GUIDE FOR

VESSELS OPERATING IN LOW TEMPERATURE ENVIRONMENTS

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Updates

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- September 2006 version plus Corrigenda/Editorials

Foreword

Vast reserves of gas and oil are expected to be developed in the offshore areas of the Russian Arctic. It is anticipated that European nations and Atlantic states in North America will be the chief consumers of these energy supplies. Year-round carriage by sea – operating in the Baltic, Arctic, and polar environments – will place extreme challenges on the vessels and their crews. To help address these challenges, the ABS *Guide for Vessels Operating in Low Temperature Environments* has been produced. This Guide provides criteria for the winterization of vessels so as to be suitable for continuous operation in arctic and polar conditions. These criteria supplement those found in Part 6, Chapter 1, "Strengthening for Navigation in Ice" of the ABS *Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*.

Where requested by the Owner, vessels designed, equipped, constructed and surveyed in accordance with the requirements of this Guide will be assigned either of the following Cold Climate Operation (CCO) class notations, as appropriate:

- **CCO** for a vessel designed, constructed and surveyed in accordance with requirements in Sections 2 through 6 of this Guide, those being:

  SECTION 2 Materials, Welds and Coatings

  SECTION 3 Hull Construction and Equipment

  SECTION 4 Vessel Systems and Machinery

  SECTION 5 Safety Systems

  SECTION 6 Specific Vessel Requirements

- **CCO+** for a vessel meeting the requirements for **CCO** notation, as well as Sections 8 and 9 of this Guide, those being:

  SECTION 8 Crew Considerations

  SECTION 9 Training and Related Documentation

The Guide also contains a series of Appendices that provide supporting information relative to the requirements in Sections 2 through 9. Additional appendices cover:

- Weather Conditions of Interest
- Guidance Notes on Vessel Operations
- Other Reference Sources
- A List of Administration Contacts associated with Baltic, Arctic, and Antarctic areas
- A List of Meteorological Organization Contacts

This Guide becomes effective immediately upon publication.

We welcome your feedback. Comments or suggestions can be sent electronically to rsd@eagle.org.

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GUIDE FOR

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SECTION 1 General

1 Application

The requirements in this Guide apply to vessels that are designed, equipped and intended to operate in low temperature environments where the design service temperature may be encountered. Examples of such regions are the Gulf of St. Lawrence, Baltic Sea, Arctic and Antarctic Oceans. Application of the requirements in this Guide is optional. When a vessel is designed, equipped, built and surveyed in accordance with this Guide, and when found satisfactory, a classification notation as specified in Subsection 1/3, as appropriate, will be granted.

Those vessels that are designed to meet the requirements of an ice class are to meet Part 6, Chapter 1, "Strengthening for Navigation in Ice" of the ABS *Rules for Building and Classing Steel Vessels (Steel Vessel Rules)* or other recognized ice class Rules prior to seeking the optional notation discussed in this Guide.

It is a prerequisite that ice class and non-ice class vessels' hull structural materials are to be selected based on the design service temperature and material class in accordance with 6-1-1/35 of the *Steel Vessel Rules*.

2 Objective

The objective of this Guide is to provide supplemental requirements that generally are not addressed by ice class Rules. Low temperature environments present numerous challenges related to operation of equipment, systems, structure, vessel maintenance and safety equipment for the vessel's personnel, as well as personnel performance. Vessels designed and constructed without addressing the effects of low temperatures typically will experience increased structural and equipment failures and nonfunctioning systems. Personnel performance will typically be reduced by the effects of low temperatures.

Vessel systems and exposed structure designed and equipped in accordance with the requirements of this Guide will obtain a class notation indicating the vessel is designed to operate at a design service temperature specified by the Owner. This Guide is applicable to design service temperatures of -10°C (14°F) or less, excluding ice class requirements, if specified. Additional requirements are provided for vessels requiring certification to operate in a design service temperature of less than -30°C (-22°F).

3 Classification Notations

Where requested by the Owner, vessels designed, equipped, built and surveyed in accordance with the requirements of this Guide will be assigned the following class notations, as appropriate:

- **CCO-HR(TEMP)** – Vessel designed, built and surveyed in accordance with requirements in Sections 2 through 6 of this Guide. The emergency service hours (18 or 36) is listed as HR. The design service temperature for which the vessel is designed is listed in the parentheses.
- **CCO-HR(TEMP)+** – Vessel designed, built and surveyed in accordance with requirements for **CCO-HR(TEMP)** along with placement of additional equipment onboard for the crew and specific low temperature environment training for the crew as per Sections 8 and 9 of this Guide. The emergency service hours (18 or 36) is listed as HR. The design service temperature for which the vessel is designed is listed in the parentheses.

4 Definitions

The following definitions are applied to the terms used in this Guide.

Ambient Temperature: The air temperature in the vicinity of the vessel.

Deck Machinery: Any machinery or equipment that operates as designed at the ambient temperature. Some examples include winches, windlasses, cranes or other lifting appliances, hatch covers, vehicle ramps, boat davits and mooring fittings.

Design Service Temperature: The design service temperature is to be taken as the *lowest mean* daily *average* air temperature in the area of operation where:

- *Mean*: Statistical mean over observation period (at least 20 years).
- *Average:* Average during one day and night.
- *Lowest:* Lowest during year.

For seasonally restricted service the lowest value within the period of operation applies.

EPIRB: Emergency Position Indicating Radio Beacon

Emergency: A serious, unexpected, often dangerous event requiring immediate action.

Essential: Systems or equipment necessary to maintain vessel propulsion, maneuvering, electrical services, firefighting (along with bilge system), ballasting or personnel safety.

In the notch: An operational mode in which a trailing vessel is moored in a specially constructed notch in the stern of an ice breaker.

Low temperature environment: Areas of vessel operations with ambient temperatures less than or equal to -10°C (14°F).

Machinery: Equipment and systems subject to the design requirements of Parts 4, 5C and 6 of the *Steel Vessel Rules*.

Maneuvering Mode: The lowest vessel speed necessary to maintain maneuverability.

MCR: The maximum continuous rating of the prime mover.

Minimum Anticipated Temperature: The minimum anticipated temperature is determined as the Design Service Temperature minus 20°C (36°F) for exposed machinery *or* plus 20°C (36°F) for machinery in unheated spaces. In no case is the minimum anticipated temperature to be greater than 0°C (0°F).

Guide for Certification of Lifting Appliances: The latest edition of this ABS Guide.

Steel Vessel Rules: The latest edition of the ABS *Rules for Building and Classing Steel Vessels*.

5 Certification Procedure

A diagram for the procedure for vessels to be certified in accordance with this Guide is shown in Section 1, Figure 1.

5.1 Engineering Review

Vessels operating in low temperature environments must be provided with certain design characteristics that will enable the vessel to perform its intended functions. These requirements are listed in Sections 2 through 5 of this Guide. Certain vessel types have unique features or operating characteristics unlike other vessels. Requirements for four specific vessel types are listed in Section 6. The design characteristics and/or equipment required in Sections 2 through 6 are assumed to be permanently installed (e.g., welded or bolted) in/on the vessel at the completion of construction.

This Guide also lists requirements for additional equipment that is not permanently installed (e.g., clothing for personnel protection, special safety equipment) and additional personnel training in Sections 8 and 9. The Owner may indefinitely delay the implementation of the requirements of Sections 8 and 9 for those instances where vessel operations in the low temperature environment are not anticipated. Prior to the vessel operating in a low temperature environment, the Owner is to provide this additional equipment onboard and provide suitable personnel training along with a vessel operations and training manual. Arrangements are to be made for a Surveyor to verify the equipment is onboard and the personnel have received proper training via onboard supporting documentation.

5.2 Initial Survey

Vessels complying with the requirements of Sections 2 through 6 and confirmed by satisfactory survey will receive the notation **CCO,** which will be listed in the *Record*. The **CCO** notation may be maintained indefinitely provided the hull and machinery are to the satisfaction of the attending Surveyor at the subsequent Annual Surveys. See 1/5.3.

When the Bureau is notified that the implementation of the requirements in Sections 8 and 9 have also been complied with and confirmed by satisfactory survey, the notation **CCO+** will be listed in the *Record*.

5.3 Annual Surveys

Simultaneously with each Annual Survey – Hull and Annual Survey – Machinery, the hull and machinery subject to Sections 2 through 6 are to be examined by the attending Surveyor. The additional equipment and personnel training requirements in Sections 8 and 9 are also to be verified by the attending Surveyor at this time, if applicable.

5.4 Notation Changes

The Owner may advise by written notice to the Bureau prior to or during the Annual Survey that the additional equipment and personnel training requirements in Sections 8 through 9 will not be complied with. The notation will be changed to **CCO** in this instance. See 1/5.2.

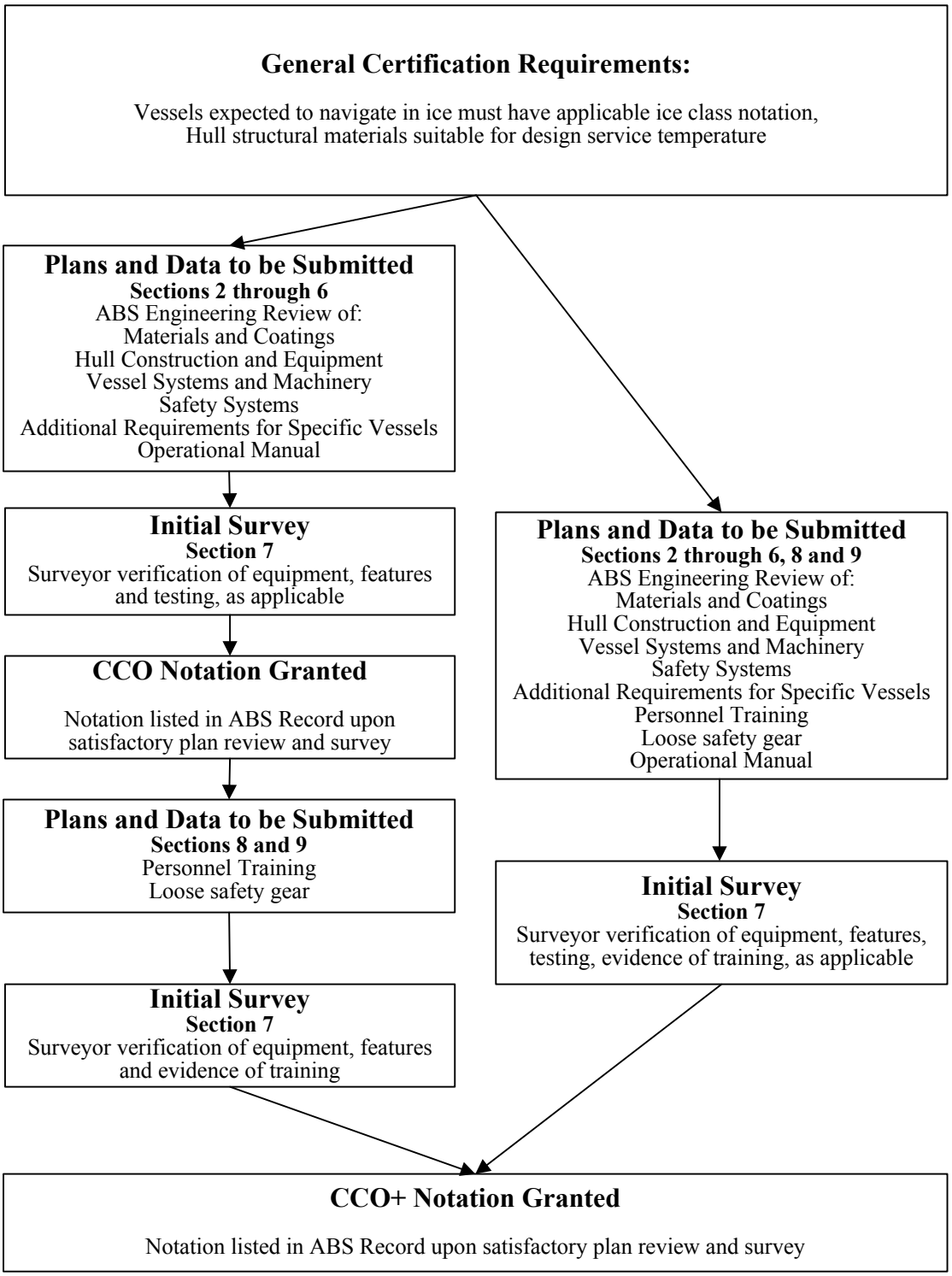
6 National Administration Requirements

National administrations have additional requirements for vessels operating in their territorial waters. These requirements may address additional vessel features, equipment, personnel training and instruction manuals. These requirements are not included in this Guide. A list of administrations is provided in Appendix 12.

7 Design Service Temperature

The design service temperature is to be selected based on the regions the vessel is designed to operate in. Temperature data for northern areas on a monthly basis are provided for guidance purposes only in Subsection A10/3, “Air Temperature”. A listing of various meteorological organizations is provided for guidance in Appendix 13.

FIGURE 1
Certification Procedure



SECTION 2 Materials, Welding and Coatings

1 General

Materials for exposed hull structures and deck machinery are to be selected so that they can perform the intended functions in cold weather.

All materials for Ice Class vessels are to be selected in accordance with the requirements for strengthening for navigation in ice provided in Section 6-1-1, "General Ice Classes", or other recognized Ice Class Rules as applicable. For non-Ice Class vessels, the requirements in this Section are applicable. For the case where there are no specific material requirements in the *Steel Vessel Rules* or other recognized Ice Class Rules, materials of hull structures and machinery exposed to the design service temperature and minimum anticipated temperature, respectively are to be selected to satisfy the requirements in this Section.

Material grades are to be selected based on design service temperature, material class and thickness. The considered design service temperature for hull and minimum anticipated temperature for machinery members exposed to low temperatures is specified in Section 2, Tables 1A and 1B. Material grade selections are to be in accordance with Section 2, Tables 2A through 2C. Special considerations shall be given to open hatch vessels.

2 Material of Hull Structural Members

The material class and design service temperature of hull structural members is to be in accordance with Section 2, Table 1A.

For rolled steel products listed in 2-1-2/Table 5 or 2-1-3/Table 5 of the ABS *Rules for Materials and Welding (Part 2)*, the appropriate grade to be used for respective material class and thickness is not to be of lower grade than those specified in Section 2, Tables 2A through 2C for respective material class and thickness.

3 Material of Machinery

3.1 Machinery Structural Members/Components Exposed to Weather

The material class and design service temperature of steel products used for exposed machinery foundations and load bearing components are to be in accordance Section 2, Table 1B. Material grade selection is to be selected in accordance with Section 2, Tables 2A to 2C.

3.2 Deck Machinery, Piping, Valves and Fittings

Deck machinery materials are to comply with material specifications in Part 2, Chapter 3 of the ABS *Rules for Materials and Welding (Part 2)* or of a national or international material standard. The proposed materials are to be approved in connection with the design. All such materials are to be certified by the material manufacturers and are to be traceable to the manufacturer's certificates. Materials for piping, valves and fittings for design service temperatures lower than -18°C (0°F) are to be selected in accordance with Section 2-3-13 of the ABS *Rules for Materials and Welding (Part 2)*.

3.3 Cranes, Lifting Appliances, Vehicle Ramps and Boat Davits

3.3.1 Cranes

In accordance with 2-1/9.19 of the ABS *Guide for Certification of Lifting Appliances*, the design service temperature for a crane is the minimum anticipated temperature at which the crane will operate (see Subsection 1/4 of this Guide), as specified by the Owner, crane manufacturer or builder, and is not to be higher than the temperature specified in Section 2, Table 1B. Having established the minimum anticipated temperature for each component, the following should be applied:

i) The material class and minimum anticipated temperature of steel products used for crane and foundation/pedestal are to be in accordance with Section 2, Table 1B. Material grade selection is to be selected in accordance with Section 2, Tables 2A to 2C.

ii) Crane structural components are to be tested in accordance with the requirements of Chapter 2, Section 3 of the ABS *Guide for Certification of Lifting Appliances*.

iii) The machinery components are to be assessed as per Chapter 2, Section 6 of the ABS *Guide for Certification of Lifting Appliances*, according to which it would have to be demonstrated by way of testing or analysis that such components will operate satisfactorily at the minimum anticipated temperature. In this regard, the testing requirements of Chapter 2, Section 3 of the ABS *Guide for Certification of Lifting Appliances* may also be applied to such components.

3.3.2 Lifting Appliances, Vehicle Ramps and Boat Davits

The minimum anticipated temperature at which lifting appliances, vehicle ramps and boat davits will operate, as specified by the Owner, equipment manufacturer or builder, is not to be higher than the temperature specified in Section 2, Table 1B. Having established the minimum anticipated temperature for each component, the following should be applied:

i) The material class and minimum anticipated temperature of steel products used for the equipment and foundation/pedestal, if applicable, are to be in accordance with Section 2, Table 1B. Material grade selection is to be selected in accordance with Section 2, Tables 2A to 2C.

ii) Structural components are to be tested in accordance with the applicable requirements of the ABS *Guide for Certification of Lifting Appliances*.

3.4 Material of Exposed Outfitting

Steel products used for deck machinery are to be selected from Section 2, Table 1B.

3.5 Insulated Members

Design service temperature for insulated members will be considered upon submission of substantiating data.

3.6 Criteria for Other Steels

3.6.1 Steels with Specified Minimum Yield Strength Below 410 N/mm^2, (42 kgf/mm^2, 60 ksi)

Where steels other than those in 2-1-2/Table 5 or 2-1-3/Table 5 of the ABS *Rules for Materials and Welding (Part 2)* are intended, their specifications are to be submitted for approval. These steels are to comply with the following impact test requirements:

Yield Strength		
N/mm^2	*kgf/mm^2*	*ksi*
235-305	24-31	34-44
315-400	32-41	45.5-58

CVN (Longitudinal)		
J	*kgf-m*	*ft-lbf*
27	2.8	20
34	3.5	25

At the following temperatures:

Class I – design service temperature

Class II – 10°C (18°F) below design service temperature

Class III – 20°C (36°F) below design service temperature

3.6.2 Steels with Specified Minimum Yield Strength in the Range of 410-690 N/mm^2 (42-70 kgf/mm^2, 60-100 ksi)

Where steels having this yield strength range are intended, their specifications are to be submitted for approval. These steels are to comply with the impact test requirements of 34 J (3.5 kgf-m, 25 ft-1bf) at the following temperatures:

Design Service Temperature	*Test Temperature*
0°C (32°F)	-30°C (-22°F)
-10°C (14°F)	-40°C (-40°F)
-20°C (-4°F)	-40°C (-40°F)
-30°C (-22°F)	-50°C (-58°F)
-40°C (-40°F)	-60°C (-76°F)

3.6.3 Alternative Requirements

As an alternative to these requirements, higher strength steels may comply with the following:

i) For transverse specimens, $^2/_3$ of energy values shown in 6-1-1/35.9.1 of the *Steel Vessel Rules*

ii) For longitudinal specimens, lateral expansion is not to be less than 0.5 mm (0.02 in.). For transverse specimens, lateral expansion is not to be less than 0.38 mm (0.015 in.).

iii) Nil-ductility temperature (NDT), as determined by drop weight tests, is to be 5°C (9°F) below the temperature specified in 6-1-1/35.9.1 of the *Steel Vessel Rules*.

4 Weld Metal

4.1 ABS Hull Steels

When the ABS ordinary and higher strength hull steels of 2-1-2/Table 5 or 2-1-3/Table 5 of the ABS *Rules for Materials and Welding (Part 2)* are applied in accordance with Section 2, Tables 2A through 2C, approved filler metals appropriate to the grades as shown in Part 2, Appendix 3 of the ABS *Rules for Materials and Welding (Part 2)* may be used.

4.2 Criteria for Other Steels

For the welding of hull steels other than the ABS grades in 6-1-1/Table 17 of the *Steel Vessel Rules*, weld metal is to exhibit a Charpy V-Notch toughness value at least equivalent to the transverse base metal requirements ($^2/_3$ of longitudinal base metal requirements).

5 Coatings

Hull coatings are to be durable and resistant to peeling, abrasion or other degradation of the coating performance because of low temperatures. Coating product information and testing results are to be submitted for information. See Subsection A2/5 for additional information.

TABLE 1A
Material Class of Structural Members

Structural Members	*Material Class*	*Design Service Temperature (DST)*
1. Sheer strake and deck stringer (1)		
i) within 0.4 *L* amidships	III	*DST*
ii) outside 0.4 *L* amidships	II	*DST*
2. Strength deck (1)		
i) within 0.4 *L* amidships	II	*DST*
ii) outside 0.4 *L* amidships	I	*DST*
3. Side shell above ice belt (1)	I	*DST*
4. Other hull structures exposed to low temperature (1)	I	*DST*
5. Plating and framing in enclosed spaces		
i) heated	I	0°C
ii) unheated	I	*MAT* (2)

Notes:

1 Include inboard framing members and other contiguous inboard members (e.g. bulkheads and decks) within 600 mm of the exposed plating.

2 Minimum Anticipated Temperature, (see Subsection 1/4).

TABLE 1B
Material Class of Machinery Structural Members/Components

Machinery Members	*Material Class*	*Design Service Temperature (DST)*
1. Exposed load bearing structural and machinery components directly exposed to the weather	II	*MAT* (1)
2. Load bearing structural and machinery components attached to and within a distance of 600 mm from the other parts which are directly exposed to the weather	II	*MAT* (1) + 10°C
3. Load bearing structural and machinery components attached to but at a distance of over 600 mm from the other parts which are directly exposed to the weather in enclosed spaces		
3a. Unheated space	II	*MAT* (1)
3b. Heated space	I	0°C

Notes:

1 Minimum Anticipated Temperature, (see Subsection 1/4).

TABLE 2A
Material Grades – Class I

Design Service Temperature					
Thickness in mm (in.)	*0 to -5°C (32 to 23°F)*	*-6 to -15°C (22 to 5°F)*	*-16 to -25°C (4 to -13°F)*	*-26 to -35°C (-14 to -31°F)*	*-36 to -45°C (-32 to -49°F)*
$t < 12.5$ ($t < 0.50$)	A,AH	A,AH	B,AH	B,AH	B [(2)],AH
$12.5 < t \leq 20$ ($0.50 < t \leq 0.79$)	A,AH	A,AH	B,AH	B,AH	D,DH
$20 < t \leq 25$ ($0.79 < t \leq 0.98$)	A,AH	A,AH	B,AH	D,DH	D [(1)],DH [(1)]
$25 < t \leq 30$ ($0.98 < t \leq 1.18$)	A,AH	A,AH	B,BH	D,DH	D,DH
$30 < t \leq 35$ ($1.18 < t \leq 1.38$)	A,AH	B,AH	B,AH	D,DH	D,DH
$35 < t \leq 40$ ($1.38 < t \leq 1.57$)	A,AH	D,DH	D,DH	D,DH	D,DH
$40 < t \leq 51$ ($1.57 < t \leq 2.00$)	B,AH	D,DH	D,DH	D,DH	E,EH

Notes:

1 To be normalized.

2 May be "A" if fully killed.

TABLE 2B
Material Grades – Class II

Design Service Temperature					
Thickness in mm (in.)	*0 to -5°C (32 to 23°F)*	*-6 to -15°C (22 to 5°F)*	*-16 to -25°C (4 to -13°F)*	*-26 to -35°C (-14 to -31°F)*	*-36 to -45°C (-32 to -49°F)*
$t \leq 12.5$ ($t \leq 0.50$)	A,AH	A,AH	B [(2)],AH	B [(2)],AH	B,AH
$12.5 < t \leq 20$ ($0.50 < t \leq 0.79$)	A,AH	A,AH	B,AH	D,DH	D [(1)],DH [(1)]
$20 < t \leq 25$ ($0.79 < t \leq 0.98$)	A,AH	B,AH	B,AH	D [(1)],DH [(1)]	D [(1)],DH [(1)]
$25 < t \leq 30$ ($0.98 < t \leq 1.18$)	A,AH	B,AH	D,DH	E,EH	E,EH [(3)]
$30 < t \leq 35$ ($1.18 < t \leq 1.38$)	B,AH	D,DH	D,DH	E,EH	E,EH
$35 < t \leq 40$ ($1.38 < t \leq 1.57$)	B,AH	D,DH	D,DH	E,EH	E,EH
$40 < t \leq 51$ ($1.57 < t \leq 2.00$)	D,DH	D,DH	D,DH	E,EH	E,EH

Notes:

1 To be normalized.

2 May be "A" if fully killed.

3 Grades D, DH are allowed for a single strake of side shell plating not more than 1.8 m wide from 0.3 m below the lowest ice waterline.

TABLE 2C
Material Grade – Class III

Design Service Temperature					
Thickness in mm (in.)	*0 to -5°C (32 to 23°F)*	*-6 to -15°C (22 to 5°F)*	*-16 to -25°C (4 to -13°F)*	*-26 to -35°C (-14 to -31°F)*	*-36 to -45°C (-32 to -49°F)*
$t < 12.5$ ($t < 0.50$)	A,AH	A,AH	B [(2)],AH	D,DH	E,EH
$12.5 < t \leq 20$ ($0.50 < t \leq 0.79$)	A,AH	B,AH	D,DH [(1)]	D [(1)],DH [(1)]	E,EH
$20 < t \leq 25$ ($0.79 < t \leq 0.98$)	B,AH	D,DH	D [(1)],DH [(1)]	E,EH	E,EH
$25 < t \leq 30$ ($0.98 < t \leq 1.18$)	B,AH	D,DH	E,EH	E.EH	E,EH
$30 < t \leq 35$ ($1.18 < t \leq 1.38$)	D,DH	D,DH	E,EH	E,EH	E,EH
$35 < t \leq 40$ ($1.38 < t \leq 1.57$)	D,DH	D,DH	E,EH	E,EH	E,EH
$40 < t \leq 51$ ($1.57 < t \leq 2.00$)	D,DH	D,DH	E,EH	E,EH	FH

Notes:

1 To be normalized.

2 May be “A” if fully killed.

SECTION 3 Hull Construction and Equipment

1 General

For vessels intended to navigate in ice, the applicable requirements for strengthening are provided in Section 6-1-1, "General Ice Classes" and Section 6-1-2, "Baltic Ice Classes", of the *Steel Vessel Rules*, or other recognized ice class Rules.

If the intended routes in which the vessel is expected to operate are ice free, then ice strengthening classification is not required.

The materials used in the hull structural members are to be in accordance with the requirements in Section 2 of this Guide.

Guidance Notes providing some additional information are provided in Appendix 3.

2 Tanks

2.1 Fresh Water Tanks

Fresh water tanks are to be arranged such that the tank boundaries do not include the side shell or the deck exposed to the weather. The tanks are to be provided with arrangements to prevent freezing.

2.2 Fuel Oil Tanks

Fuel oil tanks are to be provided with heating arrangements (See 4-6-4/13 of the *Steel Vessel Rules*). Tank heating calculations are to be provided to show sufficient heat transfer capacity for the design service temperature.

2.3 Ballast Water Tanks

Ballast water tanks for design service temperatures equal to or above -30°C (-22°F) but lower than -10°C (-4°F) are to be provided with arrangements to prevent freezing. These arrangements may be heating systems or turbulence-inducing systems, such as bubbler systems. See 4/5.2.1.

Vessels with design service temperatures less than -30°C (-22°F) are to be provided with steam heating coils. Tank heating calculations are to be provided to show sufficient heat transfer capacity for the design service temperature. See 4/5.2.

Reference is made to IMO MEPC 54/2/5 – Draft Practical Guidelines for a Ballast Water Exchange Management Strategy in the Antarctic Treaty Area.

2.4 Additional Measures for Oil Pollution Prevention

The optional requirements of 4-6-4/17 of the *Steel Vessels Rules* for the protection of fuel oil and lubricating oil tanks may be applied. The Class notation **POT** – Protection of Fuel and Lubricating Oil Tanks will also be listed in the *Record*.

3 Superstructures and Deckhouses

3.1 Forecastles

Forecastles are recommended so as to deflect waves and spray away from the deck areas aft of the bow. If a forecastle is not provided, the shell plating is to be flared so as to deflect waves and spray away from the main deck area aft of the bow. The bow area is to be designed to protect anchoring and mooring equipment and operating personnel by means of sheltered or enclosed spaces.

3.2 Deckhouses

The bridge wings are to be enclosed or designed to protect navigational equipment and operating personnel. See 5/3.1v).

External access to the navigation bridge windows is to be provided to facilitate their cleaning.

Alternate navigation bridge windows are to be heated and provided with window wipers and cleaning system for de-icing purposes.

All doors on emergency escape routes and navigation bridge doors are to be designed and arranged so that they remain free of snow and ice so as to be readily functional.

When personnel are required to perform functions such as a lookout when underway, or security at the gangway when in port, a heated deckhouse is to be provided for sheltering purposes.

3.3 Exterior Stairs

Exterior stairs are to be installed at a lower angle of about 35 degrees with landings made of grated material to permit ready removal of snow and ice.

Grating materials which increase traction are to be installed.

3.4 Operating Platforms for Deck Equipment

The operating stations for deck equipment (see Subsection 1/4) are to be provided with a grated platform to permit ready removal of snow and ice, and to increase traction.

4 Stern

4.1 Towing Notch for Ice Breakers

When provided, towing notches are to be constructed as appendages to the main hull structure.

Fendering is to be used to reduce the possibility of damage at the stern notch, including the bow of the towed vessel. The notch is to be designed to accept various bow shapes.

See A3/4.1 for additional information.

5 Stability

Vessels operating in low temperature environments will be subject to spray and subsequent build-up of ice on the exposed parts of the hull and superstructure.

Ice build-up is most probable in the forward parts of a vessel, but smaller vessels can experience significant icing thicknesses in almost all areas. This can present an extreme safety hazard, as the increase in topweight (aggravated by changes in trim) reduces the stability of the vessel. Stability information onboard should be sufficient to allow masters to recognize such risks as they arise and to take measures to address the situation.

The IMO Code on Intact Stability requires an allowance for ice accretion for certain vessel types. Other Administrations may have additional requirements for ice accretion.

The vessel is to be provided with equipment for de-icing. See 4/5.1.7 and A4/5.1.7.

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SECTION 4 Vessel Systems and Machinery

1 General

Section 4 contains the Guide requirements for machinery. These requirements are organized similarly to the sections in Part 4 of the *Steel Vessel Rules*. These requirements are in addition to those listed in Part 4 of the *Steel Vessel Rules.*

Guidance Notes have been provided in Appendix 4 to indicate background and intent of the Guide requirements and, for some cases, recommendations or examples as to how the requirements may be complied with.

