of operations for which the medical examination is required. The medical examination should clearly address specific factors that are relevant for cold work (see ISO 12894:2001, D.6 on medical fitness assessment questionnaire prior to cold exposure).

The medical examination for fitness for cold work should include information concerning:

a) cold-related symptoms and diseases such as medical conditions which can predispose a person to injury or difficulties working in the cold, e.g. general poor health, respiratory symptoms, cardiovascular symptoms, metabolic disorders, musculoskeletal symptoms, cold sensitivity, cold urticaria, symptoms related to peripheral circulatory disturbances, symptoms related to white fingers, use of medication, alcoholism and/or drug use (see the list of diseases in ISO 12894);

b) earlier cold injuries that can be sensitive to re-injury;

c) symptoms, both physical and psychological, that indicate negative health effects due to working in the cold;

d) anticipated physiological strain (work intensity, tasks);

e) anticipated cold exposure and duration.

Assessment of the anticipated physiological strain, coupled with appropriate medical fitness assessment, in most situations provides adequate safeguards against the risk of illness occurring from exposure to cold conditions.

9.7.5 Suggested health requirements

National regulations regarding health requirements for persons working on offshore or onshore oil and gas facilities should also pertain to work in cold environments.

The following general health requirements shall apply to all personnel:

— physically and mentally able to cope with living and working on the facility and with evacuation procedures;

— able to safely work offshore;

— have no medical condition that could lead to alarms not being registered;

— not have disorder that, due to lack of essential medication or for other reasons, might seriously endanger the health and safety of the worker or of others.

Any health exclusion criteria for work in the cold shall be identified at the individual level after a thorough medical examination of the employee concerned.

Potential contraindications for work in extremes of temperature are described in IPIECA/OGP Report No. 398:

— respiratory or cardiovascular problems;

— severe obesity (BMI ≥ 35);

— metabolic disorders (e.g. thyroid disease);

— alcohol abuse;

— pregnancy;

— previous cold-related illness.

Potential contraindications specific to cold include:

— Raynaud's syndrome (white finger);

— cold-induced asthma;

— cold-induced urticaria (an itchy skin condition);

— cryohaemoglobulinaemia (a rare blood condition).

Medications which can pose a problem in extremes of temperature include:

— medications that alter vigilance or perspiration (e.g. tranquillizers, sleeping pills, antidepressants, antihistamines);

— medications that act on blood circulation (blood pressure and heart treatments);

— diuretics (medications that alter body fluid balance);

— drugs with antipyretic properties that can interfere with temperature regulation (e.g. some analgesics or anti-inflammatories);

— photosensitizers (both systemic and topical), which increase the skin's reaction to sunlight.

9.7.6 Other aspects relevant to assessment of fitness for work

Many stressors result from the physical and psychosocial environment of high latitudes. Extreme cold is only one component of the total physiological stress imposed by work in an Arctic offshore environment. Other relevant stressors include prolonged periods of darkness (polar winter) and light (polar summer), humidity, remoteness, isolation, noise, vibration, and ship or platform motion in a seaway (pitch, roll, heave, etc.).

Experience gained from polar expeditions indicates that people commonly undergo psychological changes resulting from exposure to long periods of isolation and the extreme physical environment. The most common symptoms include disturbed sleep, impaired cognitive ability, negative affectivity, and interpersonal tension and conflict. Experience shows that preventing pathogenic psychological outcomes is best accomplished by psychological and psychiatric screening procedures to select out unsuitable candidates. The screening process typically consists of structured interviews by psychiatrists or clinical psychologists, standardized psychometric instruments such as the Minnesota Multiphasic Personality Inventory, and reviews of medical and employment records. Other preventive measures include providing workers access to psychological support and by training crew members in personal coping strategies, teamwork and leadership.

General aspects that should be implemented for avoiding cold-related problems include:

a) ensuring a balanced nutrient-rich diet, adequate fluid intake and minimal intake of caffeinated drinks when working in extreme cold for prolonged times;

b) paying extra attention to critical tasks when working in the cold at night;

c) work supervisor paying extra attention to the combined effects of cold and other psychosocial factors by positively influencing workers' motivation, well-being and safety;

d) workers and foremen understanding that individual differences (age, gender, fitness adaption, ethnicity, experience) in response to cold climate exist, and allowing for individual adjustments in e.g. clothing/work/rest schedules.