2 Prime Movers

2.1 Prime Mover Operating Characteristics for Ice Class Vessels

The propulsion plant is to be capable of continuous operation at low power outputs and/or low vessel speeds.

2.3 Combustion Air Systems

The combustion air system is to be based on the design service temperature of the outside air.

2.3.1 Combustion Air for Internal Combustion Engines

2.3.1(a) Means are to be provided to pre-heat combustion air for proper functioning of the main propulsion, auxiliary and emergency generator internal combustion engines in accordance with the engine manufacturer's recommendations.

2.3.1(b) The combustion air is to be led directly from the outside of the machinery space to the engines having a rated power of 100 kW (135 HP) and over by way of ducting or other suitable means such that all of the combustion air is not drawn from the machinery space.

2.3.1(c) The combustion air intakes are to be located on both sides of the vessel and arranged so as to prevent: the recirculation of engine exhaust gases into the combustion air intakes; ice accumulation; and blockage of the duct.

2.3.2 Combustion Air for Other Prime Movers

Combustion air for other prime movers is to be provided in accordance with the manufacturer's recommendations. The details and arrangements will be subject to special consideration.

2.4 Turbochargers

Turbochargers and the associated combustion air system for internal combustion engines are to be designed to obtain surge-free operation throughout the range of ambient air temperatures in which the vessel is expected to operate.

2.5 Lubricating Oil Systems

All main propulsion and auxiliary prime movers are to be provided with the capability for the lubricating oil to be maintained at the proper minimum temperature in accordance with the manufacturer's recommendations to allow equipment start-up.

The use of steam heating coils within prime mover sump tanks is not permitted.

3 Propulsion and Maneuvering Machinery

For ice class vessels, the additional requirements for propulsion and maneuvering machinery are in the applicable sections of Part 6, Chapter 1, "Strengthening for Navigation in Ice" of the *Steel Vessel Rules*.

3.1 Propulsion Shafting Bearing Lubrication for All Vessels

3.1.1 Oil-Lubricated Bearings

Vessels with mineral-based oil-lubricated stern tube bearings are to be provided with pollution-free sealing arrangements.

Means are to be provided to heat the lubricating oil to maintain viscosity in accordance with the bearing manufacturer's requirements.

3.1.2 Biodegradable Oil-Lubricated Bearings

Vessels with stern tube bearings lubricated with biodegradable lubricant may be fitted with typical shaft sealing arrangements.

The requirements of 4/3.1.1 for providing lubricating oil heating arrangements are also applicable.

3.1.3 Water-Lubricated Bearings

Vessels may be fitted with water-lubricated bearings. The bearings are to be suitable for continuous operation in low temperatures.

3.2 Fixed Pitch Propellers for Ice Class Vessels

See 4A/3.2 for guidance related to propeller blade attachment methods.

3.3 Controllable-Pitch Propellers for Ice Class Vessels

The controllable-pitch system is to be designed to take into account the numerous pitch reversals to be expected when operating in ice conditions. Calculations or service experience from the manufacturer are to be submitted for information.

4 Deck and Other Machinery

Deck and other machinery exposed to the design service temperature or located in unheated spaces are to be suitable for operation at the minimum anticipated temperature, (see Subsection 1/4).

4.1 Anchoring Arrangements for Ice Class Vessels

4.1.1 Ice Breaking Vessels

The locations of the anchors are to be considered with respect to the waterline and anticipated ice conditions. Consideration is to be given to the height of anticipated ice ridges and rubble; and whether close towing operations will be conducted.

4.1.2 Ice Class Vessels

The locations of the anchors are to be considered with respect to towing operations with the ice breaker.

4.2 Anchor Windlass

The requirements of 4-5-1 of the *Steel Vessel Rules* are to be complied with, including these following requirements:

i) The anchor windlass is to be suitable for operation at the minimum anticipated temperature.

ii) Anchor releasing arrangements are to be provided in such a manner as to reduce the effects of icing.

iii) All electric motors located on deck or in an unheated compartment are to be fitted with anti-condensation heaters.

iv) Hydraulic oil sumps are to be provided with heaters or other suitable means for heating purposes, where necessary. The use of steam heating coils is not permitted.

v) For hydraulic equipment, the hydraulic oil is to be suitable for the minimum anticipated temperature.

vi) All windlass components subject to tensile stresses are to be constructed of materials subjected to impact testing.

4.3 Towing Winch

If a vessel is expected to undertake regular towing operations, a towing winch is to be provided.

The design, construction and testing of the towing winch is to conform to an acceptable standard or code of practice. To be considered acceptable, the standard or code of practice is to specify criteria for stresses, performance and testing.

The requirements of 4/4.2i), iii), iv), v), and vi) are applicable.

Towing winches are to be of the electric or electro-hydraulic type, single drum, constant tensioning, and fitted with automatic spooling gear.

The winch is to be able to be controlled from the navigation bridge and an emergency override is to be located in close proximity to the winch itself.

The design load of the towing winch is to be based on the available total thrust of the vessel.

4.4 Towing Lines

The towing line breaking strength is to be determined in accordance with the requirements of the standard or code of practice in 4/4.3.

4.5 Towing Fittings for Ice Class Vessels

All ice-strengthened vessels are to be provided with arrangements for being towed. Substantial fittings such as bollards should be well incorporated into the hull structure and should be sized for the high dynamic loads that can be experienced in ice. The towing fittings are to be suitably marked with the maximum allowable load, manufacturer, etc. Refer to IMO DE 48 Guidelines.

In some areas (e.g., areas subject to Baltic administrations), the vessel is to be provided with arrangements to secure the anchors onboard the towed vessels. This may be accomplished by swinging the anchor aft to prevent contact with the towing vessel, in particular for ice breakers with a notch stern. This may be accomplished with shackles and cables.

Emergency towing arrangements are to be provided along with suitable arrangements or equipment to provide de-icing capability.

4.6 Cargo Handling

Cargo handling equipment that may be affected by low temperature environments include cranes, hatch covers, ramp and side doors, cargo pumps and deck cargo securing equipment.

4.6.1 Cranes

Cranes and any other lifting devices exposed to low temperatures are to be certified in accordance with the ABS *Guide for Certification of Lifting Appliances* at the minimum anticipated temperature.

4.6.2 Hatch Covers, Ramp Doors and Side Doors

Arrangements or equipment is to be provided to efficiently remove ice build up around hatches and doors. If the hatches or doors are hydraulically operated, the hydraulic oil should be suitable for the minimum anticipated temperature. A heater or other suitable means for heating purposes is to be provided for the hydraulic oil sump, where necessary. The use of steam heating coils is not permitted. Suitable materials for the minimum anticipated temperature for hatch and door seals are to be provided.

4.6.3 Cargo Pumps

Cargo pumps and their auxiliary equipment (e.g., valves) are to be suitable for operation at the minimum anticipated temperature. If the cargo pumps are hydraulically operated, the hydraulic oil should be suitable for the minimum anticipated temperature and circulated to avoid cold spots. A heater or other suitable means for heating purposes is to be provided for the hydraulic oil sump, where necessary. The use of steam heating coils in hydraulic oil sumps is not permitted. Electric motors driving cargo pumps are to be provided with space heaters.

4.6.4 Deck Cargo Securing Equipment

Deck cargo securing equipment (e.g., container lashings) is to be suitable for the minimum anticipated temperature.

5 Piping Systems

5.1 General

Auxiliary machinery systems and equipment may be subjected to the design service temperature, ice accumulation and ice ingestion. Piping systems exposed to the design service temperature or piping systems in unheated enclosed areas of the vessel are to meet the requirements of this Subsection. Piping systems are to be suitable for the minimum anticipated temperature, (see Subsection 1/4).

All piping systems throughout the vessel should be designed to minimize exposure of crew to low temperature environmental hazards during normal operation and routine maintenance.

See also Section 6, “Specific Vessel Requirements” for any additional requirements.

5.1.1 Materials

Materials subjected to the design service temperature are to be resistant to brittle fracture and are to meet the requirements of Subsection 2/3.

5.1.2 Flexible Hoses

Seals and hoses are required to remain flexible at the design service temperature. Lubricants and working fluids are to be suitable for the design service temperature.

5.1.3 Valves

Valves and closures are to be selected and located or otherwise protected to avoid freezing of fluids on either side of the valve and to prevent the accumulation of snow and spray ice. Moving parts may require to be heated, continuously or prior to operation.

5.1.4 Pipes

Pipes shall be arranged to drain effectively.

Components, such as valves, valve control units and manifolds, exposed to the design service temperature are to be in sheltered locations as far as practicable.

5.1.5 Tank Vents

Blockage of vent pipes by ice accumulation or by freezing of plugs inside the pipe are to be mitigated by configuration of the vent pipe or trace heating with consideration to the contents of the tank.

5.1.6 Pipe Drainage

Piping systems and equipment prone to freezing are to be able to be drained and are to be provided with drain cocks to facilitate drainage.

5.1.7 De-icing and Heat Tracing

As the vessel arrangements differ greatly depending on vessel size, service and operating area, guidance for de-icing and heat tracing various systems and equipment onboard are provided in A4/5.1.7.

Heating power capacity for anti-icing and de-icing shall not be less than:

- 300 W/m^2 for open deck areas, gangways, stairways, etc.
- 200 W/m^2 for superstructures
- 50 W/m^2 for railings with inside heating

Other areas will be considered upon submittal of individual specifications.

A test program for de-icing and heat tracing is to be submitted for review and use by the Surveyor. The capability of the de-icing and heat tracing systems to function as proposed by the builders is to be demonstrated by operation/testing.

5.1.8 Heating and Ventilation

i) The heating and ventilation systems are to be designed for satisfactory distribution of heating at the minimum anticipated temperature.

ii) Supplementary electric heaters may be used in cabins and other manned spaces. High amperage portable heaters are not to be wired to the same circuit breakers as vital electronic equipment.

iii) The relative humidity is to be maintained in the range between 30% to 70%.

iv) Accommodation spaces are to be able to be heated to 20°C at the design service temperature.

v) Recirculation of air in the accommodation spaces is to be a maximum of 30%.

vi) Air ventilation ducting is to be insulated with non-combustible insulation.

vii) The closing apparatus for ventilation inlets and outlets are to be located so as to be protected from snow and ice accumulation that may interfere with effective operation of the closures and recirculation of exhaust gases.

5.2 Ship Piping Systems and Tanks

5.2.1 Ballast Water Tanks

Any ballast water tank arranged such that the top of the tank is located above the lightest operating draft is to be provided with arrangements to prevent freezing of the ballast water. Acceptable arrangements include turbulence and convection-inducing systems, for example, bubble systems and heating coils. Other arrangements will be specially considered. See 3/2.3.

5.2.2 Ballast Water Tanks for Design Service Temperatures Below -30°C (-22°F)

For design service temperatures below -30°C (-22°F), steam heating coils are to be fitted.

5.3 Piping Systems for Prime Movers

5.3.1 Fuel Oil System

5.3.1(a) Fuel Oil Heating. Fuel oil heating systems are to be designed to provide uninterrupted service of fuel oil to the prime movers.

5.3.1(b) Fuel Oil Filling Stations. Fuel oil filling stations are to be located in an area sheltered from the weather. For fuel oil filling pipes located on the deck, alternative arrangements to protect the filling pipes are to be provided.

5.3.2 Cooling System

5.3.2(a) Seawater Systems for Ice Class Vessels. Seawater system requirements for Ice Class vessels are provided in the *Steel Vessel Rules*. See 6-1-1/47.15, "Sea Chests" (Ice Class **A0**, **B0**, **C0** and **D0**); 6-1-1/47.17, "Cooling Water Arrangements" (Ice Classes **A1** through **A5**); or 6-1-2/35.3, "Sea Inlet Chests for Cooling Water Systems and Fire Main for Baltic Ice Classes".

Alternative arrangements will be specially considered, such as heat exchangers integral with the hull bottom.

5.3.2(b) Seawater Piping – All Vessels

- The use of gray cast iron material for piping, valves and fittings is prohibited.
- Water drains should not generally discharge above the load waterline.
- Direct steam connections to the sea chests are to be provided for de-icing purposes.
- For vessels with a design service temperature below -30°C (-22°F), steam or heat tracing is to be provided on all overboard discharges.

5.3.2(c) Engine Cooling. Main and auxiliary engine cooling lines, if exposed to freezing temperatures, are to be suitably insulated or heated. Alternatively, antifreeze may be used in the cooling water.

5.3.3 Fresh Water Systems

i) See 3/2.1.

ii) Fresh water pipe runs through void spaces are to be insulated and heat traced.

iii) All water lines exposed to freezing temperatures are to be fitted with drain cocks at the lowest part of the piping arrangement.

iv) Fresh water generation systems' inlet temperatures are to be in accordance with the manufacturer's requirements.

5.4 Other Piping Systems

No additional requirements.

5.5 Waste Storage and Disposal Systems

Regulations in the Baltic, Arctic and Antarctic regions vary among the administrations. Guidance is provided in A4/5.5.

5.6 Starting Air System

5.6.1 General

The compressed air supplied to the control air system is to have a dew point 20°C (36°F) below the design service temperature.

5.6.2 Starting Air System – Ice Class Vessels

The requirements of 4-6-5/9 in the *Steel Vessel Rules* are applicable with the exception that the requirements in 4-6-5/Table 4 are to be replaced with the following requirements in Section 4, Table 1:

TABLE 1
Required Number of Starts for Propulsion Engines

Engine Type	*Single Propeller Vessels*		*Multiple Propeller Vessels*	
	One engine coupled to shaft directly or through reduction gear	*Two or more engines coupled to shaft through clutch and reduction gear*	*One engine coupled to each shaft directly or through reduction gear*	*Two or more engines coupled to each shaft through clutch and reduction gear*
Reversible	16	20	20	20
Non-reversible	6	8	8	8

6 Fire Safety Systems

6.1 Fire Fighting System

6.1.1 Fire Extinguishing Design and Location

Fire extinguishing systems are to be designed or located so that they are not made inaccessible or inoperable by ice or snow accumulation or low temperature. Alternative fire fighting system designs suitable for use in a low temperature environment, (e.g., aerosol fire fighting system for enclosed spaces (engine room, pump room, etc.), will be considered upon submittal of substantiating data. The fire extinguishing system is to be such that:

i) Equipment, appliances, extinguishing agents and systems are always to be protected from freezing.

ii) Precautions are to be taken to prevent nozzles, piping and valves from freezing or becoming clogged due to internal or external ice build up.

iii) Exhaust gas outlets and pressure/vacuum arrangements (e.g., prime movers or spaces) are to be protected from ice build-up that could interfere with effective operation.

6.1.2 Water or Foam Extinguishers

Water and foam extinguishers should be located in positions protected from freezing temperatures, as practicable. Locations subject to freezing are to be provided with extinguishers capable of operation at the design service temperature.

6.1.3 Fire Pumps and Associated Equipment

i) Where fixed fire fighting systems or alternative fire extinguishing systems are situated in a space separate from the main fire pumps and utilizing their own independent sea suction, this sea suction is to be also capable of being cleared of accumulations of ice. See 4/5.3.2(a).

ii) Fire pumps, including emergency fire pumps, are to be located in heated compartments. The pumps and their auxiliaries in the compartment are to be adequately protected from freezing at the design service temperature.

iii) Isolating valves are to be in accessible locations. Isolating valves located in exposed locations are to be protected from freezing spray. The fire main is to be arranged so that external sections can be isolated and means of draining are to be provided.

iv) Hydrants are to be positioned or designed to remain operable at the design service temperature. Ice accumulation and freezing are to be taken into account.

v) All hydrants are to be installed with a two-handed valve lever or hand wheels and provided with quick connects for hoses.

vi) Valves and hydrants exposed to design service temperatures less than or equal to -30°C (-22°F) are not to be of cast iron.

6.1.4 Protection Against Ice Build Up

Components of the fire fighting system that may be exposed to icing that could interfere with the proper functioning of that component are to be adequately protected.

6.1.5 Fire-fighter's Outfits

i) Fire-fighter's outfits are to be located within accommodation areas and other spaces, as appropriate, suitably protected from low temperature conditions. The outfits are to be stored in positions as widely separated as practicable and readily accessible by the crew.

ii) In addition to the fire-fighter's outfits required in 4/6.1.5i), one spare fire-fighter's outfit is to be provided. The spare outfit is to be stored in a location protected from low temperatures where access is provided to the open deck.

7 Electrical Systems

The Paragraph and Subparagraph numbering in this Subsection corresponds to the Section and Subsection numbering in Part 4, Chapter 8 of the *Steel Vessel Rules*.

7.2 System Design

7.2.3 Main Source of Electrical Power

Where central electric power plants or shaft generators are installed, the requirements in 4-8-2/3 of the *Steel Vessel Rules* are applicable.

7.2.5 Emergency Source of Electrical Power

7.2.5(a) Additional Systems, Equipment and Spaces. The following systems and equipment are to be provided with an emergency source of power in addition to those listed in 4-8-2/5.5:

- Operation and control of the auxiliary boiler, if fitted.
- Heat tracing for any piping associated with the emergency services listed in 4-8-2/5.5.

In addition to the emergency services listed in 4-8-2/5.5 of the *Steel Vessel Rules,* emergency heating is to be available for a period of 18 hours for the following spaces:

- Navigation Bridge
- Radio Room
- Engine Control Room
- Centralized Control Station
- Cargo Control Room
- Machinery Space Workshop
- Emergency Generator Room
- Battery Room
- Two common areas (e.g., Mess Room and Recreation Room)
- Hospital
- Heated Compartments for Fire Control Station and Fire Fighting Equipment

7.2.5(b) Increased Emergency Services Time. As an option, the time periods listed in 4-8-2/5.5.2 through 4-8-2/5.5.9 of the *Steel Vessel Rules* and 4/7.2.5(a) of this Guide may be increased from 18 hours to 36 hours for vessels anticipated to operate in remote areas. This increased time will be shown in the classification notation.

7.2.11 Specific Systems

7.2.11(a) Navigation Light System. Exposed lights are to be suitable for operation at the design service temperature and environmental conditions.

7.3 Electrical Equipment

7.3.3 Rotating Machines

7.3.3(a) Battery Storage Space. A battery storage space is required to be provided with mechanical ventilation to supply heated air.

7.3.3(b) Motors and Generators. Electric motors and generators in unheated spaces are to be:

i) Fitted with means to prevent moisture condensation in the machine when idle.

ii) Provided with lubricating oil suitable for the design service temperature if the bearings require forced lubrication or pre-lubrication.

All exterior electric motors are to be fitted with means to prevent moisture condensation in the machine when idle.

7.3.5 Switchboards, Motor Controllers, etc.

Switchboards, power and lighting distribution boards, motor control centers and motor controllers and battery charging panels located in compartments that may be subject to low temperatures are to be provided with space heaters.

These components are to be suitable for continuous operation resulting from vibrations from ice impacts and vessel maneuvering and not trip inadvertently.

7.3.9 Cables

Electric cables in exposed areas are to be suitable for operation at the design service temperature. Sheathing is to be provided to protect the cables from mechanical damage. Electric cables are to be in accordance with a recognized standard such as IEC 60092-350.

8 Remote Propulsion Control and Automation

8.1 Monitoring

Standby propulsion and auxiliary machinery are to be provided with low temperature monitoring and alarms to alert the operator of an event when the machinery's temperature is too low for the equipment to start.

9 Remote Control and Monitoring for Auxiliary Machinery and Systems Other Than Propulsion

No additional requirements.

SECTION 5 Safety Systems

1 General

This Section lists requirements for various equipment necessary for the protection and survival of the personnel onboard the vessel. It should be noted that for vessels operating in low temperature environments, rescue and medical services may be significantly delayed because of weather conditions or remoteness of the area.

Additional Guidance Notes have been provided in Appendix 5.

A list of Administrations with coasts on the Arctic and Antarctic Oceans and the Baltic Sea are listed in Appendix 12.

2 Heating for Survival

Heating systems are considered essential for safety and survival. Therefore, the emergency generator is to be sized to maintain crew survivability. The spaces listed in 4/7.2.5 are to be able to be maintained at a minimum of 10°C (50°F) at the design service temperature.

3 Navigational Equipment

Navigation in ice-covered waters is assisted by specialized equipment and services to support both strategic (route planning) and tactical (ice avoidance) decisions. All navigational equipment is to be capable of being operated in the environmental conditions at the design service temperature.

3.1 Equipment

The following equipment is to be installed onboard:

i) Weather telefax receivers or equivalent capable of receiving high resolution ice weather charts

ii) Radar systems capable of picking up ice targets.

iii) Adequate communications and signaling equipment.

iv) High powered xenon arc searchlights remotely operated and positioned to provide 360 degrees of lighting capability, if possible.

v) Sound reception system for navigation bridge with enclosed bridge wings for reception of exterior noises/signals.

4 Life Saving Appliances and Survival Arrangements

This Subsection lists requirements for various life saving appliances. They are based in part on the following International Maritime Organization (IMO) documents:

- MSC Circular 1056/MEPC Circular 399 (2002), Guidelines for Ships Operating in Arctic Ice-Covered Waters.
- IMO Life Saving Appliances Code (2003) (from MSC.81(70) (1998) and MSC.48(66) (1996)).

The flag state administration and the administrations responsible for the coastal areas that the vessel will be operating in may have requirements in addition to those listed.

Life saving appliances are to be of a type that is rated to perform its functions at its design service temperature or a minimum temperature of -30°C (-22°F).

Additional rations and drinking water are to be provided onboard all lifeboats and life rafts. Extra rations (caloric intake) are required by personnel subjected to extremely cold temperatures. Drinking water containers are to be suitable to allow for thermal expansion while frozen. Consideration should be given to storing rations and drinking water, in addition to those in the lifeboats and life rafts, inside the deckhouse/accommodations to protect them from freezing. These additional rations and drinking water are to be stored in such a space or container so as to be convenient for placement into the survival craft should evacuation become necessary.

It should be understood that most EPIRBs and Personal Floatation Device (PFD) lights are automatically activated by contact with water, which may not happen when vessels are evacuated in ice-covered waters. Crews need to be aware of this fact, and are to be provided with equipment (e.g., manually activated) that facilitates other ways of transmitting distress and location information. EPIRBs and PFD lights selected are to be able to operate at the design service temperature.

4.1 Lifeboats

Totally enclosed lifeboats are required for all vessels operating in low temperature environments, as they offer shelter to the occupants from the environment. Lifeboats are to meet the requirements of the IMO Life Saving Appliances Code and the flag state administration. The following additional requirements are to be complied with:

i) The capacity of the lifeboats are to be sized for 125% of crew size based on increased dimensions as crews are presumed to be dressed in bulky cold weather clothing. Lifeboat access and operations are to be based on these increased dimensions. Most lifeboats will not accommodate their SOLAS capacities when crews or passengers are dressed in bulky clothing.

ii) The lifeboat engine is to be suitable for cold starting and continuous operation at the design service temperature instead of the test temperature per 4.4.6.2 of MSC.48(66) (1996) and 6.10.2 of MSC.81(70) (1998). Engine block heaters may be considered for oil sumps. Cooling water, fuel and lubricating oils for engines are to be suitable for engine operation at the design service temperature.

iii) The propeller is to be protected from contact with ice.

iv) For ice class vessels, the lifeboat's keel is to be protected from contact with ice by a bar or similar device.

v) Lifeboats are to be provided with radio equipment and batteries suitable for operation at the design service temperature.

vi) Lifeboat releasing gear is to be shielded or protected from freezing for ready release or reattachment.

vii) Lifeboats are to be provided with heaters and heating fans to reduce humidity and prevent icing and blockage of entrance doors. For design service temperatures less than -30°C (-22°F), heater cables are to be installed for hatches and doors to prevent freezing.

viii) For ice class vessels, lifeboats are to be equipped to be capable of being hoisted/pulled onto ice so as to provide shelter.

ix) Lifeboats are to be equipped so as to be capable of deterring native animal invasion (e.g., polar bears).

4.2 Life Rafts

Life rafts are to meet the requirements of the IMO Life Saving Appliances Code and the flag state administration.

Inflation of inflatable life rafts for design service temperatures less than -30°C (-22°F) is to be completed within a period of 3 minutes at the design service temperature. After inflation, the life raft is to maintain its form when loaded with its full complement of persons and equipment.

4.3 Rescue Boat

A rescue boat, if provided, is to meet the requirements of the IMO Life Saving Appliances Code and the flag state administration. The following additional equipment is to be provided onboard the rescue boat:

i) Radio equipment with batteries suitable for the design service temperature is to be installed.

ii) A battery charger

iii) An engine block heater

4.4 Launching Stations and Arrangements

The requirements of this Paragraph are applicable for lifeboats, life rafts and rescue boats.

Launching appliances onboard ice class vessels operating in ice-covered waters need to be specially considered. Free-fall lifeboats cannot be released onto ice-covered waters without risking the safety of occupants because of impact with the ice and/or surfacing under ice floes. Where free-fall craft are required by other regulations, they are also to be provided with a secondary means of launching. Standard lifeboats have almost no ice-transit capability, and they should be launched into the vessel's track to maximize their ability to get clear of a sinking or burning vessel. Launching stations are to be located considering their suitability to facilitate abandoning the vessel during navigation in ice-covered waters.

Arrangements are to be provided to permit lowering life rafts onto the ice rather than into the water.

For ice class and non-ice class vessels, the forward end of the lifeboat stations is to be shielded with a roof and wind walls to reduce ice and snow accretion on the lifeboat canopy, davits, sheaves and wires. The launching arrangements for boats and their retrieval are to be protected with a cover over the sheaves and wires.

Grease or lubricant used for the sheaves is to be suitable and is not to exhibit degraded performance at the design service temperature.

4.5 Ice Gangway, Personnel Basket and Escape Chutes

An ice gangway or personnel basket used in conjunction with a crane may be considered, subject to approval of the flag state administration.

Escape chutes, if provided, are to meet the requirements of the IMO Life Saving Appliances Code and the flag state administration. The escape chute is to provide a means of landing safely on the ice pack. Equipment is to be provided for shelter.

4.6 Immersion Suits and Life Jackets

The requirements in Chapter 11 of IMO MSC Circular 1056/MEPC Circular 399 (2002) Guidelines for Ships Operating in Arctic Ice-Covered Waters with regard to immersion suits and life jackets and the flag state administration are to be complied with.

Adequate supplies of immersion suits and life jackets are to be provided on the vessel for all persons onboard at any time.

Personal immersion suits may be stored in cabins to be used during lifeboat musters in order to avoid moisture accumulating in suits stored at lifeboat stations.

4.7 Alarms, Escape Routes, and Access Routes

The requirements in Chapter 4, Accommodation and Escape Measures of IMO MSC Circular 1056/MEPC Circular 399 (2002) Guidelines for Ships Operating in Arctic Ice-Covered Waters, and the flag state administration are to be complied with.

5 Drills and Emergency Instructions

Crew members are to be provided with proper onboard instructions and be regularly trained in the operation of the vessel's evacuation, survival at sea and on ice/ashore, fire and damage control equipment and systems with appropriate cross-training of crew members with appropriate emphasis to changes to standard procedures made necessary by operations in low temperature environments.

6 Provisions and Spares

The flag state administration and the administrations responsible for the coastal areas that the vessel will be operating in may have additional requirements related to provisions and spares.

SECTION 6 Specific Vessel Requirements

1 Application

Many vessel types have design and operational characteristics which require special consideration. Additional requirements for some of the main vessel types now in use or under consideration for low temperature environment services are provided.

Additional Guidance Notes have been provided in Appendix 6.

2 Vessels Intended to Carry Liquefied Gases in Bulk

2.1 General

These requirements are intended to apply to vessels with the classification ✠ **A1 Liquefied Gas Carrier** or ✠ **A1 Liquefied Natural Gas Carrier** and subject to the requirements in Part 5C, Chapter 8 of the *Steel Vessel Rules*. These are additional requirements to those in the other sections of this Guide.

2.1.1 Design Loads

The requirements of this Section will only consider Liquefied Natural Gas carriers operating in waters without any significant ice cover. Loads resulting from interaction with ice and loads caused by navigation in ice are to be verified as part of the overall design development, and considered when assigning a suitable Ice Class Notation in accordance with Part 6 of the *Steel Vessel Rules*.

2.1.2 Plans and Data to be Submitted

The following systems/components will be subject to the additional requirements in this Subsection for operation at the design service temperature:

- Ballast Tank Heating Arrangements
- Cargo Piping Diagram
- Cargo Pressure and Temperature Control Systems
- Cargo Tank Vent Systems
- Interbarrier and Insulation Space Venting Systems
- Environmental Control Systems (e.g., nitrogen purging systems)
- Inert Gas System
- Electrical Installations
- Additional Fire Safety Requirements, including Water Spray System
- Mechanical Ventilation in Cargo Area
- Instrumentation for Gauging, Gas Detection, and Cargo Handling Controls

- Details of the arrangements for the use of cargo as fuel and associated fuel gas piping diagrams and other arrangements for utilization of boil-off gas (BOG)
- Details of additional Personnel Protection arrangements

2.2 Material Selection

Materials entering into the construction of Liquefied Gas Carriers and associated equipment and cargo containment systems are to be in accordance with the requirements in Section 2 of this Guide, Part 5C, Chapter 8 of the *Steel Vessel Rules* and the ABS *Rules for Materials and Welding (Part 2)*.

2.3 Hull Construction and Equipment

2.3.1 Ice Loads

Loads attributable to ice and snow accumulation on the containment system or any cover for the containment system are to be determined, taking into account both the static load and dynamic load from sliding or dropped ice

2.3.2 Weather Deck Equipment

Due to the nature of the cargo, many cargo-related systems and equipment are designed for operation at low temperatures. However, it is necessary to consider both external and internal low temperatures in the design and selection of materials.

For cargo piping and piping supports installed on the main deck and exposed to the weather, including ventilation piping, the design loads are to include the expected amount of ice and snow accumulation.

The supports for liquid and vapor cargo piping systems on deck are to be arranged so that free expansion and contraction of the pipes during cargo operations cannot be blocked by accumulated ice or snow.

2.3.3 Stability

Liquefied gas carriers with cargo tanks or tank covers protruding from deck and/or with many exposed piping systems and features in elevated locations are likely to accumulate large amounts of ice in the upper part of the vessel, adversely affecting stability.

Intact and damage stability calculations are to take into account the weight of ice accumulation in exposed areas by means of an allowance for ice accretion based on the specific configuration of decks, piping systems and features in the cargo area for the particular vessel.

2.4 Machinery and Electrical Equipment

Many LNG carriers utilize cargo boil-off as fuel for propulsion power. The normal rate of boil-off (NBOR) depends on the insulation of the cargo tanks and the external temperatures. For vessels capable of operating in the “gas only mode” and operating near the design service temperature, the expected boil-off volumes are to be determined to assure that the provisions for forced boil-off are adequate.

2.4.1 Valves

Safety Relief Valves and other valves exposed to the weather, as described in Part 5C, Chapter 8 of the *Steel Vessel Rules,* are to be arranged in such a way as to provide their local and remote activation under all circumstances. Means of ice removal and heat tracing of the valves are to be provided. Valve actuators with local position indicators are to be of the enclosed type.

Valves for cryogenic service are more susceptible to packing gland leaks at low ambient temperatures. Data is to be submitted to confirm that these valves will be suitable for service at the design service temperature.

2.4.2 Cargo Tank and Inter-barrier Space, Venting and Pressure Regulating Arrangements

All piping and pressure/vacuum preventing systems including valves are to be provided with a heat tracing system to provide for their functionality at all times.

Operational procedures for local testing are to be provided to the operator.

2.4.3 Heating Media

The maximum temperature of heating media within the cargo area must take into consideration the temperature class associated with the auto ignition temperature of the cargoes being carried. The electrical equipment and instrumentation for heat tracing systems installed within the cargo area must be of an intrinsically safe type.

2.4.4 Cargo Control/Environmental Systems

Equipment used for the environmental control of the cargo spaces, inter-barrier spaces and other spaces that require a controlled atmosphere, either by chemical composition, temperature or air quality, are to be designed to maintain a dew point below the lesser of the design service temperature or -30°C (-22°F).

2.4.5 Mechanical Ventilation

Spaces required to be ventilated before entering are to be equipped with suitable means of pre-heating the ventilation systems to provide for their proper functioning at the design service temperature.

2.4.6 Towing Fittings

The stowage compartment for emergency towing gear is to be provided with a means for de-icing and is to be readily accessible at all times.

2.5 Access to Deck Areas and Cargo Machinery

2.5.1 Electric Motor Room and Cargo Compressor Room Access

Access to the cargo machinery room is to be available at all times. Heat tracing of the door coamings is to be provided.

2.5.2 Cargo Manifold and Cargo Vapor System

If the cargo manifold and cargo vapor areas and associated valves are enclosed from the weather, the enclosures are to be arranged in such a way as to provide for sufficient ventilation of the space when the vessel is loading and unloading. When mechanical ventilation is provided, the ventilation capacity is to be at least 30 air changes per hour based on the total volume of the space. Additional gas detectors are to be provided.

2.5.2(a) Arrangement of vent mast. The vent mast head is to be designed to prevent blockage by ice accumulation. Drip pans for the purpose of collecting moisture in the vent mast are to be provided. Drip pans with associated drain pipes inside the vent mast head and foot are to be provided with trace heating.

2.5.2(b) Vapor heater. A steam-operated vapor heater for the purpose of preventing vapor descending to the deck is to be installed in the vapor line before the vent riser used for controlled venting.

2.5.2(c) Boil off gas piping. Insulation of the boil-off gas piping is required in way of areas exposed or subject to the design service temperature.

2.5.3 Access to Machinery on Deck

Access to the deck for personnel (e.g., doors, hatches, etc.) and to other equipment located on the weather deck and the bow area are required to be available at all times. Access for the operating personnel is to be arranged in such a way that they are not obstructed by ice accumulation or endangered by overhead ice accumulation.

Additional arrangements are to be made to prevent the crew from being hit by the release and sliding of accumulated ice and snow from inclined covers of the containment systems onto any walkways or passageways.

2.6 Monitoring Systems

2.6.1 Temperature Monitoring Systems

Additional temperature monitoring systems are to be installed in order to monitor the efficiency of the heat tracing systems.

2.6.2 Alarm Systems

Heat tracing and additional temperature monitoring systems are to be arranged so that any failure will result in an alarm at the manned control station.

2.6.3 Instrumentation

The following instrumentation is to be installed and fitted with heat tracing equipment as considered necessary:

- Level indicators for cargo tanks
- Overflow control
- Pressure gauges
- Temperature-indicating devices
- Instrumentation for gas detection systems

2.6.4 Other Monitoring Equipment

When remotely operated equipment, such as closed caption television (CCT), is utilized, any reduced movement of the CCT enclosure is not to impair its functionality to transmit images. Heated enclosures are to be used to provide for their continued operation.

2.7 Fire and Safety Systems

Additional fire and safety systems as required to be installed in liquefied gas carriers by Part 5C, Chapter 8 of the *Steel Vessel Rules* and the *International Gas Carrier Code* are to be arranged and installed so as to provide for their continued operation at the design service temperature. The water spray deluge system is to be equipped with heat tracing and sufficient drainage to prevent freezing. Alternative arrangements for water deluge systems and possible additives to the water may be accepted based on the approval of the flag administration. Dry chemical powder systems are to be arranged to prevent clogging of the nozzles and provide for the release of the medium at the design service temperature.

3 Vessels Intended to Carry Ore or Bulk Cargoes/Cargo Ships

3.1 General

These requirements are intended to apply to vessels with the classification ✠ **A1 Bulk Carrier**, ✠ **A1 Ore Carrier**, or ✠ **A1 Oil or Bulk/Ore (OBO) Carrier** and subject to the requirements in Part 5C, Chapters 3 or 4 of the *Steel Vessel Rules*. These are additional requirements to those in the other Sections of this Guide.

3.2 Material Selection

Materials entering into the construction of Bulk Carriers are to be in accordance with the requirements in Section 2 of this Guide and the ABS *Rules for Materials and Welding (Part 2)*.

3.3 Hull Construction and Equipment

3.3.1 Hatch Cover Sealing

Hatch cover sealing arrangements are to be suitable for the design service temperature. Arrangements are to be provided to prevent frozen water adhering to the seals. See 4/4.6.2.

3.4 Machinery and Electrical Equipment

3.4.1 Ballast Piping

If fitted, piping connecting the upper wing tank and lower wing tanks is to be protected from freezing.

3.4.2 Ballast Water Tanks

With the hatch covers open for cargo loading or discharge, the ballast tanks in the double bottom and lower wing tanks may be exposed to the design service temperature. Accordingly, the requirements in 4/5.2 are to be complied with.

3.5 Access to Deck Areas and Cargo Machinery

Requirements for cargo handling equipment are in 4/4.6.

4 Offshore Support Vessels

4.1 General

These requirements are intended to apply to vessels with the classification ✠ **A1 Offshore Support Vessel** and subject to the requirements in Part 5, Chapter 10 of the ABS *Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length* . These are additional requirements to those in the other Sections of this Guide.

Offshore support vessels in cold regions frequently double as ice breakers and ice management vessels and should be appropriately designed for these functions. This includes selection of ice class (strengthening of hull and machinery), and also the selection of hull forms and appendages suitable for ice operations.

4.2 Material Selection

Materials entering into the construction of support vessels are to be in accordance with the requirements in Section 2 of this Guide and the ABS *Rules for Materials and Welding (Part 2)*.

4.3 Hull Construction and Equipment

4.3.1 Stability

If the hull form promotes ride-up onto larger ice features, stability when beached should be specially considered. Ice knives or skegs can be fitted both to reduce ride-up and to promote splitting of large floes.

Offshore support vessels can be particularly susceptible to reduced stability because of the effects of icing. These include both accumulation on equipment, making it difficult or impossible to operate, and impacts on heel, trim, and stability in general. Design features can be selected to reduce ice build up, and de-icing equipment can be installed. See Subsection 3/5.

4.4 Machinery and Electrical Equipment

Offshore support vessels typically conduct a wide range of operations that require the operation of deck machinery such as winches, cranes, etc. These, and in particular their control stations, are to be protected from cold, ice and snow, as practicable.

Drilling muds and other specialized bulk cargoes carried by offshore support vessels may be particularly susceptible to freezing and may flow less freely at low temperatures. This fact is to be taken into account at the design stage or in the selection of existing vessels for low temperature operations. Valve and control station locations are also to be considered.

5 Vessels Intended to Carry Oil in Bulk

5.1 General

These requirements are intended to apply to vessels with the classification ✠ **A1 Oil Carrier** or ✠ **A1 Fuel Oil Carrier** and subject to the requirements in Part 5C, Chapters 1 or 2 of the *Steel Vessel Rules*. These are additional requirements to those in the other sections of this Guide.

5.2 Material Selection

Materials entering into the construction of vessels intended to carry oil in bulk are to be in accordance with the requirements in Section 2 of this Guide and the ABS *Rules for Materials and Welding (Part 2)*.

5.3 Hull Construction and Equipment

For cargo piping and piping support details, including vent piping installed on the main deck and exposed to the weather, the design loads must include the expected amount of ice and snow accumulation.

The supports for cargo and ballast piping systems on deck are to be arranged so that free expansion and contraction of the pipes during cargo operations cannot be blocked by accumulated ice or snow.

Consideration is to be given to enclosing deck piping in a tunnel or similar enclosure.

5.4 Machinery and Electrical Equipment

5.4.1 Towing Fittings

The stowage compartment for emergency towing gear is to be provided with a means for de-icing and is to be readily accessible at all times.

Emergency towing fittings at the forward end required as per SOLAS Chapter II-1, Regulation 3-4 meet the requirements of 4/4.5.4.

5.4.2 Pressure/Vacuum Valves

Acceptable means for de-icing pressure/vacuum valves are to be provided so that they remain operable at all times.

5.4.3 Cargo Tank Purging and/or Gas-freeing

The cargo tank purging and/or gas-freeing system is to be designed to be operable at the design service temperature.

5.4.4 Inert Gas System

The inert gas system scrubber is to be located in a compartment protected from the weather.

The inert gas system deck seal is to be operable at the design service temperature.

5.4.5 Piping – General

All piping with contents with freezing points above the design service temperature is to be provided with a suitable means to prevent freezing. Acceptable arrangements include suitable insulation, heat tracing or continuous fluid circulation or a combination thereof.

5.5 Access to Deck Areas and Cargo Machinery

5.5.1 Access to Bow

The bow area is to be accessible for personnel in all weather conditions.

5.5.2 Cargo Manifold

If the cargo manifold area and associated valves are enclosed from the weather, the enclosures are to be arranged in such a way as to provide sufficient ventilation of the space when the vessel is loading and unloading. Additional gas detectors are to be provided.

5.5.3 Access to Machinery on Deck

Access to the deck for personnel (e.g., doors, hatches, etc.) and to other equipment located on the main deck is to be available at all times. Access by the operating personnel is not to be obstructed by ice accumulation or endangered by overhead ice accumulation.

5.6 Monitoring Systems

5.6.1 Temperature Monitoring Systems

Additional temperature monitoring systems are to be installed in order to monitor the efficiency of the heat tracing systems.

5.6.2 Alarm Systems

Heat tracing and additional temperature monitoring systems are to be arranged in such a way that any failure will result in an alarm at the manned control station.

5.6.3 Instrumentation

The following instrumentation is to be installed and fitted with heat tracing equipment as considered necessary:

- Level indicators for cargo tanks
- Overflow control
- Pressure gauges
- Temperature indicating devices
- Instrumentation for gas detection systems

5.6.4 Other Monitoring Equipment

When remotely operated equipment, such as closed caption television (CCT), is utilized, any reduced movement of the CCT enclosure is not to impair its functionality to transmit images. Heated enclosures are to be used to provide for their continued operation.

5.7 Fire and Safety Systems

No additional guidance.

SECTION 7 Survey Requirements

1 General

The administrative and the certification procedures are listed in 1/5.1 and 1/5.2 and Section 1, Figure 1, "Certification Procedure".

These survey requirements are in addition to those listed in the *Steel Vessel Rules* and ABS *Rules for Survey After Construction (Part 7)*

Guidance Notes related to survey requirements are in Appendix 7.

2 Surveys During Construction

During vessel construction, the Surveyor is to confirm that the requirements of Sections 2, 3, 4 and 5 have been complied with.

The Surveyor is to confirm that the requirements of Section 6 have been complied with for the following specific vessel types:

- Vessels intended to carry liquefied gases in bulk
- Vessels intended to carry ore or bulk cargoes
- Offshore supply vessels
- Vessels intended to carry oil in bulk

Vessels satisfactorily complying with these Guide requirements will be distinguished in the *Record* with the classification notation **CCO**.

3 Surveys for Loose Equipment/Crew Training

3.1 Survey at Delivery

The Surveyor is to confirm that the requirements of Sections 8 and 9 have been complied with. Vessels satisfactorily complying with the Guide requirements will be distinguished in the *Record* with the classification notation **CCO+**.

3.2 Delayed Survey Option

For vessels that are anticipated to operate infrequently in low temperature environments, the Owner may arrange for the vessel to meet the requirements in Sections 2 through 6 initially. When operation in low temperature environments is planned, the Owner is to make arrangements for the loose gear to be placed onboard in accordance with the requirements in Section 8. The vessel's crew is to be trained in accordance with the requirements in Section 9. The Surveyor is to be notified with sufficient time prior to operation in low temperature environment in order to confirm that the requirements of Sections 8 and 9 have been complied with. Vessels satisfactorily complying with the Guide requirements will be distinguished in the *Record* with the classification notation changed from **CCO** to **CCO+**.

4 Annual Surveys

In order to retain the **CCO** or **CCO+** notation, the Annual Survey is to take place simultaneously with the Annual Survey – Hull for Sections 2 and 3 and Annual Survey – Machinery for Sections 2, 4, 5 and 6. Loose equipment and crew training are to be confirmed as per Sections 8 and 9, if applicable.

4.1 Annual Surveys – Hull

The hull-related items are to be generally examined as far as practicable and placed in satisfactory condition. The survey is to include, but not be limited to, the following:

i) Ballast water tank arrangements to prevent freezing

ii) Access to navigation bridge windows for cleaning

iii) Heated navigation bridge windows operable along with window wipers and cleaning system

iv) Heated deckhouses for lookout personnel

v) Towing notch and fendering, where fitted

vi) Access to the bow area

4.2 Annual Surveys – Machinery

The machinery-related items are to be generally examined as far as practicable and placed in satisfactory condition. The survey is to include, but not be limited to, the following:

4.2.1 All Vessels

i) Pre-heating and ducting of combustion air for internal combustion engines and other prime movers

ii) Towing winches, if fitted, including foundation, prime mover, shafting, brakes, controls, are to be examined as far as possible. Each towing winch is to be operated as far as possible, including control from the navigation bridge and the emergency override.

ii) Towing fittings

iv) Cargo handling equipment

v) De-icing, draining and heat tracing arrangements for piping and equipment exposed to the weather

vi) Random checking of the low temperature monitoring and alarms for standby propulsion and auxiliary machinery

vii) Check of the navigational equipment listed in 5/3.1, “Equipment”

viii) Random check of the emergency heating for the spaces listed in 4/7.2.5 are to be examined and tested where deemed necessary.

ix) Check of the fire fighting systems.

4.2.2 Liquefied Gas Carriers

i) If provided, enclosed cargo manifold areas ventilation and gas detectors

ii) Pre-heating for ventilation systems for spaces requiring ventilation before entering

iii) Arrangements to prevent release or sliding of ice on containment system onto walkways or passageways

iv) Check of heat tracing for additional fire and safety systems as per Part 5C, Chapter 8 of the *Steel Vessel Rules* and *International Gas Carrier Code*.

4.2.3 Vessels Intended to Carry Ore or Bulk Cargoes/Cargo Ships

i) Freeze protection for piping connecting upper wing tank and lower wing tanks

4.2.4 Offshore Support Vessels

No additional survey requirements.

4.2.5 Oil Carriers

i) Inert gas system deck seal anti-freezing arrangements

ii) If provided, enclosed cargo manifold areas ventilation and gas detectors

iii) Pre-heating for ventilation systems for spaces requiring ventilation before entering

iv) Check of heat tracing for additional fire and safety systems

4.3 Annual Surveys – Loose Equipment/Crew Training

Verify sufficient quantity of hand protection (e.g., gloves), head and eye protection and immersion suits onboard for crew and supernumeraries. Verify documentation available for operating the vessel and certifying crew are trained for low environmental operations, including operating and training manual, as required.

5 Special Periodical Surveys

In order to retain the **CCO** or **CCO+** notation, the Special Periodical Survey is to take place simultaneously with the Special Periodical Survey – Hull and Special Periodical Survey – Machinery and is to include sufficient examination, test and checks carried out by the Surveyors to satisfy themselves that the hull, equipment and machinery are in or are placed in satisfactory condition and are fit for their intended purpose for the next five year period, subject to proper maintenance and operation and to periodic surveys being carried out at the due dates.

5.1 Special Periodical Surveys – Hull

The hull-related items are to be examined and placed in satisfactory condition. The survey is to include the following:

i) Ballast water tank arrangements to prevent freezing are to be examined and tested as deemed necessary

ii) Access to navigation bridge windows for cleaning is to be examined

iii) Heated navigation bridge windows operable along with window wipers and cleaning system are to be examined

iv) Heated deckhouses for lookout personnel are to be examined

v) Towing notch and fendering, where fitted, are to be examined

5.2 Special Periodical Surveys – Machinery

The machinery-related items are to be examined and placed in satisfactory condition. The survey is to include, but not be limited to, the following:

5.2.1 All Vessels

5.2.1(a) Pre-heating and ducting of combustion air for internal combustion engines and other prime movers are to be examined

5.2.1(b) Towing winches, if fitted, including foundation, prime mover, shafting, brakes, and controls, are to be examined. Each towing winch is to be tested, including control from the navigating bridge and the emergency override.

5.2.1(c) Towing fittings are to be examined

5.2.1(d) Cargo handling equipment is to be examined and tested, where deemed necessary

5.2.1(e) De-icing, draining and heat tracing arrangements for piping and equipment exposed to the weather are to be examined and tested, where deemed necessary

5.2.1(f) Low temperature monitoring and alarms for standby propulsion and auxiliary machinery are to be examined, and tested where deemed necessary

5.2.1(g) Navigational equipment listed in 5/3.1 is to be examined and tested where deemed necessary

5.2.1(h) Emergency heating for the spaces listed in 4/7.2.5 is to be examined, and tested where deemed necessary.

5.2.2 Liquefied Gas Carriers

5.2.2(a) If provided, enclosed cargo manifold areas' ventilation and gas detectors are to be examined, and tested as deemed necessary

5.2.2(b) Pre-heating for ventilation systems for spaces requiring ventilation before entering is to be examined, and tested as deemed necessary

5.2.2(c) Arrangements to prevent release or sliding of ice on containment system onto walkways or passageways are to be examined

5.2.2(d) Heat tracing for additional fire and safety systems as per Part 5C, Chapter 8 of the *Steel Vessel Rules* and *International Gas Carrier Code* are to be examined, and tested where deemed necessary

5.2.3 Vessels Intended to Carry Ore or Bulk Cargoes/Cargo Ships

5.2.3(a) Freeze protection for piping connecting upper wing tank and lower wing tanks is to be examined

5.2.4 Offshore Support Vessels

No additional survey requirements.

5.2.5 Oil Carriers

5.2.5(a) Inert gas system deck seal anti-freezing arrangements are to be examined

5.2.5(b) If provided, enclosed cargo manifold areas' ventilation and gas detectors are to be examined, and tested as deemed necessary

5.2.5(c) Pre-heating for ventilation systems for spaces requiring ventilation before entering is to be examined, and tested as deemed necessary

5.2.5(d) Heat tracing for additional fire and safety systems are to be examined, and tested where deemed necessary

SECTION 8 Crew Considerations

1 General

Because of the significant environmental conditions that a vessel and its crew are operating in, particular attention must be paid to the personnel so that they remain effective in performing their duties. Additional guidance regarding human response to cold, clothing, nutrition and accommodations are provided in Appendix 8.

2 Clothing

Adequate supplies of protective clothing and thermal insulating materials are to be provided for all persons onboard at any time. Additional guidance is provided in A8/3.4, "Clothing and Personal Protective Equipment".

2.1 Hand Protection

Hand protection (mitts, gloves) is to be provided.

2.2 Head and Eye Protection

Head and eye protection gear is to be provided to reduce loss of body heat and protect vision from ultraviolet rays.

Head and eye protection is to be compatible and usable with communications equipment.

2.3 Foot Protection

Foot protection gear is to be provided.

Slip-resistant, insulated safety footwear is to be provided. For heavy work, a felt-lined rubber-bottomed, leather-topped boot with a removable felt insole is preferred. An extra pair of safety shoes for inside work is to be provided.

2.4 Maintenance of Personnel Protective Equipment

Personnel protective equipment is to be properly maintained and stored.

2.5 Immersion Suit Protection

Immersion suits are to be provided for all members of the crew and comply with the text in A8/3.4.6. See 5/4.6.

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SECTION 9 Training and Related Documentation

1 General

Vessels operating in low temperature environments are exposed to a number of unique circumstances. Weather conditions are poor. Navigation charts may be unreliable (potentially out of date). Polar ice charts are updated weekly upon processing of satellite images. There is always the possibility that local ice conditions may differ significantly from those depicted on the chart. Maintaining maneuverability for the avoidance of locally heavy ice conditions is an important consideration when using ice charts at the route planning level, and communication systems and navigational aids present challenges to mariners. The areas that the vessels operate in are remote, making rescue and any clean-up operations difficult. Therefore, additional crew training must be undertaken and operations manuals must be developed. Appendices 9, "Guidance Notes for Training and Related Information"; 10, "Guidance Notes on Weather Conditions of Interest"; and 11, "Guidance Notes on Vessel Operations" provide additional information.

2 Training

Training in ice operations, navigation and winterization are to be provided.

Training is to address means to prevent and treat potential cold weather-related maladies of crew, including hypothermia and frostbite.

Certifications are to be recorded, where applicable, and the records updated.

3 Documentation

An operating and training manual shall be submitted to the responsible ABS Technical Office for review. The manual is to be in English and the working language of the crew. Guidance Notes for Training and Related Documentation including reference to IMO Guidelines have been provided in Appendix 9.

3.1 Operations

The operating section is to include, but not be limited to, the following:

- General arrangement showing location of equipment (including loose items) installed onboard to facilitate operation of the vessel in low temperature environments.
- Specification of the equipment installed onboard to facilitate operation of the vessel in low temperature environments together with manufacturer's recommendations of use, operational limitations, maintenance and testing procedures, as applicable.

- Relevant information related to operations in ice-covered waters, including contingency planning in the event of damage. The typical format of an operating manual is described in Appendix 9 and it is to include: Normal Operation, Risk Management, and Emergency Instructions. Various operational issues for consideration are provided in Appendix 11.
- Any special operating procedures specific to the vessel and its modes of operation.

3.2 Training

The training section is to cover at least the following subject matter areas:

- Ice recognition
- Safe navigation in ice
- Conduct during escorted operations
- Instructions for drills and emergency response
- Cold weather-related maladies
- Update listing of personnel certified (if applicable) in the use of specialized equipment carried for any type of emergency response.

A training log is to be maintained documenting the conduct of the training and the names of the persons attending the training.

APPENDIX 1 Additional Resources

Additional reference related to operating vessels in low temperature environments may be found in the following publications:

Bercha, F.G. (2006), Recent Developments in Arctic EER (Escape, Evacuation and Rescue). The Bercha Group.

BIMCO (2005), Ice Handbook. Jjorn Tomsen A/S. Denmark.

Bridges, R. (2005), Cold Climate Navigation, Design and Operation Considerations. Lloyd's Register Technical Notes.

Canadian Coast Guard (1999), Ice Navigation in Canadian Waters.

Harrington, R. L. (Ed). (1992), Marine Engineering, Society of Naval Architects and Marine Engineers. Jersey City, NJ.

Finnish Maritime Administration (2005), Winter Navigation 2004-2005.

IACS. (2006), UR I1 – Polar Class Descriptions and Application; UR I2 – Structural Requirements for Polar Class Ships; UR I3 – Machinery Requirements for Polar Class Ships (effective for vessels contracted for construction after 1 July 2007).

International Labour Organization (2001), Ambient Factors in the Workplace. Geneva.

IMO DE 48 Guidelines.

IMO MEPC 54/2/5 – Draft Practical Guidelines for a Ballast Water Exchange Management Strategy in the Antarctic Treaty Area.

IMO MSC Circular 1056/MEPC Circular 399 (2002). Guidelines for Ships Operating in Arctic Ice-Covered Waters.

IMO MSC Circular 1175 (2005), Guidance on Shipboard Towing and Mooring Equipment.

IMO MSC Circular 1185 (2006), Guide for Cold Water Survival.

IMO Life Saving Appliances (2003), (from the following two codes).

IMO Resolution A.749(18) (1993) and updates (2002), Code on Intact Stability for All Types of Ships Covered by IMO Instruments.

IMO Resolution MSC.81(70) (1998), Revised Recommendation on Testing of Life-Saving Appliances.

IMO Resolution MSC.48(66) (1996), Life Saving Appliance Code.

IMO. (2002). MSC.152(78), Adoption of amendments to the International Convention for the Safety of Life at Sea, 1974, as amended. 5-20-04 (Lifeboats, EPIRB's, Immersion Suits).

Lamb, T. (Ed.). (2004), Ship Design and Construction, Volume II, Chapter 40, Ice-capable Ships, Society of Naval Architects and Marine Engineers. Jersey City, NJ.

MacKinnon, S. (2006), Operational and Human Factors in Cold Maritime Environments, Memorial University.

Magelssen, W., and Grubisic, R. (2004), Operation of Ships in Cold Climate with Emphasis on Tankers and New Requirements. Brodo Gradnja.

Mahmood, M, and Revenga, A. (2006), Design Aspects of Winterized and Arctic LNG Carriers – A Classification Perspective. American Bureau of Shipping.

Ministry of Transport of the Russian Federation. (1996), Guide to Navigation Though the Northern Sea Route.

Russian Maritime Register of Shipping. (2003), Rules for the Classification and Construction of Sea-Going Ships. St. Petersburg, Russia.

Santos-Pedro, V.M. (2005), Ice Regime System, Exporting Canada's Experience. Transport Canada.

Kitagawa, H. and et al. (2000), The Northern Sea Route – The shortest sea route linking East Asia and Europe. Ship & Ocean Foundation, Japan.

Swedish Maritime Administration. (2005), Winter Navigation 2004-2005.

Transport Canada (2005), Winter Navigation on the River and Gulf of St. Lawrence: Practical Notebook for Marine engineers and Deck Officers.

Tsoy, L.G. (2002), Report on Current Regulations and Practices and Impact of IMO Regulations). Central Marine Research and Design Institute.

Tunik, A. (1998), Major Factors in Tanker Design for Oil transportation From Arctic Regions. American Bureau of Shipping.

Tustin, R. (2005), Recent Developments in LNG and Ice-Class tanker design and the potential application to future Arctic LNG ships. Lloyd's Register.

APPENDIX 2 Guidance Notes on Materials, Welding and Coatings

1 General

The following Guidance Notes provide additional information to the user and, in some cases, recommendations as to how the Guide requirements may be complied with.

2 Material of Exposed Structural Members

No additional guidance.

3 Material of Machinery

No additional guidance.

4 Weld Metal

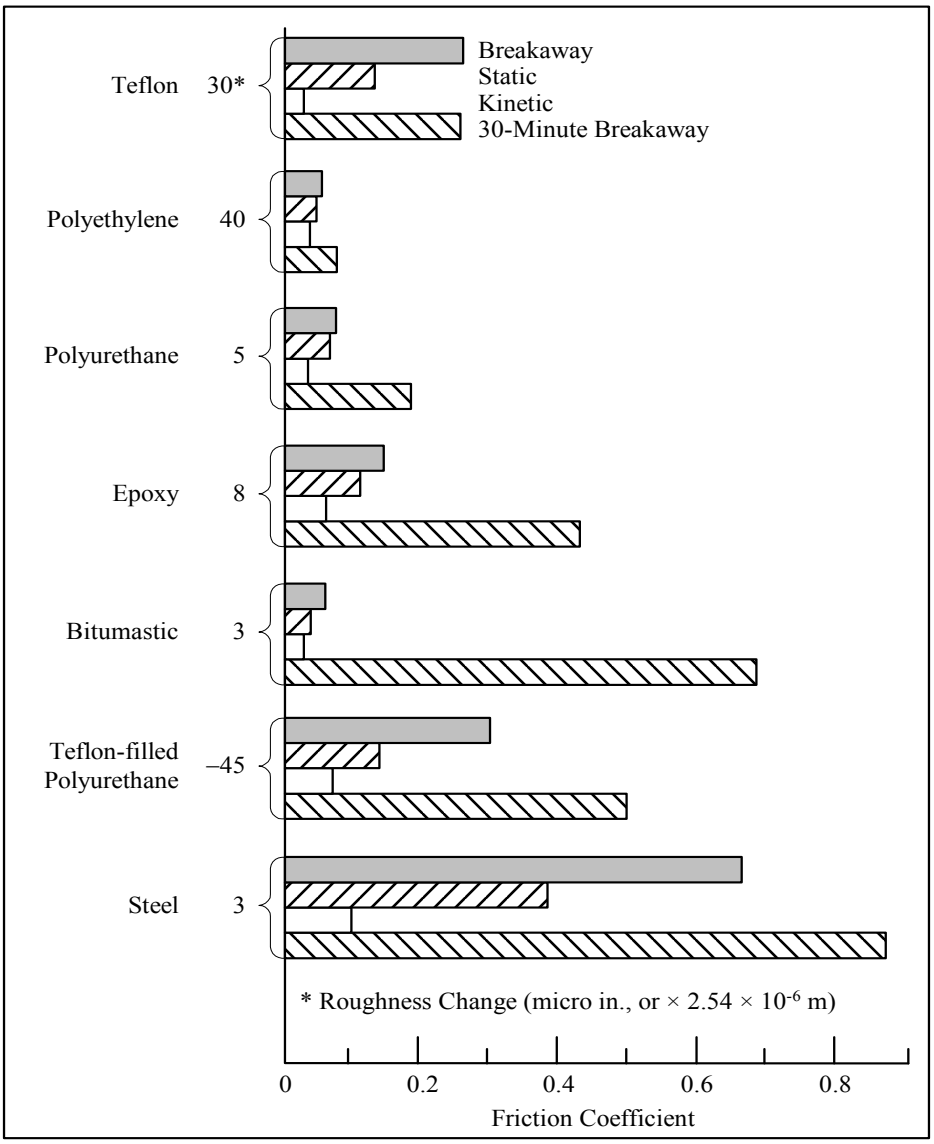
No additional guidance.