9.8 Health and stress management

9.8.1 Psychosocial stress exposure

For the various positions on the facility, a job hazard analysis (JHA) should, as a minimum, include an evaluation of the psychological job demands and the preconditions for social interaction, support and control at work. The analysis should also consider the preconditions for recovery while off-duty at the facility.

On facilities that are planned for use in areas with an Arctic climate, the JHA should include an evaluation of the psychological effects of additional stressors found in the Arctic environment, including cold, prolonged periods of darkness (polar winter) and light (polar summer), remoteness, isolation, etc.

Workers shall be monitored routinely for signs of seasonal affective disorder (a type of depression that occurs most commonly in autumn and winter, particularly in high latitudes). Special lighting solutions are not needed in general, but may be recommended by a doctor as an alternative preventive measure.

9.8.2 Health and stress management

The company should establish and follow up regular employee health monitoring (i.e. to ensure employees continue to be fit for work) based on national requirements.

An occupational health care model for cold work should be implemented. Cold-related health assessment processes should be performed as outlined in ISO 12894 and ISO 15743.

9.9 First aid and medical provision

9.9.1 Medical support assessment

Arctic offshore operations, which often are isolated and remote, are likely to require a greater degree of self-sufficiency, given their distance from shore-side medical facilities and the potential for delays in evacuating personnel for medical attention.

The company shall perform a systematic analysis of the preconditions for providing adequate first aid, emergency and interim medical care. The analysis shall consider:

a) the intended geographic location of the facility or operation;

b) its proximity to shore-side medical facilities and other area or external resources;

c) the conditions for medical evacuation from the facility;

d) the potential for extended delays in evacuation due to adverse Arctic weather conditions.

The assessment shall be used in determining the provision of adequate medical care in the workplace design (medical facilities), staffing (doctors, nurses, paramedics), supply (medicines, medical equipment and supplies), communications (telemedicine), and organization of the facility or operation.

The medical support assessment should include the functional requirements and guidelines for emergency medical response contained in ISO 15544:2000, Clause 13, and should be used to assist in the development of the facility's emergency response strategy as described in ISO 15544:2000, Clause 4.

9.9.2 Medical facilities

ISO 15544 gives the following objectives regarding emergency medical response:

— provide medical facilities on the facility for the purpose of treating sick and injured people and stabilizing them until more specialized help can be arranged;

— arrange suitable specialist medical treatment for sick and injured people who cannot be adequately treated on the facility;

— ensure that arrangements for emergency medical treatment consider:

  — injuries to personnel as a result of major accident events;

  — illness or condition of personnel on board, e.g. diabetics or heart attack, respectively;

  — transportation and evacuation of sick and injured people;

  — injuries to personnel as a result of minor accidents;

  — other medical situations which can impair the operational integrity of the facility, e.g. food poisoning;

— ensure storage of controlled drugs and medicines in a secure place accessible only to those who are trained to administer such treatments.

ISO 15544 provides the following guidance regarding emergency medical response:

— all regularly manned facilities should have a place where a suitably qualified person can supervise injured or sick people;

— the designated place on the facility for sick and injured people should be readily accessible to people carrying a stretcher, and should have easy access to the areas on the facility used for evacuation;

— medical emergencies that should be expected, particularly if the operating environment means that external assistance may not be readily available, include food poisoning and epidemics.

— the level of medical facilities and trained personnel provided should be in line with the requirements identified in the emergency response strategy.

9.9.3 Medical evacuation

Medical evacuation is not addressed in this document.

10 Education, training and supervision

Training shall provide personnel with new knowledge and skills about working in the Arctic or in extreme cold. All risk and health factors of work in the Arctic shall be considered (experience, culture, familiarization, etc.). Workers shall practice application of this knowledge in order to become competent.

Personnel shall be able to recognize cold stress and fatigue in themselves and others. Personnel shall be able to use alertness strategies effectively to overcome the effects of fatigue associated with extended hours of work outdoors or continuous operations involving shift changes. Workers and supervisors involved with work in cold environments should be informed about symptoms of adverse effects from exposure to cold, proper clothing habits, safe work practices, physical fitness requirements for work in cold and emergency procedures in case of cold injury.

All personnel shall be thoroughly trained in the special aspects of working in the cold. This training should address health and safety of supervisors, as well as that of their co-workers.

The training should include:

a) physical effects of the cold: the facts, processes and symptoms;

b) the importance and correct use of measures to avoid cold injury, such as dry and correct fitting of clothing and PPE, work warm-up regimes, buddy systems, nutrition, and working limitations/criteria, such as WCT.