5 Coatings

The hulls of ice-strengthened and ice breaking vessels are often painted with specialty coatings developed for use in ice. These coatings are especially used on the stem and the ice belt, which are in most frequent contact with the ice. One of the purposes of these coatings is to protect the shell plates of the hull. The Arctic and Antarctic Oceans pose a harsh environment for protecting the shell plates from wear and corrosion. A high concentration of dissolved oxygen in the water accelerates the corrosion rate at the shell. In ice-covered waters, the shell plates of ice-strengthened vessels are continually exposed to contact with ice, scraping the paints. Ice breakers are exposed to ice under intense pressure. To withstand these tough conditions, the paints for use in ice need to be durable and resistant to peeling, and should also serve to reduce friction between the hull surface and the ice. When an ice breaking vessel is in the process of ice breaking, various forces act on the vessel, but friction force between the hull and the ice is one of the most important. It is reported that several kinds of coatings for particular use in ice with low friction coefficients are being developed and field tested, since ice friction depends heavily on the characteristics of the hull surface. In Finnish and Russian ice breakers, use of stainless-clad steel plates in the ice belt were tested, to improve resistance to wear and corrosion and to reduce the friction between the hull and the ice. The stainless-steel surface can provide a paint-free ice belt, but galvanic corrosion may occur between metals of different electric potential. Therefore, additional anodes or equivalent galvanic protection should be installed.

Appendix 2, Figure 1 shows the coefficient of friction for various coatings as well as that of steel on ice. The polyurethane and epoxy (non-solvent coatings) proved to be the most effective in friction reduction and coating endurance.

FIGURE 1
Coefficient of Friction for Steel and Various Hull Surfaces on Ice



Source: Engineering and Design Ice Engineering, Manual No. 1110-2-1612, Figure 17-2, Department of the Army, U.S. Army Corps of Engineers (30 October 2002)

Note: The static friction measures the coefficient of friction from a stopped position to some relative speed between the ice and the steel. The breakaway friction accounts for specimen to ice contact, under load for a specific length of time. The kinetic friction coefficient is the value obtained during continuous movement between ice and test specimen.

Numerous materials, coatings and paints having low friction properties are commercially available. Coatings applied to topside weather surfaces to reduce ice accretion are referred to as icephobic coatings, meaning they have an aversion to ice. Icephobic coatings to be used onboard are to be compatible with other corrosion prevention coatings. These coatings can be applied to repel water and prevent ice build-up in areas other than walkways, due to their inherent slickness. Icephobic materials do not prevent ice formation on exposed structures but lower the adhesion strength of ice and may be considered as enhancements to other ice removal methods, such as mechanical, steam, electro-thermal or electro-mechanical.

APPENDIX 3 Guidance Notes on Hull Construction and Equipment

1 General

The following Guidance Notes provide additional information to the user and, in some cases, recommendations as to how the Guide requirements may be complied with.

2 Tanks

2.1 Fresh Water Tanks

Fresh water tanks with a space between the tank boundary and the side shell may still be susceptible to the contents freezing. The tanks should be fitted with turbulence-inducing systems, for example, bubble systems or heating coils.

2.2 Fuel Oil Tanks

No additional guidance.

2.3 Ballast Water Tanks

No additional guidance.

2.4 Additional Measures for Oil Pollution Prevention

No additional guidance.

3 Superstructures and Deckhouses

3.1 Forecastles

Forecastles are recommended for vessels less than 50,000 DWT. Forecastles are required for all bulk carriers, ore carriers and combination carriers in accordance with IACS UR S28, Requirements for the Fitting of a Forecastle for Bulk Carriers, Ore Carriers and Combination Carriers

3.2 Superstructures

No additional guidance.

3.3 Deckhouses

No additional guidance.

4 Stern

4.1 Towing Notch for Ice Breakers

The towing notch is a design feature that has been incorporated into the design of many Russian, Finnish and Swedish icebreakers, but to date not included on any North American vessel. The stern notch arrangement enables a towed vessel to be drawn into the stern of the towing vessel and together the vessels work in tandem during ice breaking. This method has been used extensively in the Baltic and Russian Arctic and its effectiveness is well documented. Because of the possibility of damage to the stern notch itself, it is common to construct the notch as an appendage to the main hull structure.

To reduce the possibility of damage at the stern notch, including the bow of the towed vessel, various methods of fendering have been employed inside the stern notch itself. Both rubber and wood have been used successfully; while bumper wheels have been found to wear quickly. Due to the wide variety of hull shapes that are likely to be towed, the notch should be designed to accept both deep and shallow V shapes.

5 Stability

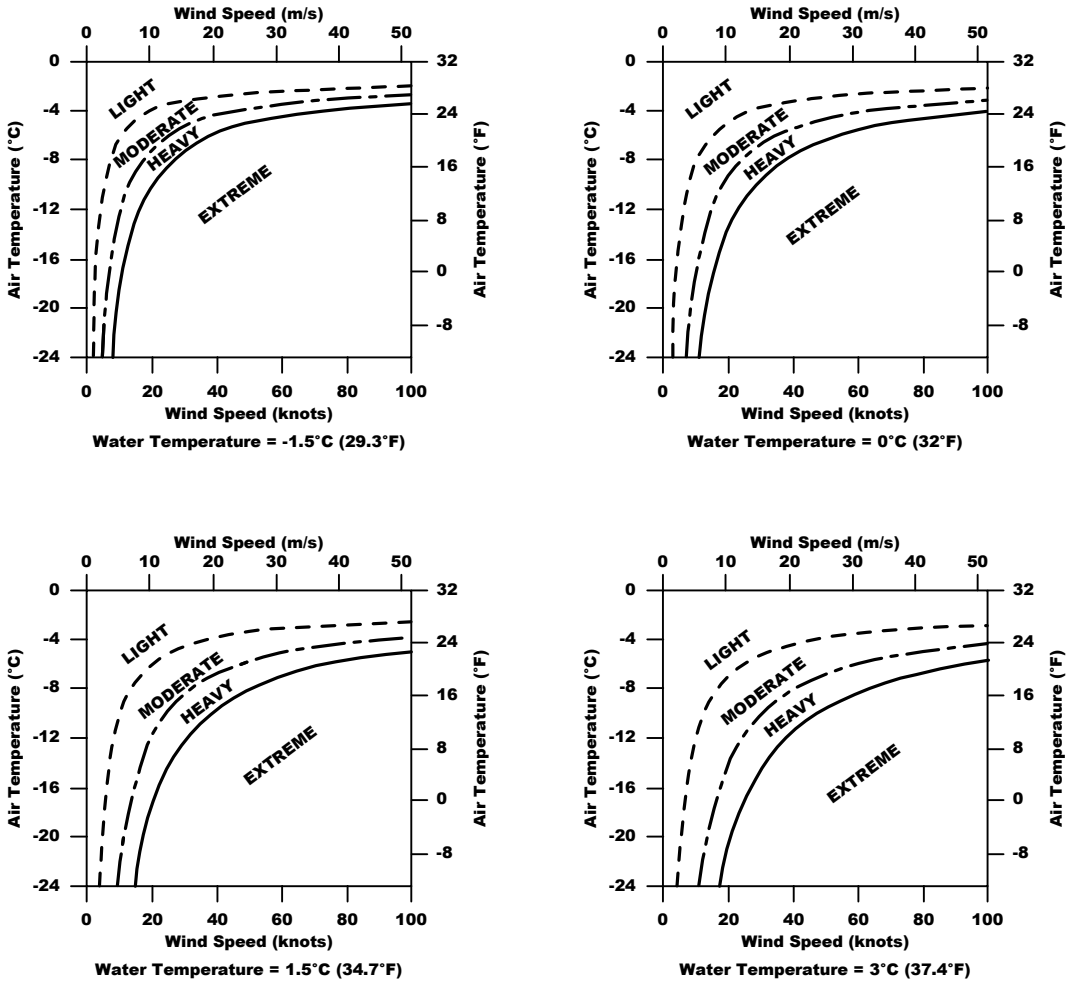
Should icing conditions develop, personnel should take all possible steps to reduce and remove ice. This may require a continuous procedure until icing conditions subside. If ice build-up cannot be controlled or removed, the vessel must be moved to a sheltered area whenever possible.

Appendix 3, Figure 1 is a grouping of icing nomographs developed by the United States National Oceanic and Atmospheric Administration (NOAA) from actual icing reports from fishing, U.S. Coast Guard and towing vessels operating in Alaskan waters. These reports were based on icing events that lasted anywhere from 1 to 26 hours but averaged 3 to 6 hours.

Appendix 3, Figure 2 provides guidance for ice accretion versus wind velocity for air temperatures ranging from -34°C (-30°F) to -7°C (+20°F).

Icing may only occur when there is a source of water for wetting the deck, superstructure and other exposed parts of a vessel. Some vessel factors to consider are vessel's speed, heading (with respect to wind, waves and swell), vessel length, freeboard height, handling and the cold soaking aspect (cold soaking occurs when a vessel has been in cold conditions for two to three weeks and the hull structure remains cold for a period of time after the vessel operates in warmer temperatures). Generally, for the same environmental conditions there will be more sea spray reaching the vessel deck, superstructure, etc. when the vessel is traveling faster, into the wind and waves, and for smaller vessels and ships with less freeboard. The threshold significant wave height, $h_{1/3}$, and associated wind speed, for a 200 km fetch (the distance over water which the wind blows to generate water waves) at which enough sea spray reaches the decks and superstructures to cause severe icing, assuming cold air and water temperatures are also present, are listed in Appendix 3, Table 1.

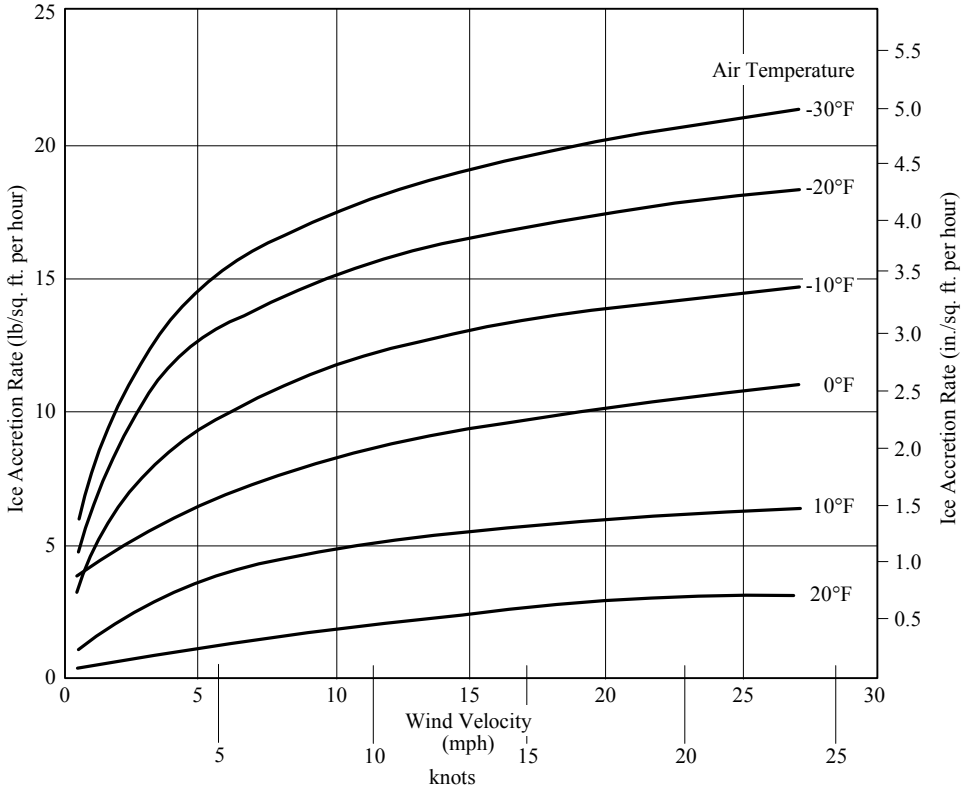
FIGURE 1
Icing Conditions for Vessels Into or Abeam of the Wind



Icing Class	*None*	*Light*	*Moderate*	*Heavy*	*Extreme*
Icing Rates					
(cm/hour)	0	<0.7	0.7-2.0	2.0-4.0	>4.0
(inches/hour)		<0.3	0.3-0.8	0.8-1.6	>1.6

Source: Guest, P. and et al. (2005). Vessel Icing, Mariners Weather Log, Volume 49, No. 3.

FIGURE 2
Ice Accretion versus Wind Velocity for Six Air Temperatures



Source: U.S. Navy Cold Weather Handbook for Surface Ships, Figure 7-3, (May 1988)
Accreting Surface: Flat Panel; Water Spray Temperature: 41 – 48°F

TABLE 1
Threshold Wind Speeds for Icing to Occur on Various Length Ships

Parameter						
Vessel Length						
meters	15	30	50	75	100	150
feet	49	98	164	246	328	492
Significant wave height – $h_{1/3}$						
meters	0.6	1.2	2.0	3.0	4.0	6.0
feet	2.0	3.9	6.6	9.8	13.1	19.7
Wind Speed at 200 km (108 nmi) fetch						
meters/second	5.0	7.4	9.8	12.5	15.0	20.0
knots	9.7	14.4	19.0	24.3	29.3	38.9

Source: Guest, P. and et al. (2005). Vessel Icing, Mariners Weather Log, Volume 49, No. 3, Table 1. Based on Overland, J.E., (1990), Prediction of Vessel Icing for Near-Freezing Sea Temperatures, Weather and Climate, pp. 5, 62-77.

APPENDIX 4 Guidance Notes on Vessel Systems and Machinery

1 General

The following Guidance Notes provide additional information to the user and, in some cases, recommendations as to how the Guide requirements may be complied with.

2 Prime Movers

Ice-strengthened and ice breaking vessels have been designed with almost all common propulsion plants, including direct drive and geared diesel, steam and gas turbines, and electric transmission versions. Russia operates a large nuclear ice breaker fleet, but nuclear power is considered highly unlikely for a commercial application in the foreseeable future and therefore is not specifically discussed within the text of this Guide.

The overriding consideration for the propulsion plant for any ice-capable vessel is that its power and thrust are matched to the ice conditions in which the vessel is intended to operate. In some areas, currently including the Baltic and the Russian Northern Sea route, minimum powering requirements are imposed on vessels as a condition of ice class (See Part 6, Section 1 of the *Steel Vessel Rules* for requirements for General Ice Classes and Baltic Ice Classes). In special cases, model tests may be used as an alternative to demonstrate adequate capability to an Administration. Refer to the ABS *Guidance Notes on Ice Class*.

For non-ice class vessels, the Guide assumes that the propulsion plant will be operated continuously with few changes in speed and direction when operating in low temperature environments.

2.1 Prime Mover Operating Characteristics for Ice Class Vessels

Much ice breaking takes place at very low speeds, and so it is necessary to consider bollard as well as free-running conditions in selecting propeller properties during design. Bollard and low-speed thrust can be augmented by fitting nozzles, which can also provide protection to the propeller blades. However, nozzles can be blocked or clogged by ice, in which case, rapid reversal of thrust is needed to clear the blockage.

Vessels following icebreakers will also have to reduce speed during ice breaking operations. Low power outputs for propulsion plants are considered to be in the range of 15 to 50% of MCR. During ice breaking, power output would be expected to be in the lower part of this range. There are various operational issues associated with low load operation to consider such as: incomplete combustion of fuel oil and subsequent effect on turbochargers and exhaust piping system; continuous operation of auxiliary blowers for long periods of time; effects on internal components of the prime mover; prime mover emissions; and, functioning of auxiliary systems.

Icebreakers, ice breaking support vessels, and higher ice class vessels as well as other smaller vessels are most likely to see frequent propeller-ice interaction. This effect places a range of demands on the propulsion system in addition to ensuring adequate component strength (see Subsection A4/3). Propellers may be slowed or jammed by ice blocks caught against the hull which is mitigated by increased propeller blade thickness and propulsion shaft diameter. The high torque available from certain electric transmission systems can be very advantageous for fixed-pitch systems. For controllable-pitch systems, rapid pitch changes may be required.

2.2 Thrust Reversal for Ice Class Vessels

If icebreaking vessels are likely to operate at or near their continuous ice breaking limit, their operation will be adversely affected by ridges, rafted ice and pressured ice conditions, and they may have to back and ram. The propulsion system should be capable of rapid and repeated variation of power and direction; and should be able to develop a significant percentage of ahead thrust when moving astern.

Ice class vessels following icebreakers should be capable of rapid and repeated variation of power and direction to avoid colliding with the icebreaker or other vessels when in a convoy. Maneuvering mode is considered to be some fraction of the full ahead speed of the vessel.

2.3 Combustion Air Systems

2.3.1 Combustion Air for Internal Combustion Engines

Vessels operating in low temperature environments are at risk that the engine may not operate as the low temperature of the combustion air-fuel mixture may fail to enable auto ignition when compressed in the engine cylinders. Engine cylinder pressure limits may be exceeded when using low temperature air because of the cold air's higher specific density. Protection can be achieved by installing a waste gate (blow-off valve) for either scavenge air or exhaust gas. This may lead to operating restrictions for the engine. Special features are incorporated within the combustion air system to preheat this cold air.

Some vessel designs are equipped with electric/steam heating to preheat the combustion air. Recent designs now use the diesel jacket water waste heat. Another strategy is to have an emergency air intake directly from the machinery space. It is not practical to have all combustion air taken from the machinery space because the space's temperature will become too low, affecting equipment function and personnel.

For typical diesel engines operating at reduced loads (e.g., low cylinder compression temperature), it is likely that preheated combustion air will be required. Two-stage charge air cooling/heating systems have been employed to raise the combustion air temperature for acceptable engine operation. Generally, for engine loads above 30% Maximum Continuous Rating (MCR), jacket water can be used as the heating medium. For engine loads below 30% MCR, external preheat sources may have to be installed. Typically, at engine loads near 50% MCR, charge air temperatures will rise above 0°C and the charge air cooler can be employed.

Valve settings must also conform to the local operational conditions and outside temperatures. Additionally, a relief valve may be installed, designed to activate (blow off) at a specific gauge pressure (typically around 2 bar). Some engine manufacturers allow the charge air blow off to be re-circulated back into air inlet ducting.

2.3.2 Combustion Air for Other Prime Movers

The prime mover manufacturer should be consulted regarding any operational restrictions imposed by low temperature conditions and for recommendations related to system arrangements and features to mitigate these restrictions.

2.4 Turbochargers

Special blow-off air intake systems may have to be engineered to obtain surge-free operation of the turbochargers over the entire range of operations for low design ambient temperatures. A blow-off valve installed in the charge air manifold of the engine has been used to blow off excess air to prevent turbocharger surging.

2.5 Lubricating Oil Systems

The lubricating oil for the main propulsion and auxiliaries, particularly for idle equipment, is to be maintained at a temperature to permit equipment start-up when demanded. Current practice is to operate a standby pump along with the lubricating oil purifier, which is fitted with a heater to keep the oil at the proper temperature.

Steam coils in lube oil sump tanks are difficult to inspect regularly and have been known to leak, rendering the equipment inoperable.

Synthetic lubricants, which have the correct viscosity at low temperatures -45°C (-50°F) without the use of heaters, may be considered on a case-by-case basis as an alternative or supplement to heating coils.

3 Propulsion and Maneuvering Machinery

Part 6, Chapter 1, "Strengthening for Navigation in Ice" of the *Steel Vessel Rules* applies a progressive strength approach to the propeller and propulsion shaft system. The philosophy of this approach is for the propeller blade to be the weakest link and the tail shaft the strongest. The relative strength of the components is diagrammatically shown as follows:

Propeller Blade	Weakest
Propeller Blade Palm Bolts	↑
Propeller Hub	
Propeller Hub Flange and Flange Bolts	↓
Tailshaft	Strongest

Propeller damage to ice class vessels is common, and can result from both encounters with heavy ice and/or from operator error. The progressive strength approach should lessen the frequency of catastrophic failures of tail shafts and propeller hubs from occurring. It may be possible for a vessel to operate at reduced capability with some level of propeller damage and to replace a broken blade alongside a dock.

The transmission system that delivers the power from the prime movers to the propulsors must also be able to cope with the demands of ice operation, which can include high dynamic loads due to ice impact and ice milling, vibration, and relatively frequent reversals or rapid changes in rotational speed. These considerations are most important for smaller, higher powered and higher ice class vessels, but require some attention in any ice class vessel.

3.1 Propulsion Shafting Bearing Lubrication

Damage statistics indicate that problems with tail shaft seals have immobilized more vessels than any other single failure associated with propulsion systems. Both radial lip and axial face type seals have been used onboard vessels transiting through ice-covered waters. Radial lip type seals have been the preferred installation to date. Although axial face seals can accommodate larger radial and axial movements of the shaft without losing seal efficiency, the large size of shafts found onboard some icebreaking vessels tends to make these more complicated and expensive compared to radial lip seals.

Radial lip seals are, however, more sensitive to shaft speed, surface finish, shaft eccentricity, shaft vibrations and pressure differences across the seals themselves. The allowable rubbing speed limit is to prevent high lip surface temperatures that could result in seal failures and is commonly set to below 6 m/s, although slightly higher allowable speeds have been recently installed on some vessels. Therefore, final selection of shaft seal type, radial or axial, must take into account the maximum diameter of the shaft itself and the speed of rotation.

Oil-lubricated bearings can be provided with pollution free sealing arrangements. These seals tend to have more sealing surfaces, or operate at reduced oil pressures, or a combination of the two. A further pollution reduction strategy can be possible with the use of newer biodegradable lubricants available on the market. Final selection of any lubricant used for stern tube bearings should always be verified with the bearing and sealing manufacturer, as the material characteristics of the contact surfaces is of paramount importance to ensuring correct operation. Water-lubricated stern tube bearings have also been proven as a pollution mitigation strategy and have also been successfully used onboard Canadian and Russian ice breaking vessels.

The selection of the shaft sealing arrangement should also consider the possibility of damage and the repair or replacement of the unit itself. Consideration should be given to the installation of split type seals.

3.2 Propellers for Ice Class Vessels

Part 6, Chapter 1, "Strengthening for Navigation in Ice" of the *Steel Vessel Rules* permits the use of solid propellers. However, since damage to ice class vessel propellers is common, consideration should be given to use of propellers with detachable blades for ease of repair.

3.3 Controllable-Pitch Propellers for Ice Class Vessels

Controllable-pitch propellers installed on ice class vessels are subjected to many more pitch changes and reversals than in seagoing service. The Guide requirement is to alert the equipment designer and Owner that the equipment design must be suitable for the service application. It is expected that fatigue calculations for the controllable pitch mechanism or service records for equipment in similar ice class service will be submitted for confirmation of suitability.

Appendix 4, Table 1 lists some pros and cons for the consideration of installing a controllable-pitch propeller versus a fixed pitch propeller.

TABLE 1
Considerations for Installation of CP versus Fixed Pitch Propellers

Pros	*Cons*
Operating conditions vary widely and maximum thrust is desired throughout these operating conditions.	Higher initial cost for more complex equipment.
Extensive low-speed maneuvering is required for a diesel powered vessel. Thrust can be varied continuously from ahead to astern, including zero thrust while operating in the minimum speed range of the diesel.	When constant shaft rpm is required over a wide range of operating powers the propeller pitch can be adjusted. However, a propeller efficiency penalty is incurred when operating the propeller off the design point.
Unidirectional rotation of a CP propeller subjects the blades to less ice damage because the leading edges of the blades are thicker and stronger than the trailing edges. Fouling of propeller blades by ice blocks is less likely with continuous propeller rotation.	Greater equipment complexity (e.g., hydraulic system, controls systems, additional moving parts in propulsion shafting and hub) requires additional maintenance and increases frequency of failure.
Improved maneuverability and a minimum vessel stopping distance. Variable thrust capability in either direction and more rapid response to thrust reversal commands improve vessel maneuverability and reduce the vessel's headreach.	
Individual blades can be replaced when damaged.	

Source: Harrington, Roy L. Editor, (1992) Marine Engineering, Society of Naval Architects and Marine Engineers

4 Deck and Other Machinery

4.1 Anchoring Arrangements

4.1.1 Ice Breaking Vessels

For ice breaking vessels, the location of the anchor should be specially considered with respect to the waterline and in particular to the anticipated ice conditions. Impacts on the anchors themselves may cause them to become jammed with ice. The potential for conducting close towing operations should also be taken into account.

While operating in ice-covered waters, towing of vessels is relatively frequent, either to supplement powering capability or when a vessel suffers propulsor damage. Ice breakers and other ice breaking support vessels are most likely to conduct towing operations, but all ice class vessels should be designed to be towed on either a longer line or 'in the notch', depending on practices in the anticipated area of operation.

4.1.2 Ice Class Vessels

When ice class vessels are towed 'in the notch' of the ice breaker, the towed vessel's anchors must be lowered and the anchors moved aft and secured so as to be clear of the ice breaker's stern. Other vessels have arrangements in which the anchors are located in an enclosure over the hawse pipe.

4.2 Anchor Windlass

The deck machinery for the anchoring systems of ice breakers and ice class vessels can be either windlasses or capstans. It is preferable to have machinery fitted under cover; hence capstans offer advantages inherent in their design. It is easier to have the machinery associated with the capstan located below deck and the wildcat or wildcat and barrel above deck. Both windlasses and capstans can be located entirely below decks, but the height required for the wildcat is generally chosen to ensure that the cable is self-stowing in the chain locker, requiring that the wildcat itself is located on an open deck. Power units located within heated spaces do not need oil sump heating.

If windlasses or other equipment are located on the exposed deck, remote release of the cable and anchor from the wheelhouse should be considered, shortening the time that crew members must spend on the open deck. The vessel should be fitted with a camera for monitoring the functioning of anchor and cable, released length of cable and monitoring of sea conditions. However, the crew must still prepare the anchor for release. Sufficient supplies of suitable cold-weather clothing and, where possible, protected access and shelter stations should be provided.

Steam-driven machinery is not recommended due to inherent problems of all piping systems; the need to provide for proper draining of all lines and the consequent freezing and possible cracking of pipes.

Stressed parts of all machinery shall take into account the design service temperature if exposed on open decks. It is preferable to encase all moving parts, such as reduction gears and brakes, to prevent icing or freezing spray build-up. Wildcats may be fitted with covers. In some cases, the rotating parts are provided with heaters. Bearings installed in motors/hydraulic pumps should be protected by suitable packing to prevent water/moisture entrapment.

4.3 Towing Winch

The sizing of towing winches should be based on the available thrust for the ice breaker concerned. In some cases, ice-strengthened vessels are capable of towing other vessels. Standard equipment today for towing in ice is the use of a traction winch. Depending on the ice breaker supporting the escorted vessel, the observed pull on the towing line will be some fraction of the ice breaker's available thrust. Historically, the Russian ice breakers tended to have high brake traction settings in the magnitude of 80% of available thrust. However, most other ice breakers operate in the 20% to 50% range.

If a vessel is expected to undertake regular towing operations, it should be outfitted with a towing winch. Protection for the winch from the elements is recommended, including arrangements for the passage of the tow line. During towing, the winch, preset for a given tow pull, will reel in or pay out on the drum as the pull on the cable varies. This line action may occur quite suddenly if ice breaks, and the vessel's crew should be trained for this specific hazard.

The haul in rate for most ice breakers is in the order of 9 m/min, with reel out approaching double that of the haul in.

4.4 Towing Lines for Ice Class Vessels and Ice Breaking Vessels

Each vessel is to be capable of passing an emergency towing line to the towing vessel by a line throwing appliance or similar device. A "slip" should be provided to allow the towing hawser to be disconnected rapidly from the vessel in the event of imminent danger.

The towline should, as for all mooring arrangements, break before damage to the towing winch takes place, not withstanding the constant tension features of the winch. Towlines in ice-covered waters are considerably shorter than those often seen for open water tows. These shorter tows are carried out to prevent the channel formed by the ice breaker or ice-strengthened vessel from quickly closing and increasing the resistance of the towed vessel. Towlines generally fall between 200 to 500 meters in length, keeping the wire length to a minimum on the drum. This minimizes cable wear resulting from the outer windings depressing on the inner windings during a towing operation. The number of windings on a drum should not exceed 4 or 5 for any vessel expected to conduct regular towing operations.

4.5 Towing Fittings

Any vessel that is intended to operate in ice-covered waters should have some arrangements for being towed. Whether towed in close tandem configuration or at a distance in a more separated mode, substantial fittings such as bollards should be well incorporated into the hull structure and should be sized for the high dynamic loads that can be experienced in ice. Towing fittings are to be marked with their Safe Working Load (SWL). IMO MSC/Circ. 1175, Guidance on Shipboard Towing and Mooring Equipment provides additional information. Anchoring systems should be provided with an independent means of securing the anchor so that the anchor cable can be disconnected for use as an emergency towing bridle. When this is accomplished, the anchor chain is generally brought on deck and led out the forward chocks. The storage of the anchor has always been an issue with the tow hook-up. Previously, the anchors were lowered down onto the deck of the towing vessel. However, recent recommendations from Baltic administrations indicate that a vessel should have arrangements to secure the anchors onboard the towed vessels. For some vessels, it may become necessary to swing the anchors aft to prevent contact with the towing vessel, in particular, for ice breakers with a notch stern. This may be accomplished with shackles and cables.

Another method to secure a towed vessel is to simply secure the towing line onto the forward bollards. Most vessels are fitted with capstans or other systems such as warp ends for line hauling. However, if towing in ice is anticipated, it is advised to have a bow roller fitted to accept the towline.

A bridle is preferred to a single line hauled onboard and it is recommended that this be included within the vessel's own equipment.

4.6 Cargo Handling

4.6.1 Cranes

Crane size and type should suit the proposed functions for the crane. However, having an operator's cab with electric heater and at least one heated window with an electrically heated wiper is advised. If the crane is hydraulically actuated, the hydraulic oil should be suitable for the design service temperature, including an electric heater within the oil sump. If the crane is not controlled from an operator cabin, it is recommended to have, as a minimum, nylon or other synthetic material covers for all controls to keep ice/snow off the controls.

4.6.2 Hatch Covers, Ramp Doors and Side Doors

Materials selected for hatch and door seals are to remain pliant at the design service temperature.

If the power unit and hydraulic lines are located in a heated space, a heater is not necessary.

4.6.3 Cargo Pumps

Any components in the cargo piping system are to be designed to function properly when exposed to the design service temperature. These components include cargo pumps exposed to the weather and associated valves and their controls.

If the cargo pumps are located in a heated space, the requirements in 4/4.6.3 are not applicable to those components in the space.

4.6.4 Deck Cargo Securing Equipment

Materials for deck cargo securing equipment are to be suitable for their intended function at the design service temperature.

5 Piping Systems

5.1 General

5.1.1 Materials

Materials subjected to the design service temperature are to be resistant to brittle fracture because, on occasion, it may be necessary to use hammers or axes to clear ice accumulation, making fracture a possibility.

Materials used in piping systems and equipment should be suitable for operations at the design service temperature, considering also specific circumstances such as the lay up of the vessel for extended periods. Particular attention should be paid for those components required for the prevention of pollution or the safety of the vessel. Areas of concern are the areas external to the hull and the unheated areas inside the hull and above the waterline. In all cases, these materials should not be susceptible to brittle fracture.

5.1.2 Flexible Hoses

No additional guidance.

5.1.3 Valves

No additional guidance.

5.1.4 Pipes

Horizontal runs of piping may be unavoidable on certain vessel types, such as a tanker. Effective drainage of these pipes can be accomplished by trimming the vessel aft or installing drain lines in the piping.

Vents, fittings, valves and other piping components should be protected from ice accumulation or be provided with a means to provide for functionality.

5.1.5 Tank Vents

The blockage of vent pipes by ice accumulation at the deck or by the freezing of plugs inside the pipe can result in safety hazards, for example, due to over-pressurization. It is common to fit, or provide for, heat tracing.

5.1.6 Pipe Drainage

All piping within areas that can be expected to freeze shall be designed to prevent freezing or shall be able to be drained of contained fluids. This applies to exposed pipes, valves, pumps and fittings, including those found in areas onboard with no heating available such as voids, cofferdams, etc. Additional heat tracing and insulation should be installed on all safety-related piping exposed to extreme cold temperatures unless other means to provide for operability have been introduced.

5.1.7 De-icing and Heat Tracing

Icing can be a major issue for vessels that operate in low temperature but open water conditions. These conditions are common around northern Norway, off the east coast of Canada, and on a number of other shipping routes and fishing grounds. In ice-covered waters, icing is less of a problem, as wave-induced spray is the main source of thick ice accumulations. Ice build up is most probable in the forward parts of a vessel, but smaller vessels can see significant icing thicknesses in almost all areas.

Spray, fog, freezing rain and snow can all also cause sufficient icing to render equipment inoperable or extremely difficult to operate, and measures should be taken to manage icing issues. Icing of safety-related equipment, exposed working areas and access routes can also lead to safety hazards, while icing of deck machinery, valve manifolds and other systems can interfere with cargo handling operations, causing delays and economic loss.

Depending on the operations of the vessel, de-icing or more permanent heat tracing equipment should be considered. Vessels intended to operate for extended periods of time in arctic climates should be designed with permanently installed equipment. Vessels normally operating in open oceans and only occasionally required to experience extreme conditions should be equipped with de-icing equipment.

Smaller vessels have been equipped with pneumatically operated rubber pillows to break ice away from superstructure fronts and masts, reducing the risk of loss of stability due to ice build up. However, for larger vessels, portable de-icing equipment is normally preferred.

Equipment for de-icing includes steam generators, steam hosing, hot water and even salt water spray. Steam is extremely effective, but requires training to be used safely. As with all fluid lines, de-icing systems should be kept heated or drained when not in use. Pumps used for de-icing systems should be provided with redundant arrangements. Any equipment used for de-icing must be suitable for operation onboard, particularly when operating in hazardous areas on oil carriers, chemical carriers and liquefied gas carriers.

Portable hot air generators can also be used for de-icing purposes. These units, if used, can be electric, or can operate on diesel fuel oil with a self-contained fuel system.

Care is to be taken to provide that any de-icing equipment used is suitable for the location, particularly in hazardous locations.

Even where specialized de-icing equipment is carried onboard, manual means to remove ice and snow build-up should also be considered. This includes the use of mallets, shovels, axes, etc., and in some cases snow blowers and other mechanical equipment. Care must be taken in the operation of all these to ensure that onboard fittings to ensure that, valves and electrical components are not damaged. Storage of all de-icing equipment should be such that items can always be accessed, and that if located within exterior compartments, their access is itself protected from freezing.

There are also many methods to ensure that icing does not occur or to limit its effect. Anti-icing methods used successfully include:

- Protective locations/covers with or without heating
- Bow form
- Electric trace wiring
- Heating coils
- Steam generators
- Ice repellent coatings
- Self draining piping
- Circulation of media (e.g., hydraulic oil)

For testing of de-icing and heat tracing equipment, two approaches may be considered. The systems may be tested in the actual environmental conditions. Alternatively, the power provided to the equipment or area subject to de-icing or heat tracing may be measured and calculations performed to verify the requirements in 4/5.1.7 are complied with. For example, in the case of electric heating, the power supplied to a heat tracing strip may be determined by the amperage and voltage levels.

Arrangements should be made to prevent freezing of all exterior moving equipment. This includes heat tracing in way of bridge and other windows, davits, deck equipment, lifeboats and other personnel safety and rescue equipment, hatch and door seals etc. Tracing systems include electric wired tape, hot water, steam and heated glycol, although water-based systems must be kept in operation to avoid freezing themselves.

Protective covers can be a cost-effective option to protect fire hydrants, mooring equipment and other operational components exposed on open decks. Although the cover itself does not prevent ice accumulation onboard, it will provide local protection around fittings, valves and controls where ice removal may be more difficult or may risk damage to the equipment.

Special consideration may be warranted for exterior electronics equipment. Communication transmitters and receivers may require anti-icing features to provide continual functionality, although whip type antennas can usually be de-iced with a strike of a wooden mallet, or shaken to remove ice build-up. Other communications antennas with horizontal surfaces or dish shaped configurations may require built-in heat elements. Exposed rotating radar scanners normally require no special measures, even at extremely cold temperatures, due to internal heating elements. However, the smaller enclosed type arrays can become encrusted with ice and can be difficult to de-ice due to their inherent fragility of construction.

5.1.8 Heating and Ventilation

Standard heating, ventilation and air conditioning (HVAC) systems (coupled with typical levels of insulation) do not have the capacity to provide adequate comfort levels during operations in extreme cold conditions. Furthermore, they may not take account of the temperature gradients that are likely to exist between the outer and inner areas of the accommodation block. Approved insulation of the steel structure inside the accommodations area will be increased significantly and this must be taken into account in the design. It is therefore not only important to calculate the overall heating demand accurately, but also that the layout of HVAC systems provides for a satisfactory distribution of heating.

Where existing vessels with inadequate systems are used in cold regions, supplementary electric heaters may be added in cabins and other manned spaces. In this case, care must be taken to avoid overloading switchboard sections, wiring and even generators.

Another consideration is relative humidity. Cold air is dry air, and humidity must be added to make-up air to provide acceptable comfort levels and to prevent static electricity build up, which can have other undesirable effects when discharges (shocks) pass through sensitive electronic equipment. Humidity control can be difficult when distributed equipment (e.g., local electric heaters) is used to supply adequate heat. Adding large volumes of water at a central plenum can lead to condensation and its associated problems. In general, the design of HVAC systems for vessels intended to operate in extreme cold conditions requires a sound understanding of the issues.

Heating can be a major issue for propulsion and auxiliary machinery spaces when combustion air is drawn into and from the compartment. At very low external temperatures, the machinery waste heat may not be adequate to provide acceptable temperatures. Additional heating will be required, both in operation and for periods alongside when machinery is shut down or idling. Combustion air requirements and guidance are in 4/2.3 and A4/2.3.

Two-speed fans offer flexibility within the system design. For extreme cold temperatures, consideration should be given to a cross-over between the supply air inlet and the exhaust trunking.

Air ventilation ducting is to be insulated to prevent condensation, which leads to corrosion and mold growth.

Closing apparatus for ventilation inlets and outlets must be able to be operated at all times, particularly for closing in the event of a fire.

5.2 Ship Piping Systems and Tanks

5.2.1 Ballast Water

Cargo vessels operating in cold regions are likely to make one leg of any voyage in ballast. Ice class vessels are likely to have significant ballast capacity to reduce the range of waterlines at which ice has to be broken. Local regulations regarding the discharge of ballast water are to be considered. Ballast water systems, therefore, need both design and operational consideration.

Ballast water in side or hopper tanks above the waterline may freeze, starting at the top of the tank and at the side walls. In new designs, it is advisable to minimize the amount of ballast carried high in the vessel, especially in stand-alone tanks. Even where the tank itself does not freeze completely, valve and suction line freezing can occur. In extremely cold regions, thick ice formation or complete blockage within air and vent pipes has been noted.

The extent of freezing will depend on the temperatures encountered and on the duration of the voyage; and also on the salinity of the ballast water. Fresh or brackish water will freeze more easily, and so higher salinity sea water should be used where voyage routing and local or regional environmental regulations allow.

It is highly unlikely that any sizeable tank will freeze solid, as the ice itself acts as an insulating layer, reducing the rate of heat transfer. However, ice represents a weight that may not be dischargeable when the vessel is loading, reducing deadweight capacity. If ice chunks fall from the tank sides after the discharge of the liquid ballast, they may damage coatings or components. Ballast tanks should not be pressed full in any conditions when freezing is possible, as expansion during the freezing process can damage structure and pipes.

Ballast tank freezing can be prevented or minimized by adding heat. This will generally be most practical for oil tankers, where cargo heating systems can be adapted to be operated on both loaded and ballast voyages. Circulating the water within the tanks is only effective over the short term, and on longer voyages can actually aggravate problems by increasing heat transfer from ballast water to air.

5.2.2 Ballast Water Tanks for Design Service Temperatures Below -30°C (-22°F)

No additional guidance.

5.3 Piping Systems for Prime Movers

5.3.1 Fuel Oil System

5.3.1(a) Fuel Oil Heating. The fuel oil heating system must be designed for uninterrupted service so that heavy and intermediate fuels are available at all times. Steam systems are standard equipment on most ocean-going vessels. However, problems associated with freezing of the steam system have occurred. Additional problems with condensate returns and failure of heaters exposed to cold air can be eliminated with the newer thermal fluid heating systems.

It may also be necessary to add heating coils to distillate fuel tanks in order to prevent clouding or waxing of these fuels at low temperatures. These systems would normally be secured and only put into use in extreme conditions.

5.3.1(b) Fuel Oil Filling Stations. Fuel filling stations should be located in a protected compartment for reliable access and operation. However, if fuel oil filling pipes have to be located on deck, alternative arrangements such as a removable or hinged cover may be installed.

5.3.2 Cooling System

5.3.2(a) Seawater Systems for Ice Class Vessels. Seawater systems draw their supply from the sea around the vessel, and must be designed to reduce the risk that inlets will become blocked by ice being ingested by the systems or forming within them. This can be accomplished by:

- Location – placing sea chest and sea bays low in the vessel, and away from ice flow lines;
- Configuration – using weirs, strainers and other means to separate ice from the water;
- Heating – normally by re-circulating hot water from cooling systems into the inlet areas.

The most cost-effective solution will depend on the type of vessel and the nature of the service. Specific guidance for the design of sea box/bays, including special considerations for piping and valves, is provided. Box coolers have been installed in recent years. In these arrangements, cooling water is forced through a U-tube-bundle, which is placed in a sea-chest having inlet- and outlet-grids. Cooling is achieved by natural circulation of the outboard water in the sea-chest or by circulation because of the vessel speed. However, ice may still accumulate during periods alongside in cold conditions, and so it will still be advisable to provide heating/water recirculation to deal with possible freeze-up and associated problems during start-up.

i) *Sea Box/Bay Arrangement.* Sea inlets should be located to prevent ingestion of ice. Locations offering the best protection depend solely on the hull form and the size of the vessel. For example, larger tankers or bulk carriers of conventional ice breaking form will see very little ice at the aft end below the turn of bilge. If sea suctions are located in this area of the hull, ice ingestion during voyages is unlikely to be a serious problem. Smaller vessels with limited draft may locate the sea inlets closer to the vessel's centerline, thereby offering somewhat better protection to ice floes projected downwards along the length of the hull.

However, since ice may still accumulate during periods alongside in cold conditions, it is advisable to provide additional protection by way of heating/recirculation to avoid problems during equipment start-up.

The sea boxes should be configured to run the maximum vertical extent possible. A sea box designed with its associated tank top well above the load waterline offers a region for any ice floes that may pass through the sea grid to float clear of the sea suctions. The suctions in turn should be located as low as possible to decrease the likelihood of ice being ingested.

To improve the protection of any sea suction inlet, the use of weirs or baffle plates have been used successfully in the past. A weir type sea box will reduce the possibility of suction pipe clogging. As the suction is isolated from the sea inlet grill by way of a solid vertical plate or a perforated baffle, ice that may enter the sea box will float to the top of the sea box and in turn be prevented from being dragged down to the suction inlet. See Appendix 4, Figures 1 through 5 for example configurations. Perforations for a baffle plate are recommended to be nominally 20 mm diameter to prevent large ice particles from being ingested yet still provide sufficient cooling capacity.

There should be the capability of manually clearing the systems of all ice blockages. This can be accomplished by designing efficient access points at strainers and designing the sea box for access above the load waterline.

ii) *Piping & Valve Arrangements.* Sea bays should be supplied from at least two (independent) sea suctions. For sufficient cooling water to enter the system, the area of the inlets themselves between the sea box and the sea bay should be a multiple of the total suction sectional areas of all seawater pumps. The selection of the multiple can be based on the ice class of the vessel. As a minimum, four (4) times is required per the Baltic Ice Class Rules in 6-1-2/35.3 of the *Steel Vessel Rules*, however, where vessels operate in regions of high frazil ice conditions (see Subsection A10/2) or are themselves ice breakers, six (6) times is required as per 6-1-1/47.17 of the *Steel Vessel Rules*

As noted previously, the location of sea suctions is critical for adequate cooling water to the vessel's systems. Ice blockage can result in overheating of the vessel systems and has caused shut downs in the past.

Sea bays can be protected by extra capacity strainer boxes. These sea bays should have additional isolation valves installed to allow access to the strainer boxes for removing debris without the need of shutting down the vessel's systems.

iii) *Cooling and Heating.* Ice-classed vessels operating in extremely cold temperatures must consider the effects that the temperature itself may have on the vessel. Although the design of the sea bays, strainers and inlets may reduce the effects of ice ingestion or prevent some icing, these will not eliminate the possibility. There are proven practices and functional designs for heating and cooling arrangements to reduce this potential inherent for vessels operating in cold regions.

Most high ice class vessels have an emergency supply of seawater separate from the standard engine room sea bay. Ballast tanks or an entirely separate emergency sea bay have been used in the past. Many vessels have a recirculated seawater cooling system back to the sea bay. This limits the amount of cold seawater entering the vessel system and aids in reducing icing of the sea bay itself. Recirculating cooling water through ballast tanks provides an additional level of reliability. If sea boxes become blocked, these tanks may be used for cooling purposes.

De-icing systems within the sea boxes and at cooling system suctions are another feature which may be incorporated to eliminate ice accumulation and blockages. Additionally, these sea boxes and bays may be provided with steam de-icing systems. The steam system requires isolating valves, strainers, and pressure gauges sized for adequate steam capacity and supply characteristics. Hot water has also been used effectively in the past.

Examples of sea inlet design using a combination of location, configuration, and heating to prevent icing problems are shown in Appendix 4, Figures 1 through 5. Most of these designs are taken from ice breaker design practice, as these vessels face the most severe challenges due to small size, high power and aggressive operation.

5.3.2(b) Seawater Piping - All Vessels

i) Standard piping, valves and fittings may be used in the sea water system. However, the use of cast iron material is not advised for any vessel operating in heavy ice conditions. Previous experience has shown that heavy vibrations during propeller/ice interactions may result in system failures because of fracture of this material.

ii) Overboard discharges should be kept to a minimum to reduce the possibility of ice forming in the vessel's valves, and wherever possible, water drains should not generally be discharged above the load waterline.

iii) In areas of extreme temperatures, steam or heat tracing is advised on all overboard discharges.

iv) Alternative means to de-ice sea chests and sea bays such as through electric heating will be considered.

5.3.2(c) Engine Cooling. Main and auxiliary engine cooling is the most frequent cause of operational problems for vessels operating in cold regions and ice-covered waters. This generally results from the inlet blockage problems discussed in A4/5.3.2(a)i), but may be caused by other effects such as the freezing of cooling lines serving harbor and emergency generators.

Insulating, heating, and/or adding antifreeze to any lines exposed to freezing temperatures may be required for any engine, and particularly for those using freshwater cooling systems.

FIGURE 1
Reduction of Ice Ingestion – Baffles

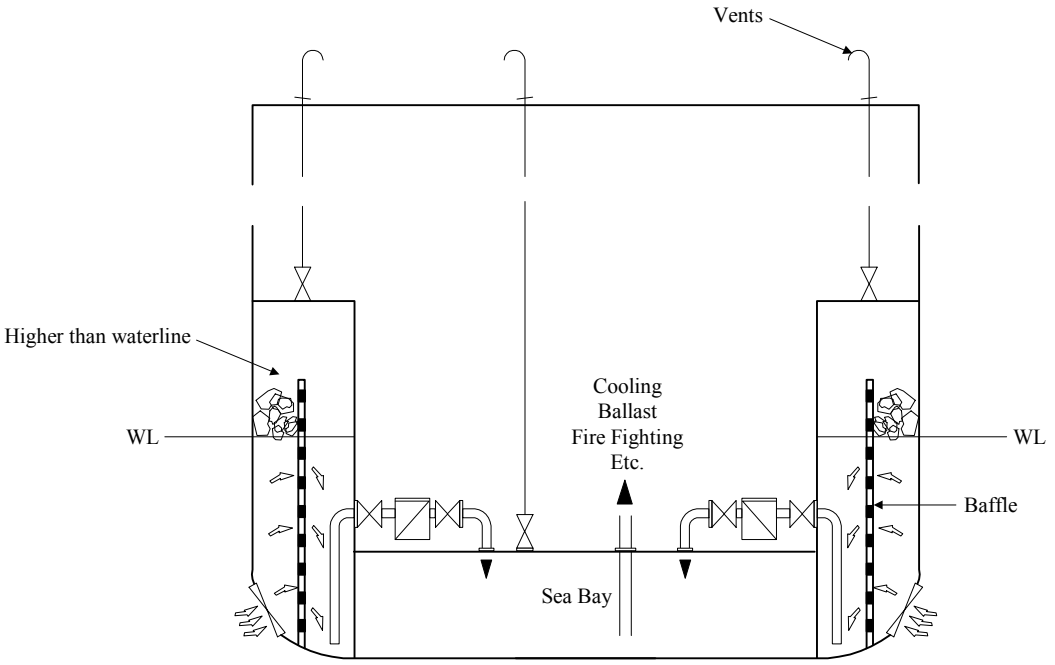


FIGURE 2
Reduction of Ice Ingestion – Weirs

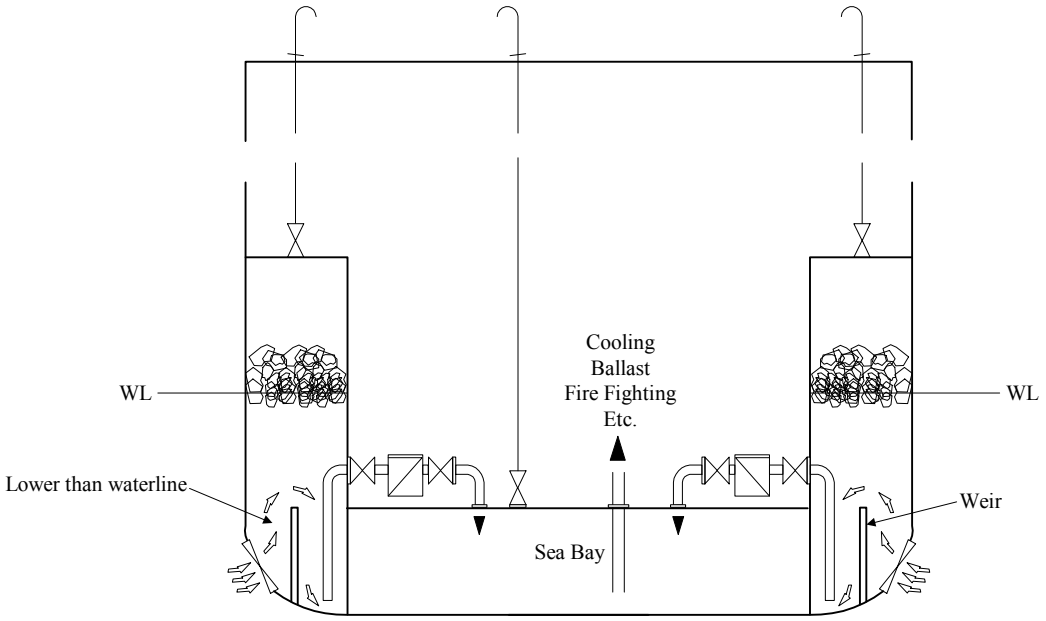
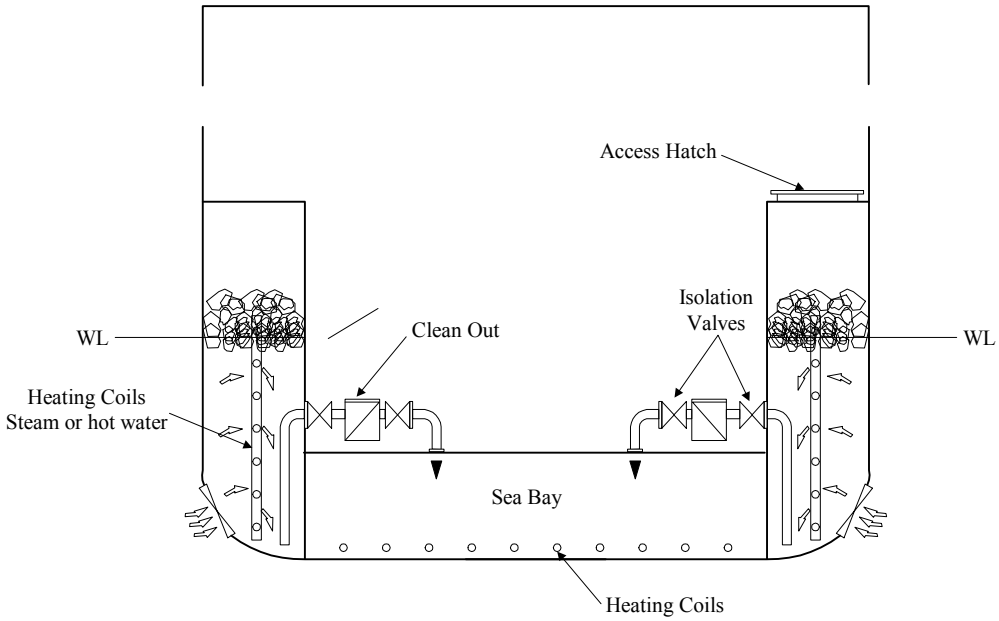
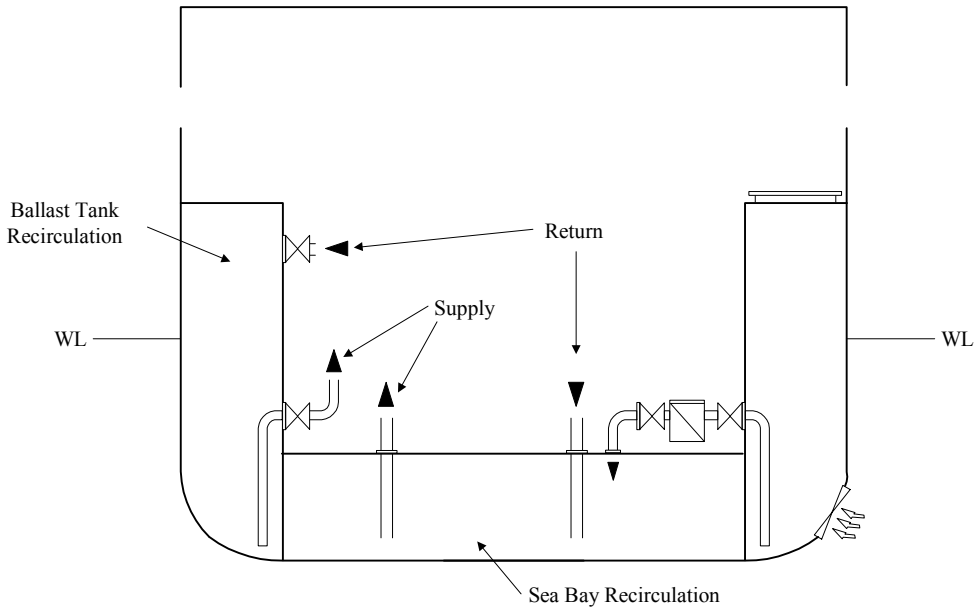


FIGURE 3
Freeze-up Prevention and Clean Outs for Ice Clearing



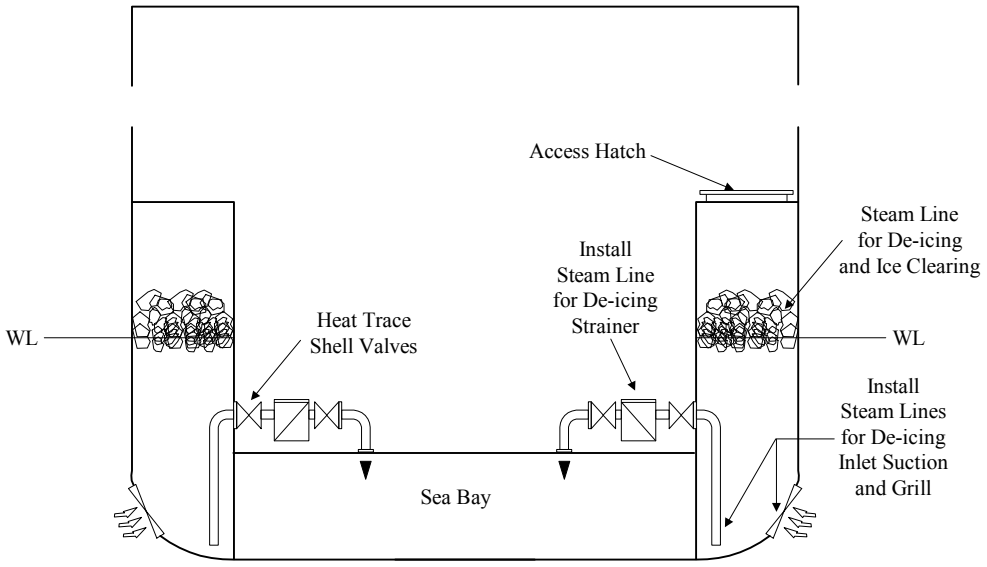
Note: Sea chest vents not shown for clarity

FIGURE 4
Recirculation – Prevents Icing and Emergency Seawater Supply



Note: Sea chest vents not shown for clarity

FIGURE 5
Recirculation – Heat Tracing and Freeze up Prevention Strategies



Note: Sea chest vents not shown for clarity

5.3.3 Fresh Water Systems

i) Fresh water tanks should be located away from the vessel's sides to prevent freezing of contents.

ii) As with all water-filled systems onboard, pipe runs throughout void spaces should be insulated and heat-traced to prevent freezing.

iii) The lowest part of the pumping arrangement and pipe runs are to be fitted with drain cocks.

iv) Fresh water generation systems may be sensitive to low sea water (inlet) temperature. The system designer must consult with the manufacturer to determine inlet temperature requirements and any other requirements necessary for satisfactory operation. In particular, reverse osmosis systems are not efficient at low temperature and will require preheat arrangements. Other auxiliary equipment may need to be considered.

5.4 Other Piping Systems

No additional guidance.

5.5 Waste Storage and Disposal Systems

Many voyages in ice-covered waters are prolonged by the need to maintain safe (low) operating speeds and by the long distances involved. For wastes normally stored for subsequent disposal ashore, this may impose additional space requirements. Few ports in polar regions have adequate waste disposal arrangement for shipboard wastes. These must generally be carried back to ports with better infrastructures.

Many arctic and Antarctic waters are also covered by restricted discharge requirements for waste streams such as oily, grey and black water, leading to additional requirements for onboard storage or to the installation of more capable treatment and disposal systems.

Waste compactors and incinerators can be used to reduce storage volumes and may be essential for vessels with a high number of persons onboard, including both passenger and science vessels. For other waste treatment systems, care should be taken that these will function adequately at low temperatures where both chemical and biological reactions may slow down markedly.

5.6 Starting Air System – Ice Class Vessels

5.6.1 General

Extremely dry control air is required to avoid condensation forming in the control air piping and ship's service air piping from freezing.

5.6.2 Starting Air System – Ice Class Vessels

The increase in the required number of starts for propulsion engines addresses the propulsion reliability and faster reaction time required for ice class vessels following an ice breaker. Loss of starting air after an engine shutdown increases the risk of collision when navigating in escorted formation.

6 Fire Safety Systems

6.1 Fire Fighting System

Many fixed and portable fire fighting systems can suffer from performance degradation due to low temperatures or to ice and snow accumulation at locations ranging from sea water intakes to hydrants and hoses. It is extremely important that the selection and configuration of fire fighting systems for vessels operating in low temperature environments give proper consideration to potential scenarios under extreme operating conditions.

Equipment, appliances, extinguishing agents and systems should always be protected from freezing. For water piping, if draining the system is not possible, options include charging the system with low temperature fluids (such as glycol) or maintaining continuous flow through the system.

Any valves or hydrants exposed to low temperatures may become difficult to operate, and require extra torque. Hydrants should be installed with two-handed valve levers or hand wheels, and configurations should take into account the need for operators to be wearing bulky and cumbersome cold weather gear.

7 Electrical Systems

The Paragraph and Subparagraph numbering in this Subsection corresponds to the Section and Subsection numbering in Part 4, Chapter 8 of the *Steel Vessel Rules*.

Most aspects of electrical system design and operation can be identical to normal practice for ocean-going vessels. Some issues do, however, need to be considered as follows:

7.2 System Design

7.2.3 Main Source of Electrical Power

Where central electric power plants or shaft generators are used, speed fluctuations during ice interactions can create frequency instability, which can damage certain subsystems and components.

7.2.5 Emergency Source of Electrical Power

The time period for emergency services may be either 18 or 36 hours depending on the intended service of the vessel. The longer time is optional.

The time periods listed in 4-8-2/5.5.2 through 4-8-2/5.5.9 of the *Steel Vessel Rules* have been increased from 18 to 36 hours because rescue times in the remote Arctic and Antarctic regions may be increased as a result of weather conditions and distances.

Heat tracing of the piping systems for the various equipment and systems listed in 4-8-2/5.5 of the *Steel Vessel Rules* is to be functional during the 18 or 36 hour period to permit continued system/equipment functionality, such as heat tracing of the steering gear equipment in a very cold steering gear compartment.

7.2.11 Specific Systems

7.2.11(a) Navigation Light System. Certain lighting designs will fail frequently in low temperature environments. Light manufacturer should certify by way of testing or service history that the lights are suitable.

It is recommended that navigation lights be of a greater intensity for improved visibility at an acceptable range. Dual filament lights would be acceptable for this purpose.

7.3 Electrical Equipment

7.3.3 Rotating Machines

7.3.3(a) Battery Starting Systems. Conventional battery capacity is influenced strongly by temperature. Where batteries are installed, this should be taken into account, or battery banks should be provided with supplementary heating.

7.3.3(b) Motors and Generators. No additional guidance.

7.3.5 Switchboards, Motor Controllers, etc.

Vibration during ice breaking can cause circuit breakers and other components to trip.

7.3.9 Cables

Electric cables in exposed areas that are not designed for the design service temperature may experience failure of the sheathing and insulation.

8 Remote Propulsion Control and Automation

8.1 Monitoring

No additional guidance.

9 Remote Control and Monitoring for Auxiliary Machinery and Systems Other Than Propulsion

No additional guidance.

APPENDIX 5 Guidance Notes on Safety Systems

1 General

The following Guidance Notes provide additional information to the user and, in some cases, recommendations as to how the Guide requirements may be complied with.

2 Essential Services

2.1 Essential Heating for Survival

An electric or steam pre-heater should be fitted in the air-handling unit for ventilation emergency use. Emergency generators should be sized for additional heating loads during an emergency as per 4/7.2.5.

Emergency generators should be suitable for de-waxed diesel oil. Special low temperature fuel may be required onboard for reliable start-up and operations during an emergency.

Emergency generator cooling should be preferably from an air-cooled radiator with sufficiently protected coolant for the design service temperature.

Where batteries are used to provide power for emergency equipment, they should be suited and sized for low temperature operation.

3 Navigational Equipment

i) All vessels should have sufficient communications capability to download ice charts and forecasts (where available) from local ice service providers. Prior to a voyage, arrangements should be made for this information to be available, as the most useful information is frequently provided on a fee-for-service basis. Systems are also becoming available to download and display higher-resolution imagery from satellites or aircraft-based radar systems. Typically, this information requires specialized equipment and training before it can be interpreted, but can be a cost-effective investment for vessels making regular polar voyages.

ii) Standard marine radar does not provide a good picture of ice conditions. As visibility is frequently limited by darkness, snow, or fog, other navigation aids should be considered. Cross-polarized radar systems can provide much better resolution of ice features, including bergy bits and other dangerous free-floating ice. These are now becoming available from specialized radar suppliers.

iii) Operations under escort or in a convoy can use standard navigation and communications equipment. Masters should verify that procedures and protocols are understood prior to commencing such operations, and that other vessels are made aware of any vessel characteristics that may influence their conduct and safety.

iv) Operation of a vessel in 24 hour darkness requires installation of remotely operated high powered Xenon Arc searchlights, suitable for operation at the design service temperature, and preferably positioned to provide 360 degree lighting capability.

v) A sound reception system is to be installed to allow the personnel in the navigation bridge to hear noises produced by the vessel passing through ice, any signals or sounds from personnel on the deck or other vessels, if in a convoy.

4 Life Saving Appliances and Survival Arrangements

Adequate supplies of protective clothing and thermal insulating materials should be supplied for all vessels operating in Arctic ice-covered waters for all persons onboard at all times. The IMO Guidelines for ships operating in Arctic waters, MEPC Circular 399 contain recommendations for Personal and Group survival kits for polar operations, over and above standard SOLAS requirements for open-water vessels.

Ice build-up in way of all lifeboats, life rafts, cradles, davits and other launching gear should be regularly removed so that launching arrangements are not hindered. This may include ensuring a wooden mallet is available at each station or in the vicinity of the lifesaving appliances.

Additional rations stored in the deckhouse/accommodations are recommended so that water is readily available to the crew as the water stored onboard the lifeboats will be frozen.

Note that most EPIRBs work only down to -20°C according to manufacturers' instructions. Care must be taken to verify that the selected EPIRBs are suitable for the design service temperature. The manufacturer should be consulted for guidance.

4.1 Lifeboats

Air-cooled engines provide additional heating and can reduce problems associated with frozen valves, piping and water intakes.

The lifeboat's propeller is susceptible to damage from ice, particularly when operating astern.

Another issue will be condensation, as humidity from survivor breathing touches the cold hull and canopy. This can render survivors even more uncomfortable, and can fog the windows at the coxswain station (and elsewhere). Consideration should be given to installing supplementary ventilation or air circulation features, and to heaters for the craft interior.

Lifeboat engine distillate fuel should have a cloud point well below the design service temperature.

Lifeboat engine lubricating oil should have the correct viscosity at the design service temperature without the use of a heater.

4.2 Life Rafts

The IMO Life Saving Appliances Code requires inflatable life rafts to be capable of inflation within 3 minutes at a temperature of -30°C (-22°F). Lower design service temperatures may result in inability to inflate properly at low temperatures, and so operators should verify that adequate air or other proven cold temperature gas is used for the inflation of life rafts. Manual inflation pumps are to be suitable for operation at the design service temperature.

See A5/4.4 for additional guidance regarding storage and launching considerations.

4.3 Rescue Boat

Refer to A5/4.1.

4.4 Launching Stations and Arrangements

Lifeboats should be capable of being launched into the vessel's track because it is assumed there will be little room to transit between the vessel side and the ice cover.

It may be necessary or desirable to lower life rafts onto the ice rather than into the water; in which case it is better to do this in an un-inflated condition to allow the raft to be dragged clear of the vessel. Storage and launching arrangements should be installed with this possibility in mind. An inflated life raft can act as a tent on the ice surface, protecting survivors from the worst of the cold and wind.

4.5 Ice Gangway, Personnel Basket and Escape Chutes

An ice gangway or personnel basket used with a crane is often used to bridge over the gap between the vessel and solid ice.

Caution is recommended relative to the consideration of the use of escape chutes with regard to crew safety. When there is a mix of ice and open water, evacuation is difficult and can be dangerous.

4.6 Immersion Suits and Life Jackets

Refer to A8/3.4.6 for additional guidance.

4.7 Alarms, Escape Routes and Access Routes

Escape routes are to be clearly marked. External escape routes such as walkways are recommended to be heated.

5 Drills and Emergency Instructions

Refer to the requirements for Personal Survival Kits and Group Survival Kits in Chapter 11, Life-Saving Appliances and Survival Arrangements of IMO MSC Circular 1056/MEPC Circular 399 (2002) Guidelines for Ships Operating in Arctic Ice-Covered Waters.

The flag state administration may have additional requirements.

6 Provisions and Spares

Refer to the requirements in 13.4 of Chapter 13, Operational Guidelines of IMO MSC Circular 1056/MEPC Circular 399 (2002). Guidelines for Ships Operating in Arctic Ice-Covered Waters.

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APPENDIX 6 Guidance Notes on Specific Vessel Requirements

1 General

The following Guidance Notes provide additional information to the user and, in some cases, recommendations as to how the Guide requirements for specific vessel types may be complied with.

2 Vessels Intended to Carry Liquefied Gases in Bulk

Liquid Natural Gas carriers, due to the nature of the cargos carried onboard, are constructed with containment systems specifically designed with cryogenic insulating characteristics. Many other systems and equipment are also designed with materials and equipment capable of operating at low temperatures. However, it is necessary that both external and internal low temperatures are taken into consideration. In particular, safety systems such as venting arrangements need to be protected from ice and snow accumulation.

2.1 General

No additional guidance.

2.2 Material Selection

No additional guidance.

2.3 Hull Construction and Equipment

Some concerns have been expressed about the robustness of different gas containment systems under the acceleration loads that may result from ice impact. There are no inherent reasons why any system capable of open water operation and meeting gas carrier damage tolerance standards cannot be used in vessels intended for navigation in ice. Ice breaking loads should be verified as part of the overall design development, especially as LNG carriers may need to maintain relatively high service speeds to keep voyage schedules.

Ice loads on the containment systems or any cover for the containment systems may be estimated by applying the allowance for ice accretion in accordance with the IMO Code on Intact Stability or the requirements of the flag state Administration. See Subsections 3/5 and A3/5.

2.4 Machinery and Electrical Equipment

2.4.1 Valves

No additional guidance.

2.4.2 Cargo Tank and Inter-barrier Space, Venting and Pressure Regulating Arrangements

No additional guidance.

2.4.3 Heating Media

No additional guidance.

2.4.4 Cargo Control/Environmental Systems

No additional guidance.

2.4.5 Mechanical Ventilation

No additional guidance.

2.4.6 Towing Fittings

No additional guidance.

2.5 Access to Deck Areas and Cargo Machinery

2.5.1 Electric Motor Room and Cargo Compressor Room Access

No additional guidance.

2.5.2 Cargo Manifold

The design of a dedicated watch station in way of the cargo manifolds should be considered for vessels that are expected to regularly load/discharge cargoes in extremely harsh environments.

Note: Emergency disconnection is performed by the terminals (without purging) to protect their terminal loading arms. The vessel provides the Emergency Shutdown System (ESDS). When an ESDS is activated, the manifold valves close (under all service conditions within 30 sec), thus discontinuing loading or unloading operations.

During the discharge/loading operation, some operators will pump seawater over the decks and manifold areas to act as a thermal barrier should there be an LNG leak.

The cargo loading platform drip tray should be so designed that filling with seawater during the discharge/loading operation is not required. Seawater for the water curtain may be preheated to avoid excessive ice build up at the side shell plating.

Vent masts – It is extremely important that the vent mast is drained of any accumulation of water. The purpose of this is to ensure that the relief valves operate at their correct settings, which would otherwise be altered if any water were to accumulate in the vent mast and flow onto the valve assembly.

Vapor heater – LNG carriers are generally fitted with vapor heaters for use during controlled venting of vapor. Controlled venting is rarely done. At low ambient temperatures a vapor heater is mandatory, preventing the cold gas vapor to fall directly on deck. However, individual tank vents are not designed to be routed to the heater. In the instance of an individual tank relief valve lifting, uncontrolled venting occurs and cold vapor will be released to the atmosphere.

2.5.3 Access to Machinery on Deck

No additional guidance.

2.6 Monitoring Systems

No additional guidance.

2.7 Fire and Safety Systems

No additional guidance.

3 Vessels Intended to Carry Ore or Bulk Cargoes/Cargo Ships

3.1 General

No additional guidance.

3.2 Material Selection

In cold conditions, the chance of brittle cracking will be increased with frequent impact loading associated with cargo and by mechanical handling equipment. Accordingly, consideration may need to be given to using tougher materials in the cargo hold bottom and side plating, particularly if the vessel has the **GRAB** notation.

3.3 Hull Construction and Equipment

3.3.1 Hatch Cover Sealing

The selection of hatch sealing material should be specially considered in light of their reduced ductility in extremely cold temperatures. OBOs in particular may have sealing problems of their main hatches, posing increased risk of cargo contamination and release of products.

3.4 Machinery and Electrical Equipment

No additional guidance.

3.5 Access to Deck Areas and Cargo Machinery

No additional guidance.

4 Offshore Support Vessels

4.1 General

No additional guidance.

4.2 Material Selection

No additional guidance.

4.3 Hull Construction and Equipment

4.3.1 Stability

With regard to vessels' stability, it is important for masters to have a full understanding of the special challenges of cold weather operations and of the operating limits of their vessels.

4.4 Machinery and Electrical Equipment

No additional guidance.

5 Vessels Intended to Carry Oil in Bulk

5.1 General

Arctic maritime administrations and global and regional intergovernmental organizations have recognized that pollution of polar waters can have particularly severe consequences for the environment, aggravated by the limited availability of response infrastructure and the specific challenges of spill treatment in the presence of ice. As a result, tankers are frequently subjected to additional design and operational requirements which should be verified prior to any voyage.

Specific regulations and guidelines may include oil transfer requirements, restricted operations and routing, carrying dedicated ice navigators or observers and, in some circumstances, arranging for mandatory ice breaker support.

Equipment and outfit issues particularly relevant to tankers include arrangements to prevent the freeze-up of vent lines, measures to protect valves and manifolds from icing, and special consideration of ballasting arrangements. Tankers intended for operations in ice may need additional ballast to immerse vulnerable elements such as propellers and rudders, which are near or above the waterline in some standard open water designs.

5.2 Material Selection

No additional guidance.

5.3 Hull Construction and Equipment

No additional guidance.

5.4 Machinery and Electrical Equipment

5.4.1 Towing Fittings

No additional guidance.

5.4.2 Pressure/Vacuum Valves

Some vessel operators fill the pressure/vacuum valves with anti-freeze fluid. Other operators regularly de-ice pressure/vacuum valves using an on-deck steam supply. Some valve manufacturers permit a certain amount of icing on the valve before de-icing must be performed. The valve manufacturers should be consulted for guidance.

5.4.3 Cargo Tank Purging and/or Gas-Freeing

No additional guidance.

5.4.4 Inert Gas System

The inert gas system scrubber is to be located in a compartment protected from the weather so that the fluids do not freeze.

The inert gas system deck seal is either filled with anti-freeze or heat traced to keep the seal operable.

5.4.5 Piping – General

Insulated piping should be properly installed and maintained to prevent moisture becoming entrapped between the insulation and the pipe and causing corrosion.

5.5 Access to Deck Areas and Cargo Machinery

5.5.1 Access to Bow

No additional guidance.

5.5.2 Cargo Manifold

The design of a dedicated watch station in way of the cargo manifolds should be considered for tankers that are expected to regularly load/discharge cargoes in extremely harsh environments. At many offshore terminals, tankers may be forced off their moorings by ice movement, and may need to shut down transfer operations rapidly to avoid spills. Quick disconnect and purging arrangements may need to be provided.

5.5.3 Access to Machinery on Deck

No additional guidance.

5.6 Monitoring Systems

No additional guidance.

5.7 Fire and Safety Systems

Additional fire and safety systems as required to be installed are to be arranged and installed for continuous operation at the design service temperature. If fitted, the water spray deluge system is to be equipped with heat tracing and sufficient drainage to prevent freezing. Alternative arrangements for water deluge systems and possible additives to the water may be accepted based on the approval of the flag administration. Dry chemical powder systems are to be arranged to prevent clogging of the nozzles and release the medium at the design service temperature.

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APPENDIX 7 Guidance Notes on Survey

1 General

At this time there are no additional guidance notes related to survey requirements. As additional experience is gained, this Appendix will be revised.

2 Damages

2.1 Controllable Pitch Propellers – Pitch Actuation System

In the event of propeller blade damage, the pitch changing mechanism of the controllable pitch propeller is recommended to be inspected.

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APPENDIX 8 Guidance Notes on Crew Considerations

1 Introduction

Working in cold weather environments has significant implications on human capabilities and unless proper precautions are made can be hazardous to a person's health. In recognition of these implications on human health and performance due to working in cold climes, this Appendix is offered to provide:

- Basic information on human performance and health hazards
- Guidance for design or selection of clothing
- Design of equipment to be operated in cold conditions
- Information that can be used to help generate cold weather operations' safety and operating procedures
- Information that can be used to preserve the health of persons working in cold environments

The guidance that follows is simply guidance and carries no weight as Rules or requirements leading to Notations or Certifications. The information is provided for those Owners, designers, or operators that would like information of the sort provided as a reference to consider in the course of ship design and operation. The material in this Appendix is applicable to extreme cold weather working conditions. Some of the hazards discussed here are a concern under exceptional circumstances which force personnel to stay in cold temperature for extended periods.

2 Definitions

Atrium: A body cavity or chamber, especially either of the upper chambers of the heart that receives blood from the veins and forces it into a ventricle

Chilblains: An inflammation followed by itchy irritation on the hands, feet, or ears, resulting from exposure to moist cold

Clo-units: The rate of a person's heat loss as measured in watts per square meter of skin area per kelvin of temperature difference across the clothing; the value of insulation is measured by the reciprocal of this rate, in square meter kelvins per watt (m^2-K/W)

Ergonomics: The applied science of equipment design, as for the workplace, intended to maximize productivity by reducing operator fatigue and discomfort

Fibrillation: Rapid uncoordinated twitching movements that replace the normal rhythmic contraction of the heart and may cause a lack of circulation and pulse

Hypothermia: Abnormally low body temperature

Melatonin: A hormone that plays a role in sleep

Physiologic: Being in accord with or characteristic of the normal functioning of a living organism

Raynaud's Sign: A bluish discoloration of the extremities; can occur when a spasm of the blood vessels is caused by exposure to cold or by strong emotion

Triglyceride: A naturally occurring ester of three fatty acids and glycerol that is the chief constituent of fats and oils

Ventricle: The chamber on the right side of the heart that receives venous blood from the right atrium and forces it into the pulmonary artery; any of the interconnecting cavities of the brain

Wind Chill: A still-air temperature that would have the same cooling effect on exposed human flesh as a given combination of temperature and wind speed; called also *chill factor, wind chill factor, wind chill index*

3 Human Response to Cold and Arctic Exposure

The core (trunk) of the human body should remain within a small temperature range for healthy function. Excessive cooling or excessive heating will result in abnormal cardiovascular and neurological function. The skin is the organ through which a person regulates body temperature. With an average skin temperature of 33°C (91.4°F), conductive heat loss occurs at temperatures below this value. Therefore, it is easy to see how cold weather performance can significantly influence normal body function. As a person cools:

- Metabolism is increased to generate more body heat – as cooling continues a person will begin to "shiver" – a visible sign that body cooling has progressed beyond a comfortable level. Increased metabolism will reduce the amount of time a person can sustain work.
- Safe manual materials handling tasks require the use of tactile senses, hand dexterity, strength, and coordination. Decreases in the ability to produce force, exhibit fine control over objects, and sustain muscular work loads occur in cold working environment.
- Work in cold environments is related to an increased risk for musculoskeletal injury.
- Motor function impairments of the arms and hands will occur long before cognitive or hypothermic-related disabilities occur. Impaired cognitive performance will lead to poor decision-making and increased risk for accident.
- Persons suffering from arthritis or rheumatism will generally experience increased levels of pain during cold weather operations.

3.1 Decreases in Cognitive/Reasoning Ability Due to Cold Exposure

Extremely cold conditions [below 10°C (50°F)] adversely influence mental skills and coordination. As operational temperatures decrease, the frequency of cognitive error will increase.

Tasks requiring vigilance may be hampered after prolonged exposure to cold. Decision verification procedures should be implemented.

Cold weather operations, coupled with other physical distracters, such as noise or motion environments, will influence the quality of perception, memory and reasoning and compound the risk of decision-making error.

3.2 Health Hazards Related to Cold Exposure

The list of potential injuries and issues for occupational work in cold environments is lengthy. Personnel should have adequate training to enhance preparation for work in cold environments. Proper planning and precaution can deter the potential risks of cold work.

3.2.1 Non-freezing Tissue Injury

In nonfreezing tissue injuries, parts of the skin are chilled but not frozen.

- *Frostnip* is a cold injury in which the chilled areas of skin become numb, swollen and red. The only treatment needed is warming the area for a few minutes. During warming, the area may hurt or itch intensely. No permanent damage results, although sometimes the area is particularly sensitive to cold for months or years afterward.
- *Immersion foot (trench foot)* is a cold injury that develops when a foot is kept in wet, cold socks and boots for several days. The foot is pale, clammy and cold. After warming, the foot becomes red and painful to the touch. Sometimes blisters develop, which may become infected. Rarely, this type of injury occurs in the hands. Treatment consists primarily of gently warming, drying and cleaning the foot; elevating it; and keeping it dry and warm. Medical doctors (aboard or ashore) should be consulted regarding need for treatment with antibiotics to prevent infection or whether a tetanus booster is recommended if the person's tetanus vaccination is not current. Trench foot can often be prevented by changing socks and drying the feet at least daily.
- *Chilblains (pernio)* is an uncommon reaction that may occur with repeated exposure to cold. Symptoms include itching, pain and, in rare cases, discolored areas or blisters on the affected area (usually the leg). The condition is uncomfortable and recurrent. Preventing exposure to cold is the best treatment. Treatment includes re-warming, using blankets, lukewarm baths or heating pads positioned at low heat setting, which will allow blood flow to return to the peripheral tissues.

3.2.2 Freezing Tissue Injury

Damage to tissue during cold exposure is commonly caused by freezing of the tissue and surrounding area. Tissue freezing is more commonly referred to as frostbite, and is a common occurrence in colder climates. Frostbite occurs most often at ambient temperature below -20°C (-2°F). Frostbite occurs as a result of limbs and facial areas being exposed to low ambient temperatures and wind. Generally, frostbite is accompanied with discoloration of the skin, along with burning and/or tingling sensations, partial or complete numbness, and possibly intense pain. Hands, feet, noses and ears are more commonly affected by frostbite. If the nerves and blood vessels have been severely damaged, gangrene may follow, and amputation may eventually be required. If left untreated, frostbitten skin gradually darkens after a few hours. Skin destroyed by frostbite is completely black and looks loose and flayed, as if burnt.

The crucial factor in the development of frostbite is not necessarily the ambient temperature and wind, but whether the tissue reaches a temperature of -4.8°C to -7.8°C (23.4°F to 18°F). Cellular structural damage occurs when cells freeze. There are four levels of frostbite.

- First-degree frostbite results in vesicles (blisters) that damage only the outer skin.
- Second-degree frostbite is associated with full thickness skin loss.
- Third-degree frostbite involves the skin and underlying tissue.
- Fourth-degree frostbite is the worst and results in freezing to the bone. This level of frostbite typically results in amputation of the affected tissue.

Diagnosis of whether superficial or deep tissue was damaged involves analysis of blisters; superficial injury will have clear blisters, while deeper tissue injury will have blisters filled with blood as a result of damage to vascular tissues.

Frostbite requires emergency medical care. Procedures should be in place to provide first aid for victims of frostbite. Means to get medical advice (from physicians either aboard or ashore) should be in place as part of these procedures. A person who has frostbite should be covered with a warm blanket and given a hot beverage because people with frostbite may also have hypothermia. Rubbing the area (particularly with snow) leads to further tissue damage. Because the area has no sensation, it should not be warmed in front of a fire or with a heating pad or electric blanket. The frostbitten area becomes extremely painful on warming and medical attention likely will be urgently needed for pain management. Blisters should not be broken. If blisters break, they should be covered with antibiotic ointment.

It is common for individuals who experience severe frostbite to later experience such problems as: hypersensitivity to cold, cold feet, burning/prickling/itching or tingling sensations, chronic pain, loss of sensation of touch, white fingers, excessive sweating, pain when walking, and other such problems causing a hindrance to work performance. Causes are generally thought to be related to permanent nerve and tissue damage, and in severe frostbite there can even be degeneration of bone and onset of arthritis.

3.2.3 Raynaud's Sign (White Finger):

Raynaud's sign represents a disease and relates to the body's hypersensitivity to cold, causing the arterial musculature to spasm and constrict peripheral blood flow at a much higher level than typical for a given ambient temperature. Less severe cases of Raynaud's sign, referred to as primary Raynaud's, are idiopathic (a medical condition of unknown origin), while secondary cases occur as a result of a underlying physiologic condition or environmental exposure. Secondary Raynaud's sign often occurs as a result of thickening in underlying tissue and vascular beds through mechanisms such as previous severe frostbite or exposure to vibrating tools. The term most often associated with vibration-induced impairment in hand-arm circulation is termed vibration-induced white-finger. White-finger describes the loss of color, increased numbness, and decreased tactile sense associated with circulation impairment for individuals exposed to vibration and/or cold. At the end of a white-finger attack, blood flow returns to the area causing redness, swelling and pain. In severe cases, the symptoms can cause debilitation of performance. The condition may take a few months or several years to develop, depending on the individual physiologic tolerance and the level of cold. With the decreased ability for blood to be delivered to the peripheral areas, there are often symptoms of burning/throbbing pain, numbness, stiffness, diminished sensations and swelling from fluid pooling. These symptoms, even at mild levels, are likely to make manual performance uncomfortable and unreliable.

There is no known cure for Raynaud's sign. However, there are known intervention techniques to alleviate symptoms. Exercise and using warming devices to increase blood flow to affected areas has been successful.

3.2.4 Hypothermia

Hypothermia is a rapid, progressive mental and physical collapse due to the body's warming mechanisms failing to maintain normal body temperatures.

While hypothermia is often associated with immersion in cold water, it can also occur in air when suitable cold weather protection is not employed. Conditions of extremely low dry-ambient temperature or mildly cold ambient temperatures with wind and dampness can lead to a general cooling effect on the body. If metabolic heat production is less than the gradient of heat loss to the environment, hypothermia becomes an issue.

As a result of loss of core temperature, damage to more central organs and systems presents a problem. As the temperature of the core body decreases, so does the heart and associated tissue, which ultimately results in a reduction in heart rate and therefore blood output to the body's tissues and organs. A natural protective mechanism occurs where the brain progressively shuts down cerebral (brain) areas. As core temperature drops, more areas of the brain shut down, leading to reports of amnesia during hypothermic situations, and eventual loss of consciousness in severe hypothermia. At core temperatures less than 34°C (93°F), cognitive function begins to become impaired and at temperatures below 28°C (82.4°F), there is a risk of ventricular fibrillation ("twitching" of the heart and loss of pulse) and cardiac arrest.

People with diabetes, injuries, kidney problems, epilepsy and arthritis are at a higher risk of hypothermia in comparison to healthy people.

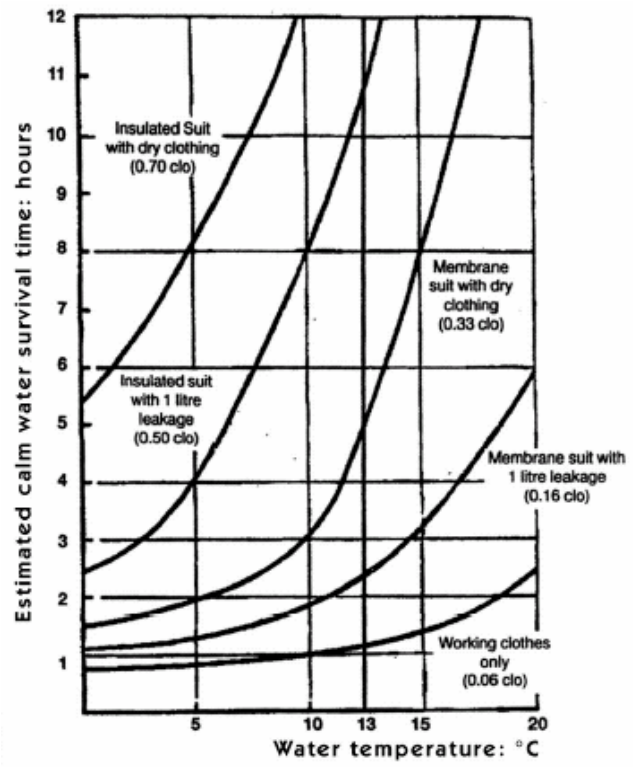
Classification of hypothermia ranges from mild to severe. Mild hypothermia involves core body temperatures between 32°C and 35°C (89.6°F and 95°F), moderate involves temperatures between 28°C and 32°C (82.4°F and 89.6°F), and severe hypothermia involves core temperatures below 28°C (82°F). Appendix 8, Table 1 presents the symptoms of hypothermia.

TABLE 1
Symptoms of Hypothermia

Mild Hypothermia	*Moderate Hypothermia*	*Severe Hypothermia*
Increased heart rate, resulting from venous return increase Shivering Excessive discharge of urine - resulting from central pooling of blood flow and resulting in rapid delivery to the kidneys Increased muscular tone Decreased nerve conduction Shivering	Impaired respiration Decreased heart rate, blood pressure Blue-gray lips, nail beds or skin color Muscle spasms Loss of feeling in or use of arms and legs Loss of muscle function Slurred speech Blurred vision Impaired cognition Confusion Shivering stops (resulting of used energy in prior stages)	Limited or no cognitive ability Twitching of the heart muscles (atrial and ventricular fibrillation) Possible cardiac arrest Unconsciousness Death

Appendix 8, Figure 1 presents the relationship between clothing and water survival time.

FIGURE 1
Relationship between Clothing and Water Survival Time



Source: Information originally developed by the United States Air Force School of Aerospace Medicine and presented by Reeves (no date)

Procedures devised in consultation with physicians should be in place to guide treatment of a hypothermic person. Means to access medical advice should be in place (aboard or ashore access to physicians). The guidance contained in MSC.1/Circ 1185, "Guide for Cold Water Survival" is also applicable to the treatment of hyperthermia.

Treating the hypothermic victim generally involves the following:

i) Immediate treatment is much more important than any later action in reviving victims of immersion hypothermia.

ii) Get the person out of the cold, wind, rain or water.

iii) Be gentle with the victim, restricting their movements.

iv) Do not allow him or her to walk unless absolutely necessary.

v) Take precautions to warm the victim up slowly.

Note: Rapidly applying heat to a hypothermia victim can send the person into shock and cause permanent brain and organ damage

vi) Replace the victim's wet clothes with dry clothes.

vii) If the victim is conscious and alert, you can allow him or her to drink warm liquids that do not contain alcohol or caffeine.

viii) Re-warm the victim:

a) Cover the person in a blanket or any other material such as trash bags that will help heat retention.

b) A hot bath (the temperature no higher than the immersed hand will tolerate) is the most effective method of achieving re-warming.

c) As the only non-invasive hospital treatment suitable for active core re-warming in the field, inhalation re-warming donates heat directly to the head, neck, and thoracic core (the critical core) through inhalation of warm, water-saturated air at 43°C to 45°C (107°F to 122°F). This method also warms the hypothalemus, the temperature regulation center, the respiratory center, and the cardiac center at the base of the brainstem.

d) In more severe cases of hypothermia, non-clinical attempts to re-warm the body should revolve around passive re-warming – covering the body to prevent any additional heat loss and letting the body's metabolism gradually raise internal temperature. Rapid re-warming can cause immediate changes in peripheral blood distribution, cardio-pulmonary function, perfusion ratio, and nervous control of circulation; with the impaired cardiac output associated with moderate and severe hypothermia, sudden changes in peripheral blood flow can force the individual into cardiovascular shock

ix) If the victim is semi-conscious, keep the person awake.

x) If the victim is unconscious and shows no signs of life, then begin CPR immediately.

xi) Severely hypothermic individuals have a greater chance of survival if greater travel time is taken to reach a facility with appropriate treatment equipment, rather than settling for the closest facility and relying on more primitive re-warming methods.

3.2.5 Cardiovascular Function and Cold Exposure

Sudden changes in cardiovascular function occur every day when individuals are exposed to cold weather after previous exposure to a thermo-neutral climate. These changes cause a sudden increase in the workload placed on the heart and may cause subsequent cardiovascular problems.

Systolic blood pressure can increase by about 30 mm Hg, and diastolic blood pressure can increase about 20-22 mm Hg in older subjects and increases by 23 mm Hg in systolic and 12 mm Hg in younger subjects. In both populations there is a significant increase in blood pressure, and for individuals who are hypertensive, the strain on the heart may result in a cardiovascular incident. Blood pressure can be easily monitored and should be recommended for persons with existing coronary and respiratory disorders.

Cardiovascular problems associated with cold exposure rarely occur upon the initial exposure; usually a resultant case of heart attack or stroke will occur 24 to 54 hours after severe cold exposure.

3.2.6 Respiratory Function and Cold Exposure

Cold air has an influence on airway resistance and pulmonary function. This response can cause significant problems for individuals with asthma.

There is evidence of long-term occupational exposure to cold causing chronic obstructive pulmonary disorders. The increased constriction of the bronchial air passages causes an increase in airway resistance and thus greater effort in breathing. These effects are not seen in thermo-neutral air, and even when present, they are not likely to cause performance limitations, but the increased constriction may further complicate symptoms of asthmatic individuals.

3.2.7 Physiologic Changes in Arctic Environments Unrelated to Cold

Seasonal changes in circadian rhythms are common and result in changes in melatonin release. Melatonin (a hormone that plays a role in sleep) is released in response to decreased light exposure, and release is depressed with greater light. A change in melatonin release can cause disruption in the physiologic sleep-wake cycle, and this effect can reach extremes in Arctic and Antarctic environments where there are prolonged periods of light or darkness.

There is also evidence of work schedules and daily routine having an influence on sleep-wake cycles; in arctic environments where light conditions persist several months followed by months of darkness, the melatonin-mediated control of circadian rhythm can clash with the social and work-mediated sleep-wake cycle. Interruptions in sleep patterns are common in arctic regions for this reason, often leading to increased fatigue and sleep deprivation.

To counteract the physiologic reaction to decreased light, a strategy of matching lighting conditions to work patterns, using blinds and artificial lighting, has shown success. Releasing melatonin by natural or artificial conditions to match work schedules will allow for matching circadian rhythms to social demands and an overall improved sleep pattern. Shift work on ships is suspected to cause both physiological and psychological problems with crew, and these problems are expected to be amplified in arctic conditions. Suntan beds have been employed in vessels operating at near-polar locations to counteract light deprivation periods of the year.

Sleeping areas should be capable of being well "blacked out" to reduce problems in falling asleep due to excess light in the sleeping quarters.

In snow-covered environments, the snow can act as a reflective surface for sunlight without absorbing the light in the same manner as pure-water reflective surfaces. Exposure to direct sunlight for more than 10 minutes requires use of protective eyewear. Using glass lenses for protective eye equipment to filter UV and IR light from entering the retina and using brimmed hats to reduce sun exposure is recommended.

3.3 Monitoring Environmental Conditions

Working in cold environments requires an understanding of the interaction between ambient temperature, wind speed, relative humidity, personnel protective equipment and task being performed. In order to limit the risk during operational activities due to cold stress and further prevent local cold injuries and general freezing, specific preventative measures should be evaluated and introduced during the planning and execution of the daily work activities.

A plan for monitoring exposure to cold should be devised and should take account of variations in thermal conditions.

Ship managers should, if practicable, eliminate the need for extended work in cold conditions (for example, by rescheduling work to be performed in a warmer season, or by moving the work from outdoors to indoors, or separating the cold parts of a process from the workers, as far as practicable). If elimination of such work is impracticable, other measures to reduce risk from cold conditions should be devised.

Employers should ensure that workers are not positioned near very cold surfaces or, if this cannot be avoided, that the workers are protected by radiation shields. For standing tasks, the floor should, where practicable, have an insulating surface.

Climatic metrics such as temperature, wind speed and humidity should be regularly monitored in the locations where outside work is to be performed. Of primary importance is a regular reporting of the wind chill or equivalent temperature.

Regular communications should be maintained regarding allowable time to work outside. Indoor personnel should regularly monitor outside workers so that best work-to-rest/warming schedules are maintained.

Appendix 8, Table 2 presents information regarding the relationship of wind chill and exposure danger.

Appendix 8, Table 3 presents information on maximum work times for different levels of exposure to cold.

Appendix 8, Table 4 presents threshold limit values for work/warm-up schedule for four-hour shifts/watches.

TABLE 2
Relationship between Wind Chill and Exposure Danger

WIND CHILL CHART

		Ambient Temperature (°C)								
		4	-1	-7	-12	-18	-23	-29	-34	-40
Wind km/h	Velocity mph	Equivalent Chill Temperature (°C)								
Calm										
0	0	4	-1	-7	-12	-18	-23	-29	-34	-40
8	5	3	-3	-9	-14	-21	-26	-32	-38	-44
16	10	-2	-9	-16	-23	-30	-35	-43	-50	-57
24	15	-6	-13	-20	-28	-36	-43	-50	-58	-65
32	20	-8	-16	-23	-32	-39	-47	-55	-63	-71
40	25	-9	-18	-26	-34	-42	-51	-59	-67	-76
48	30	-16	-19	-22	-36	-44	-53	-62	-70	-78
56	35	-11	-20	-29	-37	-46	-55	-63	-72	-81
64	40	-12	-21	-29	-38	-47	-56	-65	-73	-82

Source: Threshold Limit Values (TLV™) and Biological Exposure Indeces (BEI™) booklet; published by ACGIH, Cincinnati, Ohio

Little danger in less than one hour exposure of dry skin

DANGER – Exposed flesh freezes within one minute

GREAT DANGER – Flash may freeze within 30 seconds

Source: Canadian Center for Occupational Health and Safety, 1999

TABLE 3
Suggested Maximal Allowable Work Times

Equivalent Temperature	*Consequence – Action*
Below -30°C	No outdoor work performed unless deemed critical from a safety or operational perspective
Below -21°C	Available outdoor working time is below 50% of working hour.
Below -12°C	Available outdoor working time is below 75% of working hour.
Below -6°C	Available outdoor working time is below 90% of working hour.
Above -6°C	Normally 100 % Available working time

TABLE 4
Threshold Limit Values Work/Warm-up Schedule for Four-Hour Shift

THRESHOLD LIMIT VALUES WORK/WARM-UP SCHEDULE FOR FOUR-HOUR SHIFT*

Air Temperature Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C (approx)	°F (approx)	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
-26° to -28°	-15° to -19°	(Norm breaks) 1		(Norm breaks) 1		75 min.	2	55 min.	3	40 min.	4
-29° to -31°	-20° to -24°	(Norm breaks) 1		75 min.	2	55 min.	3	40 min.	4	30 min.	5
-32° to -34°	-25° to -29°	75 min.	2	55 min.	3	40 min.	4	30 min.	5	Non-emergency work should cease ↓	
-35° to -37°	-30° to -34°	55 min.	3	40 min.	4	30 min.	5	Non-emergency work should cease ↓			
-38° to -39°	-35° to -39°	40 min.	4	30 min.	5	Non-emergency work should cease ↓					
-40° to -42°	-40° to -44°	30 min.	5	Non-emergency work should cease ↓							
-43° to below	-45° & below	Non-emergency work should cease									

Source: Adapted from Threshold Limit Values (TLV) and Biological Exposure Indices (BEI) booklet: published by ACGIH, Cincinnati, Ohio, 2000.

3.4 Clothing and Personal Protective Equipment

For appropriate protection/isolation against cold climate conditions, adequate clothing should be selected and used onboard during cold periods. Such optimal clothing should be able to mitigate water and humidity during work and at the same time insulate sufficiently to maintain thermal comfort during rest. The insulating effect of the clothing is influenced by different factors including temperature, wind and humidity.

The measure of clothing insulation is determined by clo-units. The rate of a person's heat loss is measured in watts per square meter of skin area per kelvin of temperature difference across the clothing; the value of insulation is measured by the reciprocal of this rate, in square meter kelvins per watt (m^2-K/W). One clo is equal to 0.155 m^2-K/W attire, which allows an individual to remain comfortable at an ambient temperature of 21°C (70°F).

Garments are to be labeled with exposure protection information (for example, hours of protections at a particular temperature).

TABLE 5
Protective and Functional Properties for Outdoor Work Garments

Parameter	*Limit*	*Basis*	*Method**
Thermal insulation (T < -20°C)			
• Long-term cold exposure	≥ 3 clo	BS EN ISO 11079	BS DD ENV 342
• Short-term cold exposure	≥ 2.5 clo	BS EN ISO 11079	BS DD ENV 343
• Gloves	2.5…3.0 clo	Frostbites	BS EN 511
Air permeability			
• In wind. Rest (100 W/m^2)	< 20 l/m^2-s	Preventing of cooling	BS EN 31092
• Heavy work (> 300 Wm^2)	20…150 l/m^2-s	Evaporation	BS EN 31092
Ventilation			
• Heavy work (> 300 Wm^2)	≥ 300 l/min		
Water vapor permeability			
• Cold weather clothing	≤ 13 m^{2}Pa/W	Evaporation	BS EN 31092
• Cold/foul weather clothing	≤ 20 m^{2}Pa/W	Evaporation	BS EN 31092
Resistance to water penetration			
• Light rain	≥ 2200 Pa	Protection against moisture	BS EN 20811
• Heavy rain	≥ 33000 Pa	Protection against moisture	BS EN 20811

Source: Adapted from a collaboration of information by Biem, Koehncke, Classen, & Dosman, 2003; Giesbrecht, 2000; and Golden, & Tipton, 2002

* List of Standards noted in the "Method" column of Appendix 8, Table 5:

British Standard EN ISO 11079: Ergonomics of the Thermal Environment - Determination and Interpretation of Cold Stress when Using Required Clothing Insulation (IREQ) and Local Cooling Effects

British Standard DD ENV 342: Protective Clothing - Ensembles for Protection against Cold

British Standard DD ENV 343: Protective Clothing - Protection against Foul Weather

British Standard EN 511: Specification for Protective Gloves against Cold

British Standard EN 31092: Textiles - Determination Of Physiological Properties – Measurement of Thermal And Water-Vapour Resistance Under Steady-State Conditions (Sweating Guarded-Hotplate Test)

British Standard EN 20811: Textiles - Determination of Resistance to Water Penetration. Hydrostatic Pressure Test

3.4.1 General Recommendations for Clothing

In order to decide on the appropriate dress, it is important that the clothing be as comfortable as possible. It needs to provide optimal transportation of humidity from the body to the environment, good insulation and sufficient dexterity.

Each garment in the clothing ensemble is important and all pieces should be considered part of the protective system.

For temperatures between:

-8°C (17.6°F) and -25°C (-13°F) an average of 3.67 clo is recommended

-20°C (-4°F) to -48.2°C (-44°F) an average of 4.26 clo is recommended

With the addition of wind and humidity to low ambient temperature, greater clo units are required. Wind has an effect of compressing clothing, decreasing the overall amount of trapped air that creates an insulating layer.

General body protection from cold should be provided.

For optimal protection, the following three (3) clothing protection layers are recommended for outdoor work activities onboard (for an effective insulation of 2.6 clo):

- Inner Layer of two layer underwear effectively absorbing and transporting perspiration:
  - "Super" underwear or similar products against the skin
  - Wool as second layer
- Middle Layer which provides an isolating effect:
  - Fiber/fleece (pants and sweater/jacket), wool sweater, woolen socks
- Outer Layer which protects against the environment and should be waterproof

Sufficient amount of appropriate skin protective cold cream should be available at all times onboard, located at the assigned heating huts, common rooms and sickbay. Someone should be designated to be responsible for ensuring that cold creams are available as required onboard. Dispensers should be used instead of jars containing cold cream.

Clothing should have adjustable neck and sleeves to influence air exchange when internal temperature becomes unfavorable and to prevent sweating/moisture build-up under the clothing.

Cotton or polypropylene long underwear is recommended for all-over warmth.

Multiple layers of light, loose-fitting clothes are recommended.

Use suspenders instead of belts (tight belts can constrict blood circulation).

3.4.2 Hand Protection

Do not wear gloves or scarves that can get caught in moving parts of machinery.

While glove use is always recommended for outside work, the use of cold-protective gloves likely impairs the ability to carry out fine motor skills, while gross motor skills are less affected.

Mittens or gloves provide sufficient insulation to prevent frostbite. Mittens will retain heat for a longer period of time compared to wearing gloves. However, mittens can interfere with a person's ability to grasp and manipulate objects.

3.4.3 Head and Eye Protection

As much as 40% of body heat can be lost from an uncovered head. Use an appropriate hard hat liner to reduce heat loss when wearing protective headwear.

It is often noted that the choice of safety hat takes priority over the choice of its insulating properties. This is not a desirable principle procurement criterion for cold weather operations.

Wear a warm hat with ear protection to prevent heat loss from the head.

Protect vision from UV rays by wearing appropriate sunglasses while working in snow and ice on a bright day.

3.4.4 Foot Protection

The surface contact area of the sole is important for frictional force on ice. It is suggested that shoes/boots with rounded heels increase the contact with the surface and reduce the risk of slipping. When there is a layer of water along icy surfaces, the contact with the sole of the shoe is reduced. Therefore, the addition of sharp cleats to shoes is suggested. However, wearing shoes/boots with steel cleats on steel decks can be quite dangerous because of the loss of frictional force.

Boot selection should involve procuring a boot with proper insulation for the duration of the activity, required protection and the intensity of the work.

Woolen, polypropylene, or other thermal socks should be worn to protect ankles and feet. Keep snow and water out of footwear and replace damp socks with a dry pair.

3.4.5 Maintenance of Personnel Protective Equipment

Dirty and oily clothing loses much of its insulation value, and wearing of dirty/oily clothing should be avoided.

Do not keep cold weather clothing stored or compressed in a duffle bag for long periods of time. Fluff waterfowl down garments when removing them from the duffle bag following initial boarding of vessel.

Keep garments dry; brush off snow and frost before entering warm buildings or vehicles.

Follow manufacturer's guidelines for cleaning clothing. Failure to do so may reduce the protective capacity of the clothing.

Do not leave rips or tears unmended. Temporary repairs can be made with electrical or duct tape.

3.4.6 Immersion Suit Protection

In work where there is a risk of accidental immersion or abandonment into cold-water, specific protective equipment is recommended:

- Dry-suits and marine anti-exposure suits are commonly worn during marine operations and have been found not to impair working ability. These provide both protection and buoyancy in the water.
- A fully insulated dry suit has a clo value of approximately 0.7, leading to survival time up to 15 hours of immersion at 12°C (53.6°F), compared to 1-6 hours without the suit.
- Protective suits should be checked regularly for wear and accidental rips. In some cases, replacement of the suit is recommended

There are marine immersion suits available that protect the wearer from wind and cold in a dry environment and have isolative properties and buoyancy in water as well. While on land, these suits also have the ability to increase ventilation by opening collars and sleeves as needed, thereby accounting for individual variation in thermal comfort.

3.5 Nutrition Considerations in Cold Climates

The added weight of protective clothing and the limitations in mobility created by protective equipment will increase the mobility demands of the operator, thus increasing the metabolic needs for a given task.

A mixed diet of protein, carbohydrates and fats combining for a caloric intake of 4500 kCal for an average man is recommended for demanding labor in the cold.

Normal physiologic water loss is unavoidable in cold environments. There is a loss during physiologic activities such as metabolism, from sweat production inside protective equipment, and from increased urination related to cold-induced excessive discharge of urine. It is recommended that 3-6 liters of daily intake of water be maintained. For warming purposes, hot non-alcoholic beverages or soup are suggested. Caffeinated drinks such as coffee should be limited because it increases urine production and contributes to dehydration.

Generally, tobacco prevents the periodic blood vessel dilation needed for preventing tissue injury. The risk of frostbite and peripheral injury may increases with tobacco use.

Alcohol use should be avoided. The use of alcohol increases the flow of blood to the skin, and can lead to rapid loss of body temperature, increasing the likelihood of hypothermia.

Frequent, small meals will allow a constantly high metabolism to help maintain body temperature, whereas large meals served only 2-3 times per day will result in a decreased metabolic rate after digestion and decrease the "heat production to heat loss" ratio.

In the event of ship abandonment, a food stores carry-off kit should be provided, containing water and nonperishable foods. The carry-off kits should be stored in areas not subject to freezing temperatures. The carry-off kits should be stored in immediately accessible locations.

3.6 Workstation Design and Operational Considerations

The analysis of outdoor work situations should be performed early in design/layout development and should be updated when design changes are made that will influence personnel's exposure to cold stress.

Outdoor operations analyses (an examination of the tasks to be carried out in cold conditions) should be carried out for open work areas and semi-open work areas. The objective of these analyses is to identify and remedy task performance issues due to overall exposure to temperature, wind, icing and precipitation, including investigation of the weather protection necessary to comply with exposure limits.

Environmental measurements and assessments (air temperature, humidity and wind speed and direction) should be performed on a routine basis and at regular intervals throughout the day during cold periods with temperatures below zero degrees. All personnel working in exposed locations should be monitored at regular intervals. A person is usually unable to recognize their own signs and symptoms of hypothermia. As a precaution, use of the "buddy system" to detect signs of cold injury in coworkers is recommended.

Crew should be allowed sufficient time to acclimatize to an extremely hot or cold environment, including major changes in climatic conditions.

Monitoring of thermal conditions should be performed and should take account of:

- All stages of work cycles and the range of temperature and humidity under which tasks are performed,
- The range of clothing worn during the tasks,
- Major changes in physical activity level (metabolic heat production),
- Occasional tasks such as cleaning and maintenance of hot equipment and cold areas, and renewal of hot or cold insulation.

A log that is to be maintained by the onboard Safety Officer during operations in cold periods to keep records of the specific areas and work activities where administrative measures are introduced is recommended. Work areas where administrative measures are introduced on a regular basis should be identified by periodical review of such records.

Workers in the cold will often need to urinate more frequently, and employers should ensure that suitable arrangements are available, where feasible, and that the design of protective clothing allows easy urination.

Suitable protection should be given to the hands and fingers, particularly where dexterity is needed, as well as other exposed parts of the body. Employers should provide:

- Facilities for warming the hands, for example, by warm air, where appropriate,
- Tools with insulated handles, especially in temperatures below the freezing point,
- Measures to ensure that the bare hand does not touch surfaces below -7°C (workplace design or protective clothing),
- Measures to ensure that bare skin does not touch liquids below 4°C,
- Appropriate measures to be taken in the event of insulating clothing getting wet,
- Face and eye protection, as appropriate, for outdoor work and working in snow (e.g., safety goggles against glare),
- Adequate facilities for changing,
- Arrangements for cleaning such clothing and drying clothing and footwear between shifts.

Slips and falls are much more common in winter seasons.

- Walk slowly on slippery, icy surfaces to prevent danger of slipping. Stop occasionally to break the momentum.
- Avoid carrying heavy loads or loads that obstruct vision during transportation.
- Use approved snow removal compounds.
- Use mats at entrances to prevent slippery conditions indoors caused by melting snow or ice.
- Stairs, ladders and walking surfaces should be provided with non-skid surfaces
- Hand railings should be provided with non slip surfaces or should be heated to prevent formation of ice
- Exterior stairs should be made of grated material to aid in snow and ice removal

Post visible signage emphasizing the risk for cold-related injuries at all outdoor workstation locations. Knowledge of the work area at risk for slippery conditions, augmented with proper hazard signage, is important. If individuals are aware of the cold weather conditions, they will rely on additional muscle-based reflexes (i.e., reaction time), postural control, and muscular strength to adjust to the environment and prevent slipping and falling.

Consider providing enclosed bridge wings.

Consider providing a temperature transition area (such as a heat vestibule) at exit/entry points to soften the often harsh transition from bitter cold to warmth, and vice versa)

Assess possibility for temporary local shielding around working area(s) if permanent shielding is not possible.

Clearly post locations for nearest re-warming or break areas.

Power tools and other equipment generally require specific maintenance schedules for usage in cold weather.

Cold tool handles reduce grip force. Therefore, tools with larger handles may be required for cold weather usage to accommodate the protective hand wear and reduced grip capacity.

Cold exposure aggravates the effects of mechanical vibration, making manual work more difficult and painful. Effort should be made to minimize exposure to vibration at its source.

Hospital/medical kits should be stocked with materials appropriate to treat cold weather illnesses and maladies.

Cold weather illnesses training and procedures should be provided with emphasis on both symptom identification and treatment of the cold-related illness.

3.7 Accommodations and Environmental Control

All personnel accommodations should be designed and arranged to protect the occupants from unfavorable environmental conditions and minimize risk of injury during normal (including ice transiting or ice breaking) operations and emergency conditions.

Appendix 8, Tables 6 and 7 provide guidance on exposure standards for vibration and vibration effects on various personnel functions.

All personnel accommodations, public spaces and the equipment installed in them should be designed so that each person making proper use of them will not suffer injury during normal open water operations and emergency maneuvering conditions.

All facilities should include non-slip decking, three rigid sides, handholds and insulation from exposed hot water pipes.

Personal quarters should have sufficient room to dry and store cold weather protective equipment.

Cabin heating systems should be thermostat controlled and have shielded elements, if appropriate.

- Protective clothing should not be dried directly upon heating system
- Protective skin cream dispenser should be supplied in each room

Consideration should be given for providing a sauna for crew recreational use and for re-warming cold persons.

Additional accommodations and environmental control guidance is available in the ABS *Guide for Crew Habitability on Ships.*

TABLE 6
Exposure Standards and Action-Limits for Vibration

	Hand-transmitted Vibration		*Whole-body Vibration*			
	Exposure Action Value	*Exposure Limit Value*	*Exposure Action Value*		*Exposure Limit Value*	
Exposure Duration	*R.M.S. Method*		*R.M.S. Method*	*VDV Method*	*R.M.S. Method*	*VDV Method*
1 s	424.26	848.53	84.85	6.51	195.16	14.98
10 s	134.16	268.33	26.83	3.66	61.72	8.42
1 m	54.77	109.54	10.95	2.34	25.20	5.38
10 m	17.32	34.64	3.46	1.32	7.97	3.03
1 h	7.07	14.14	1.41	0.84	3.25	1.93
2 h	5.00	10.00	1.00	0.71	2.30	1.63
4 h	3.54	7.07	0.71	0.59	1.63	1.37
8 h	2.50	5.00	0.50	0.50	1.15	1.15
12 h	2.04	4.08	0.41	0.45	0.94	1.04
16 h	1.77	3.54	0.35	0.42	0.81	0.97
24 h	1.44	2.89	0.29	0.38	0.66	0.87

Source: Adapted from Griffin M. J. (1990). *Handbook of human vibration*. London: Academic Press

TABLE 7
Vibration Effects on Function and Performance

Vibration Induced Effect	*Frequency (Hz) at Which There is Occurrence*
Decreased tactile sensation	0.1 to 1 000 000
Motion Sickness	0.1 to 1
Vibrating Hand Tools Diseases	5-10
Respiration Difficulties	1.5-15
Abdominal Pain	5-15
Increased Muscle Tone	10-20
Lower Back Pain	7-20
Head Sensations	10-20
Disturbance of Speech	1-100
Urge to Defecate and Urinate	10-20
Speech Difficulties	7-20

Source: Wilson, & Corlett, 1990

APPENDIX 9 Guidance Notes on Training and Related Documentation

1 General

Training and manning are both important considerations for all vessels. However, this is especially true on those vessels which operate in cold climate areas. Operations in ice require special skills if they are to be accomplished safely and efficiently; and even the most capable ice breakers cannot be piloted without the exercise of due caution and respect for the environment.

The importance of having an experienced Ice Master or Ice Navigator has been recognized for centuries, on voyages of discovery and for commercial operations. Ice breakers and other vessels that spend much of their time in ice-congested waters may have masters and officers with sufficient expertise to provide the ice navigator function. For many other vessels, it is necessary to supplement the regular crew with supernumerary ice advisors or ice navigators, either to provide a basic capability or to comply with national regulations for local experience. Where such personnel are used, the number carried should be matched to the nature of the service and the anticipated nature of the operation.

The terminology used to describe personnel with ice-related expertise is not standardized, and so its usage may lead to some confusion. In these Guidance Notes, the following definitions apply:

- *Ice Advisor*: an individual with expertise in the interpretation of ice information and in forecasting future ice conditions
- *Ice Navigator*: a mariner (usually a master mariner) with extensive experience in the operation of vessels in ice who can provide guidance to the vessel's master and other watchkeepers
- *Ice Pilot:* a mariner individual with similar qualifications and experience to an ice navigator who may be required in some areas and jurisdictions to undertake pilotage duties
- *Ice Master*: a vessel's master with sufficient ice-going expertise to undertake the functions of ice navigator

While these personnel require extensive specialized training, some level of training should be given to all officers and crew of vessels involved in ice operations. It should also be recognized that operations in remote regions may have very limited support from shore-based infrastructure, and sufficient skills should be available onboard to cover both normal and emergency situations.

General guidance on training and crewing is offered in the IMO Guidelines; MSC Circular 1056, MEPC Circular 399. National administrations, including those of Canada and Russia, have specific requirements that must be respected in waters under their jurisdiction. This Guide aims to provide additional useful information that Owners, operators and vessels' crews can utilize in the planning and conduct of cold climate operations.

2 Training

Mariners exposed to cold and their supervisors should be trained:

- To recognize symptoms which may lead to hypothermia in themselves or others, and the steps to be taken to prevent onset and/or emergencies,
- In the use of rescue and first-aid measures, ice control equipment and procedures, personal protective equipment, and other devices and procedures intended to counter the effects or working in cold conditions,
- About action to be taken in the event of increased risks of accidents because of low temperatures.

Mariners should be advised of:

- The importance of physical fitness for work in cold environments,
- The importance of drinking sufficient quantities of liquid and the dietary requirements providing intake of salt and potassium and other elements that are depleted due to sweating,
- Effects of drugs which can reduce their tolerance to thermal extremes.

Mariners normally use classroom training, self-study, and operating experience to develop competencies and achieve certifications. Until recently, there have been very limited formal training resources for developing ice-operational knowledge. Now, several training institutes around the world can offer some level of course for ice advisors, ice navigators and/or ice masters. There are also some simulator facilities that offer training in ice recognition and other aspects of ice operations. However, these still have very limited fidelity in representing ship-ice interaction. On-board training remains the most valuable means of developing expertise, and minimum durations of operation and watchkeeping experience are specified by most national administrations before personnel can be qualified as ice navigators.

There are no formally mandated requirements for the content of training courses in ice navigation. However, any comprehensive training program needs to address the demands of Strategic, Tactical and Close Quarters navigation. Strategic navigation is concerned with the general routing of a vessel in the geographic region in which a vessel will operate, for example, the Baltic, Northern Sea Route, Northwest Passage, etc. At the tactical level, considerations include the selection of way points according to current and forecast ice conditions. At the close quarter level, active navigation evaluates the local ice conditions and the maneuvering of the vessel around and through ice floes.

Strategic Level (voyage planning) decision-making includes:

- Obtaining relevant ice information from ice maps, satellite imagery and medium-term forecasts;
- Evaluating ice conditions and environmental forecasts to verify the feasibility of the voyage and its probable duration;
- Optimizing route to minimize the time that will be spent in the ice and to avoid potentially dangerous ice features

Tactical Level (transiting) decision-making includes

- Obtaining more local ice information from enhanced satellite imagery, airborne radar images and visual reports, reports from other vessels in the area, etc;
- Optimizing the route to minimize encounters with ice that will impede vessel's progress or cause structural damage.

Close Quarters Level (maneuvering) decision-making includes

- Using radar and visual data to assess the properties of the ice cover;
- Selecting safe speeds to reduce the risk of structural or mechanical damage;
- Maneuvering in a manner that minimizes impacts against vulnerable regions of the hull, steering gear, etc.

As can be seen from the above, an essential area of expertise – and, therefore training – is the ability to interpret various ice information ranging from charts and imagery to direct visual observation. Several good pictorial guides to ice recognition have been developed, examples of which are included in the reference list. Simulators with high quality graphics can also be valuable training aids. Ice advisors will have received training in these areas, but not necessarily in navigational skills.

A key element of expertise for an ice navigator, pilot or master is the ability to relate the ice conditions to the capabilities of a vessel, based on its ice class, powering and other features. This can be taught in general terms by training institutes, though all vessels have their own specific capabilities that will influence performance and safety.

Amongst issues where not only the ice navigator but all deck officers should have some level of understanding is the relationship of the vessel's ice-strengthening class to the limiting safe ice conditions. For the new IMO/IACS Polar Classes, the general definitions provided in Appendix 9, Table 1, "IMO/IACS Polar Classes," offer some guidance (see Appendix 10 for additional information on ice types and conditions). Vessels operating in many Russian waters are provided with an Ice Certificate, which provides more detailed information on safe speeds in different ice conditions. However, it is also necessary for operators to understand how the overall ice strengthening of any vessel can vary around the hull; and, for example, how operating in ballast conditions may expose weaker areas of the hull or appendages to ice impacts. The sides and stern of most vessels are considerably less strong than the bow area, and vessels should not be operated in ways that expose these areas to significant ice impact loads.

TABLE 1
IMO/IACS Polar Classes

Polar Class	*Ice Description (based on WMO Sea Ice Nomenclature)*
PC 1	Year-round operation in all Polar waters
PC 2	Year-round operation in moderate multi-year ice conditions
PC 3	Year-round operation in second-year ice which may include multi-year ice inclusions.
PC 4	Year-round operation in thick first-year ice which may include old ice inclusions
PC 5	Year-round operation in medium first-year ice which may include old ice inclusions
PC 6	Summer/autumn operation in medium first-year ice which may include old ice inclusions
PC 7	Summer/autumn operation in thin first-year ice which may include old ice inclusions

The maneuverability of most vessels is reduced dramatically by the presence of any ice, and as ice cover thickens, it may become almost impossible to alter course by conventional maneuvers. This is particularly true of vessels with long parallel midbodies and no side flare (i.e., most commercial vessels). However, even ice breakers may find it necessary to change course by backing into a broken track in order to generate a change in heading. This type of maneuver is known as the Captain's Maneuver, or Star Turn, due to the appearance of the track.

Another situation that may require a vessel to reverse course is the need to make repeated rams to traverse thick ice or pressure ridges. Only vessels with reasonably high levels of ice capability should attempt to ram, and great caution is required during the backing phase of any maneuver to avoid damage to propellers. It is particularly dangerous for propellers to hit ice when the shaft is stopped, which can exert very high bending loads on the blades. Ramming speeds should be selected to avoid beaching the vessel in an attitude that creates stability problems, or that will lead to problems of extrication.

Ice navigators should be able to recognize the onset of pressure events, which can cause a vessel to become beset and may pose both direct and indirect safety hazards. This pressure can be sufficient to damage the hull, and general ice drift may carry the vessel into shallow or dangerous waters. Pressure can be managed to some degree by ice breaker intervention, or if time permits, the vessel can be oriented into rather than across the direction of compression. As pressure events are usually of reasonable short duration, stronger vessels may find it best to wait them out. The ice navigator should therefore also be sensitive to signs of reducing pressure.

A significant number of high ice class vessels incorporate unusual design features ranging from azimuthing propulsors to bubbler, water wash and heeling systems. Ice navigators and other personnel should have an understanding of why such systems are used and how they can be operated for maximum effectiveness.

Training for deck officers should address ice breaking procedures and the conduct of escorted operations. While these differ somewhat in different national waters, many general principles apply. These include ensuring that communications are established and protocols understood. Potential problem areas for escort include maneuvering (if the ice breaker makes too close a turn); stopping (if the ice breaker is brought to a halt by heavy ice); the risk of damage due to impact with track sides for a wide vessel escorted by a narrower ice breaker; and the risk of damage due to bow or bottom impact with large ice pieces submerged below the ice breaker. Masters should understand that an escort does not take over responsibility for the safety of the escorted vessel.

The points covered above are not intended to represent a complete listing of subject areas for training courses, but rather an illustration of the types of knowledge that training should aim to provide. They are also amongst the type of material that should be covered in a vessel's onboard documentation, as discussed further below.

3 Documentation

Under the IMO Guidelines, "all ships operating in Arctic ice-covered waters should carry onboard at all times an operating and training manual for all Ice Navigators onboard the ship." The IMO Guidelines provide a basic overview of the type of content that each manual should cover. Manuals and other documentation should conform to the intent of other requirements, such as those of the International Safety Management (ISM) Code, Contingency Planning for Shipboard Emergencies (IMO A852(20)), and other international and national standards. As such, they need to address the information needs of all crew members and procedures for making any passengers aware of specific requirements and challenges.

3.1 Operating Manual

This manual should contain relevant information directly related to operations in ice-covered waters including contingency planning in the event that the vessel suffers damage. The typical format of any operating manual should include the following sections, tailored to operations in ice and in cold temperature conditions: Normal Operation, Risk Management, and Emergency Instructions

3.1.1 Normal Operation

This should include measures to be taken when planning a voyage into cold or ice-infested waters, including:

- Contacting maritime administrations well in advance to confirm if special requirements, crewing or personnel are required onboard
- Arranging for the availability of ice and weather data and forecasts
- Identifying any loading restrictions that may be required for safety or pollution prevention reasons
- Ensuring that the vessel is adequately outfitted and supplied for the voyage.

As the vessel approaches the cold region, additional checks should be undertaken, such as:

- Contact the vessel traffic control services for the area
- Verify operation of VHF radio including confirming channel used by ice breakers operating in the area
- Take measures to prevent freezing damage; (e.g., piping on deck, sounding pipes and air vents, etc., are to be drained of water) (see Appendix 11)
- Check drafts and trim to verify that the ice belt covers the waterline area and that propeller and rudders are adequately submerged
- Verify the operation of searchlights and signaling devices
- Ready anchors and towlines
- Position protective covers on exposed equipment
- Configure HVAC and other systems (where possible) for cold weather operations
- Implement any other measures required for safe navigation.

The completion of checklists should be recorded. Once the vessel is operating in cold and ice, other issues that should be covered by the Operations Manual (as applicable) may include:

- Use of special features and systems installed on the vessel, such as water wash and bubblers, etc
- Cold start and run-up of systems, including preheating of lubricating and hydraulic oils
- Procedures for clearing ice and snow accumulations without damage to equipment
- Recording and reporting local conditions to assist in forecasting and to comply with regulatory requirements.

3.1.2 Risk Management

Risk Management for cold regions should cover all hazards that may result from or be accentuated by the cold temperature environment, and by operations in ice-infested waters. This includes ensuring the operability and checking the functionality of all operational and safety systems, including firefighting and lifesaving, as discussed in previous chapters. Other issues that should be addressed include monitoring of:

- Hull integrity, by sounding tanks and voids at regular intervals
- Water temperatures in tanks and systems, to provide warning of freeze-up problems
- Performance of pollution prevention systems, to prevent the discharge of wastes.

In general, risk management requires an understanding that many systems and components will be operating at or near their design limits, and their performance may degrade rapidly. Monitoring and testing should be conducted more frequently than is the case in normal operations.

3.1.3 Emergency Instructions

Emergency instructions should address the unique aspects of certain types of incidents in cold and/or ice-infested regions. These range from communicating with support and search and rescue organizations to abandoning ship in the presence of ice. Emergency instructions cannot take the place of proper training in emergency response management, but can be extremely valuable in reminding crew members of the procedures to be followed. As with all other elements of the Operating Manual, the instructions must be tailored to the specifics of the vessel and its modes of operation. They should also be integrated with the drills and exercises covered by the Training Manual and onboard training procedures, as discussed in A9/3.2.

3.2 Training Manual

A training manual should be provided onboard all vessels. The contents of a manual for vessels operating in cold regions should be an informational and educational tool for personnel and a guide for the types of training exercise that should form part of risk management for cold regions operation. As such, it should cover at least the following subject matter areas:

- Ice recognition
- Safe navigation in ice
- Conduct of escorted operations
- Instructions for drills and emergency response

Drills are covered in some detail by the IMO Arctic Guidelines, which addresses lifesaving, firefighting, damage control and other exercises. These should be carried out under as realistic conditions as possible consistent with maintaining the safety of those onboard. Crew members should all be given the opportunity to undertake drills while wearing cold weather survival gear to gain a proper appreciation of how this will affect their mobility and dexterity.

Where specialized equipment is carried for any type of emergency response, an adequate number of crew members should be trained in advance (and certified as necessary) in its use. Some examples may include firearms training, if firearms are carried as part of the evacuation kit, and any specialized pollution clean-up systems.

APPENDIX 10 Weather Conditions of Interest

1 Overview

The dominant factor for operations in polar and sub-polar regions is the occurrence of extremely low temperatures and the associated formation of ice. In low temperatures, any precipitation will be in the form of snow, or at closer to the freezing point as freezing rain, sleet or ice pellets. Visibility in any of these conditions can be very limited and ice build up can produce a range of hazards, as described earlier. Ice accumulation due to spray is most likely in air temperatures below 2°C (36°F), and wind speeds of above 20 knots (10 m/s). It will worsen as wind speeds increase beyond this, and in higher sea states.

In very low temperatures, sea ice can form quite rapidly once the water temperature itself falls below 0°C (32°F). Vessels with little or no ice capability can find themselves at risk if caught in these conditions, which are most likely to occur towards the onset of winter.

More generally, most vessels can be put at risk by ice movement, which can occur with considerable rapidity under conditions of high wind or currents. Conditions reported on ice charts or by remote imagery can change fast, particularly the reported positions of the ice edge and the location of leads through the pack. It is important for mariners to be able to recognize the conditions in which such changes can occur, and signs of the proximity of ice. These can include:

- "Ice blink" – a reflection of ice from the underside of cloud cover; most apparent when there is snow cover on the ice
- The onset of fog, which is often present near the ice edge
- The appearance of small ice floes, which can indicate that larger amounts are present nearby
- Rapid moderation of waves, when approaching the ice edge from downwind

2 Ice Types

For vessels intended to operate in ice, it is important to be able to distinguish between the different ice types that may be encountered, both for efficiency and or safety. The two most fundamental properties of ice cover are thickness and age, both of which are reported on standard ice charts using World Meteorological Organization (WMO) terminology and symbols, as outlined in Appendix 10, Table 1. Other terminology is also used, particularly for the initial freezing stages, including frazil, grease, shuga, and slush ice. These are all thin forms of ice cover that will normally be reported as new ice.

TABLE 1
Sea Ice Stages of Development

Description	*Thickness*	*WMO Code*
New ice	< 10 cm	1
Nilas; ice rind	0 – 10 cm	2
Young ice	10 – 30 cm	3
Grey ice	10 – 15 cm	4
Grey-white ice	15 – 30 cm	5
First-year ice	30 – 200 cm	6
Thin first-year ice	30 – 70 cm	7
Thin first-year ice first stage	30 – 50 cm	8
Thin first-year ice second stage	50 – 70 cm	9
Medium first-year ice	70 – 120 cm	1.
Thick first-year ice	120 – 200 cm	4.
Old ice		7.
Second-year ice		8.
Multi-year ice		9.
Ice of land origin		.
Undetermined or unknown		x

Ice services use a number of techniques to derive the thickness of ice cover, but all of these are approximate. The symbols on ice charts should always be treated with some caution.

Old ice is ice that has survived one or more melt seasons. It encompasses both second-year and multi-year ice, but the term multi-year is frequently applied to either old ice form. Multi-year ice becomes much stronger than first year ice, due in part to its reduced salinity. Floes also tend to have much more variable thickness than younger ice, as they incorporate weathered ridges and other features. This and other features help experienced ice navigators to distinguish between first-year and multi-year ice.

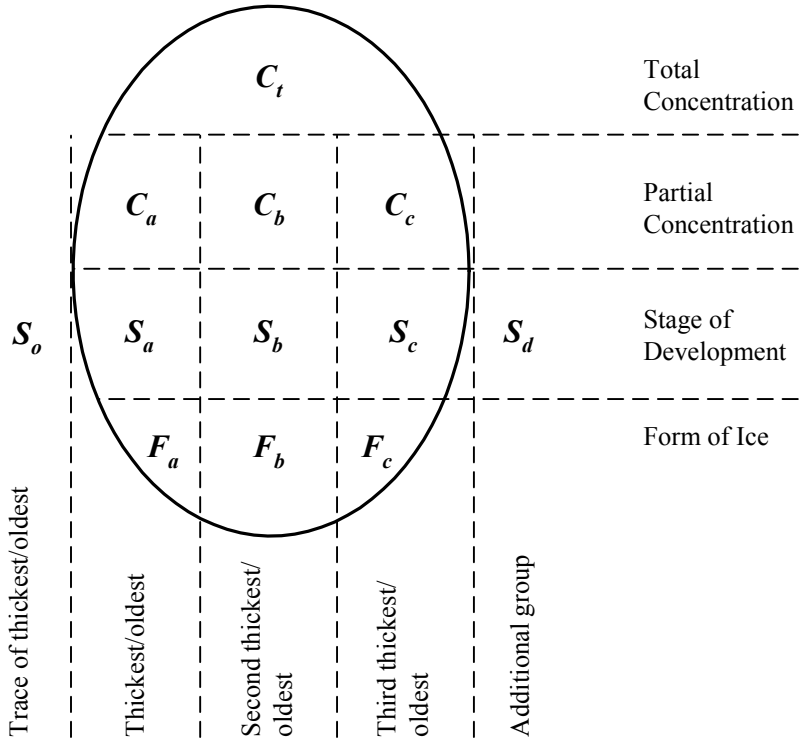
Ice "of land origin" is generally glacial ice, formed over thousands of years by the accumulation and re-crystallization of packed snow. Ice islands and icebergs enter the sea from glaciers and ice sheets, and may in turn 'calve' smaller bergy bits and growlers as they degrade. Glacial ice is very hard, and represents a major hazard for vessels with even the highest level of ice capability. Growlers and bergy bits have small freeboards, and can be very difficult to detect either when part of the general ice cover or in open water with moderate sea states. Due to their origin, they are usually found in proximity to icebergs, whose own presence is a good indicator of the potential risk of encountering these smaller fragments.

Ice cover is very rarely uniform or homogeneous. Near the coast, ice may be 'land fast', anchored in place by the shoreline and possibly by grounded pressure ridges. Land fast ice tends to have relatively consistent properties, but may still include ridges and rubble piles. At the edge of the land fast ice, shear zones may occur where the free-floating pack and land fast ice collide. The shear zone can be a chaotic amalgamation of ridging and rubbling. It can be both difficult and dangerous to transit, especially if the pack is in motion at the time. Even the most powerful ice breakers have become trapped, and less capable vessels have suffered damage or been sunk by pressure events in shear zones. Shear zones should be transited, where necessary, with extreme caution.

The general ice pack is typically a mix of ice types, thicknesses and floe sizes at various total ice concentrations. Patches or stretches of open water can be found even in the winter polar pack as floes move relative to each other. In some areas, more or less permanent polynyas of open water exist due to water upwelling. When ice floes move against each other, they may raft, increasing local thicknesses, form rubble, or generate ridging. All of these increase the difficulty of ice transit. Ridges may have sail and keel heights totaling in the tens of meters which can only be penetrated by repeated ramming.

Ice charts consolidate all available information on ice cover using the "ice egg", which in most sea areas will be developed using WMO principles and terminology. An example of how the ice egg is developed is shown in Appendix 10, Figure 1. Each of the fields is filled out using codes, of which the 'stage of development' code given in Appendix 10, Table 1 is one example. More complete explanations can be found in sources such as the Canadian government's MANICE, available on line at http://ice-glaces.ec.gc.ca/content_contenu/ice_codes/manice.

FIGURE 1
The Egg Code



3 Air Temperature

Traditionally, many operations in polar regions have been conducted in the summer and autumn seasons when air temperatures are not normally as low as may be encountered in mid-winter. In sub-polar areas such as the Baltic and Gulf of St. Lawrence, all-year operations have become the norm. For all of these services, air temperatures below -20°C (-4°F) are relatively rare; though they can be experienced.

Midwinter operations are becoming increasingly common on some Arctic routes, and here, temperatures can be considerably lower, with -30°C (-22°F) to -35°C (-31°F) not uncommon. Year-round temperature data can be obtained for coastal sites throughout the Arctic and for most sub-polar regions. Temperatures at sea (in the ice) are on average slightly above those on the adjacent land, therefore, port temperature data will normally represent the worst case for equipment functionality and crew comfort.

Isotherms for the surface air temperature for latitudes north of 60° are presently being developed as this Guide goes to press. A Corrigendum will be issued when this information is available. This data is provided for guidance only in determining the design service temperature for the vessel.

4 Humidity

As noted earlier, at extremely cold temperatures, the relative humidity in the air drops to well below that found typically elsewhere. Unless moderated by the vessel's HVAC system, dryness may cause crew discomfort. It may also increase the probability of static electricity build up and discharge, which can damage sensitive equipment and increase fire and explosion risk.

5 White Outs, Blizzards and Fog

Fog is commonly observed in areas of sea ice. Advection fog is a common occurrence in summer months when warm air masses pass over cold water areas and sea ice and the air mass cools below the vapor dew point.

Evaporation fog or steam fog is formed when water vapor is added to air which is much colder than the vapor's source. This most commonly occurs when very cold air drifts across relatively warm water.

Blowing snow has a significant impact on visibility. Depending on grain size and compaction, visibility in snow at wind speeds over 35 knots becomes extremely limited, to a few meters in most cases.

6 Hours of Darkness

Although not strictly a weather condition, the extended hours of darkness at the higher latitudes during the winter months should not be ignored. Extra lighting capacity for deck operations and additional searchlight capability for safe navigation results from this limiting visibility. Additional deck watches for areas where sea ice and glacial ice may be encountered can cause crew fatigue and should be considered when operating in any ice -covered waters.

An opposite problem is the effect of almost continuous daylight during the summer months. Crew fatigue needs to be considered when operating for extended periods in ice conditions. Additional blinds for crewing quarters will provide proper resting periods. Ice blindness may be a risk for lookouts and bridge crew, who should be provided with appropriate eyewear.

Navigation lights should be of sufficient brightness to be visible in arctic lighting conditions.

APPENDIX 11 Guidance Notes on Vessel Operations

1 Overview

The following Guidance Notes related to vessel operations in low temperature environments are recommendations only and cannot possibly list all operating scenarios or equipment types that a vessel may encounter or have installed onboard. The vessel's crew will need to make regular checks of safety-critical systems and equipment so that these are still functioning or capable of functioning as intended. The vessel's Owner and Operator are responsible for developing relevant and appropriate operational guidelines and keeping these procedures up to date.

This Appendix is organized similarly to the Guide's Sections: deck (hull), machinery and safety systems. Within each Subsection is a list of operational issues that should be considered when developing the operations manual.

2 Deck Recommendations

2.1 Ice/Snow Removal

The deck and associated piping should be cleaned up periodically, particularly due to spray and bad weather. Ice can quickly build up on the vessel, affecting safety of the crew's movement and vessel stability.

2.2 Crew Access

2.2.1 Access Routes

Access ways should be checked each day when snow or under-cooled rain occurs.

De-ice chemical mix (glycol mix) should be applied to deck plating when freezing occurs.

Deck drains should be opened using steam, pressure air and/or de-ice chemical mix

Snow and ice should be removed by use of shovels, hardwood clubs, steam or equal.

Heated walkways are activated at 10°C with increasing heat as the temperature drops.

Where necessary, additional safety lines should be run and crew members instructed on tethering themselves.

2.2.2 Escape Routes

Escape routes should be clearly marked and checked at least once a day or more often when required. Escape routes should be cleared of debris, snow and ice.

2.2.3 Emergency Exits

Gaskets, hinges, dowels and locks should be checked and treated with approved de-ice chemicals before the temperature drops below 0°C (32°F).

Exits should be checked once a day or more often when required.

Snow and ice should be continuously removed using shovels, hardwood clubs, steam and/or compressed air.

Pre-treatment with de-ice chemicals should be applied at least each month or when required.

The Derrick man's escape (Geronimo Chutes) should be checked and treated with de-ice chemicals before the temperature drops below 0°C (32°F). The chute should be function tested every day when the temperature is zero or below.

2.2.4 External Emergency Lights

External emergency lights should be operative at all times and kept free from snow and ice.

The lights should be checked daily when the temperature is below 0°C (32°F).

3 Vessel Systems and Machinery Recommendations

3.1 Fire Fighting Equipment Readiness

Door gaskets should be treated with de-ice treatments at least each month or when required.

All snow and ice accumulation on equipment should be removed by using steam, compressed air or equal.

Fire water hoses that have been used should be drained and dried immediately after use or stored at a frost-free location.

Fire mains should be drained until needed when the temperature is 0°C (32°F) or below.

When temperature drops below 0°C (32°F), all external fire equipment should be checked daily or more often when required.

Portable fire extinguishers at anchor stations should be kept in operator's cabins when the temperature is -15°C (5°F) or below.

All the fire dampers directly exposed to the weather are to be checked and function tested every day when the temperature is 0°C (32°F) or below.

Exposed deck machinery should be checked frequently to verify correct operation.

3.2 Tanks

Any tank, its associated piping system and venting condition should be checked prior to loading or discharging operations.

3.3 Exterior Alarms

All external alarm equipment should be inspected daily when temperature is below 0°C (32°F).

3.4 Helicopter Deck

3.4.1 General

Foam monitors should be properly drained.

De-ice chemical mix should be applied to the helicopter deck.

Deck border lights and floodlights should be treated with de-ice cure.

Portable fire extinguishers should be kept in a heated area close to the helicopter deck.

Drains should be checked daily to verify heat tracing is working.

3.4.2 Procedures When Operating in Snow and Freezing Rain

In addition to the items above, the following procedures should be performed:

Snow should be removed from helicopter deck and access/escape ways, when required, by using shovels, steam and/or pressure air.

De-ice chemical mix should be applied to deck when required.

Ice should be removed from deck border lights and floodlights. Steam and compressed air can be used. De-ice cure should be applied at least every month or when required.

3.4.3 Procedures Before Landing and Take-off

Helicopter deck should be checked before landing.

Snow and ice should be removed. Special attention should be paid to landing area of helicopter deck and to walkways/escape routes.

Ice should be removed from deck border lights and floodlights.

Personnel should be kept in protected spaces until departure to avoid cold exposure.

4 Safety Systems

4.1 Evacuation Systems

4.1.1 Launching/Lifeboat Stations

Steam hoses should be rigged and ready for use at stations.

All hinges, lashes and gaskets on life-vest and survival suit boxes should be checked and treated with de-ice treatments.

Means to de-ice should be applied to deck plating where required to prevent icing.

Lifeboat stations should be inspected two times per day or more often when required.

Ice and snow should be removed from deck, grating, handrails, rope escape ladder, life vest and survival suit boxes using shovels, hardwood clubs, steam or compressed air.

Glycol/water mix or salt should be applied on deck plating as required.

Lashings on life jacket and survival suit boxes should be checked. Ice can be removed by steam and compressed air. De-ice treatments should be applied at least each month or when required.

4.1.2 Lifeboats

Lifeboat heaters in all lifeboats should be switched on.

Hooks, latches and hinges should be checked and treated with de-ice treatments.

Radio equipment with batteries should be thoroughly checked every second day.

Lifeboats should be checked two times a day or more often if required.

Engine heaters, lifeboat heating fans and battery chargers should be checked each day.

Snow and ice should be removed.

Hooks, lashes and hinges should be checked. Ice should be removed using steam and compressed air.

De-ice treatments should be applied at least each month or when required.

Lifeboat engine should be run each day until it reaches operation temperature.

Lifeboat engine fuel should be checked daily for clouding or waxing.

Lifeboat engine lubricating and hydraulic (starting) oils should have correct viscosity at design service temperature without the use of heaters.

4.1.3 Launching Arrangements

Hooks, latches and hydrostatic release couplings should be checked and treated with de-ice treatments.

Brake guide wire and sheaves should be checked and properly greased, if necessary.

Lifeboat launching arrangements should be inspected two times a day or more often when required.

Snow and ice should be removed from winches.

Ice on hooks, latches and hydrostatics release couplings should be removed using steam and compressed air. De-ice treatments should be applied at least every month or when required.

Winches should be run each day.

Free-fall lifeboats cannot be released onto ice-covered waters without risking the safety of occupants due to impacting the ice and/or surfacing under ice floes. Standard lifeboats have almost no ice-transit capability, and so they should be launched into the vessel's track to maximize their ability to get clear of a sinking or burning vessel.

4.1.4 Life Rafts

Latches/hydrostatic release couplings should be checked and treated with de-ice cure.

Launching arrangements should be checked two times per day or more often if required.

Snow and ice should be removed.

Ice on lashes/hydrostatic release couplings should be removed using steam and compressed air.

De-ice cure should be applied at least every month or when required.

4.1.5 Life Raft Launching Arrangements

Winch should be checked and greased according to lubrication chart if required.

Brake guide wire and sheaves should be checked and properly greased if required.

Life raft launching arrangements should be checked two times per day or more often if required.

Snow and ice should be removed using steam and compressed air.

Ice should be removed from release hooks using steam and pressure air and should be treated with de-ice cure at least each month or when required.

4.2 Rescue Boats

4.2.1 Rescue Boat

Radio equipment with batteries should be thoroughly checked every second day.

Rescue boat should be inspected two times a day or more often if required.

Engine heaters and battery charger should be checked each day.

Ice and snow should be removed using shovel, steam gun or pressure air. De-ice means such as glycol/water mix should be used if necessary.

Engine should be run each day until operating temperature is reached.

Rescue boat engine fuel should be checked daily for clouding or waxing.

Rescue boat engine lubricating oil should have correct viscosity at design service temperature without the use of heaters.

4.2.2 Rescue Boat Launching Arrangement

Brake guide wire and sheaves should be checked and properly greased if necessary.

Quick release hook should be checked and treated with de-ice cure.

Rescue boat launching arrangement should be test run each week or more often if required.

Brake guide wire should be thoroughly checked two times a day or more often if required.

Snow and ice should be removed from winches.

Ice on quick release hook should be removed using steam and compressed air. De-ice cure should be applied at least every month or when required.

Launching arrangement should be checked three times a day or more often when required.

4.3 Escape Systems

4.3.1 Escape Chutes and Life Raft Stations

Steam hoses should be rigged and ready for use on both stations.

De-ice chemical mix should be applied to deck plating to prevent icing.

Life raft station should be checked two times per day or more often if required.

Ice and snow should be removed from deck handrails, raft and launching arrangements using shovel, steam hardwood clubs or equal.

De-ice chemical mix should be applied to deck if required.

4.4 Personal Safety Equipment

4.4.1 Immersion Suits and Life Jackets

If immersion suits are stored at stations, they should be checked for moisture and dried if necessary.

Personal immersion suits should be stored in cabins to avoid moisture accumulating in the suits if stored at lifeboat stations.

4.1.2 Life Jackets

Life jackets should be free from moisture when returned back into boxes after use.

APPENDIX 12 List of Administrations

1 Overview

Various national Administrations have additional regulations for vessels operating in their territorial waters beyond those listed in this Guide. It is recommended that vessel designers, owners and operators contact these Administrations directly regarding these regulations. Appendix 12, Table 1 provides a list of Administrations in areas subject to low temperatures.

TABLE 1
Administration Contact Information

Country/	*Address*	*Contact/Telephone*	*Web Site Address*
ARGENTINA, REPUBLIC OF Prefectura Naval Argentina	Av. Eduardo Madero, 235 (C1106 CCA) Buenos Aires, Rep. of Argentina	Director Policia Seguridad de la Navegacion Jefe Departmento Reglamentacion de la Navegacion: (54-11) 4318-7475 ext 2411 or (54-11) 4318-7467	http://www.prefecturanaval.gov.ar
AUSTRALIA, COMMONWEALTH OF Australian Maritime Safety Authority	GPO Box 2181 Canberra City ACT 2601 Commonwealth of Australia	Principal Adviser Technical: (61-2) 6279 5049 or (61-2) 6279 5966	http://www.amsa.gov.au/
CANADA Transport Canada Safety & Security	Tower "C", Place De Ville 11th Floor 330 Sparks Street Ottawa, Ontario K1A 0N8, Canada	Director of Ships and Operations Standards: (1-613) 991-3131 or (1-613) 993-8196	http://www.tc.gc.ca/en/menu.htm
CHILE Direccion General del Territorio Maritimo y de Marina Mercante Armada de Chile	Avenida Errazuriz 537 Valparaiso, Chile	Director General: (56-32) 258091 or (56-32) 252539	http://www.directemar.cl/
DENMARK Danish Maritime Authority	Skibsregistret 38C, Vermundsgade P. O. Box 2605 DK-2100 Copenhagen O, Denmark	(45-39) 17 44 00 or (45-39) 17 44 01	http://soefart.inforce.dk/
ESTONIA Estonian Maritime Administration	Valge 4 11413 Tallinn, Estonia	Director General: (372) 6205 700 or (372) 6205 706	http://www.vta.ee/atp/?lang=en

TABLE 1 (continued)
Administration Contact Information

Country/	*Address*	*Contact/Telephone*	*Web Site Address*
FINLAND Finnish Maritime Administration	Maritime Safety Department P. O. Box 171 FIN-00181 Helsinki, Finland www.fma.fi	(358-20) 448 4249 or (358-20) 448 4336 (358-20) 4481 (Operator)	http://www.fma.fi/e/
GREENLAND Danish Maritime Authority	Skibsregistret 38C, Vermundsgade P. O. Box 2605 DK-2100 Copenhagen O, Denmark	(45-39) 17 44 00 or (45-39) 17 44 01	http://www.sofartsstyrelsen.dk/sw164.asp
ICELAND Icelandic Maritime Administration	Vesturvor 2 P. O. Box 120 202 Kopavogur, Iceland	Head of Technical Regulations Section: (354) 560 0000 or (354) 560 0060	http://www.sigling.is/English
LATVIA Ministry of Transport of Latvia, Maritime Administration	Trijadibas iela 5 Riga, LV-1048, Latvia	Director: (371) 7062101 or (371) 7860082	http://www.jurasadministracija.lv/index.php?pid=211
LITHUANIA Ministry of Transport and Communications of the Republic of Lithuania	Gedimino Av. 17 Vilnius 2679, Republic of Lithuania	Minister: (370-5) 239 3911 or (370-5) 212 4335	http://www.msa.lt/eng/index.htm
NETHERLANDS Inspectorate Transport and Water Management	Netherlands Shipping Inspectorate Gebouw Prinsenpoort ‘s-Gravenweg 665 (PO Box 8634, 3009 AP) Rotterdam, The Netherlands	Director: (31-10) 266 8500 or (31-10) 202 3424	http://www.ivw.nl/en/water/koopvaardij/
NEW ZEALAND Maritime New Zealand	Level 8, gen-i Tower 109 Featherston Street (P. O. Box 27006) Wellington, New Zealand	General Manager, Maritime Operations: (64-4) 4730111 or (64-4) 4941263	http://www.maritimenz.govt.nz/
NORWAY, KINGDOM OF Norwegian Maritime Directorate	Stensberggt. 27 0170 Oslo, Norway	(47) 22 45 4441 or (47) 22 56 87 80	http://www.sjofartsdir.no/english.asp
POLAND Ministry of Transport and Maritime Economy	Department of Maritime and Inland Waters Administration U1. Chalubinskiego 4/6 00-928 Warsaw, Poland	Ships inspection – Head Office (48-22) 621 1448 or (48-22) 621 9437	http://www.mi.gov.pl/en/moduly/jednostki/dane.php?id_jednostki=14
RUSSIAN FEDERATION Ministry of Transport of the Russian Federation Russian Northern Sea Route Administration	Maritime Administration ul. Rozhdestvenka, 1/4 103759 Moscow, Russia	Head of Maritime Administration (7-495) 926 10 00 or (7-495) 978 91 70	Ministry of Transport http://www.mintrans.ru/ Northern Sea Route http://www.morflot.ru/Default.aspx?lvl=1&href=html/sevmorput/sevmorput_VV.htm

TABLE 1 (continued)
Administration Contact Information

Country/	*Address*	*Contact/Telephone*	*Web Site Address*
SWEDEN, KINGDOM OF Swedish Maritime Administration	Maritime Safety Inspectorate Slottsgatan 82, SE-601 78 Norrkoping Kingdom of Sweden	Director of Maritime Safety: (46-11) 19 10 00 or (46-11) 10 19 49	http://www.sjofartsverket.se/
UKRAINE Ministry of Transport of Ukraine	State Department of Maritime and Inland Water Transport 14, prospect Peremogy Kyiv 01135, Ukraine	Director General: (380 44) 461 5320 or (380 44) 461 5304 (Emergency Officer)	http://www.kmu.gov.ua/mtunit/control/morskyj/uk/index E-mail: security@morrechflot.gol.ua
UNITED STATES OF AMERICA U. S. Coast Guard	Commandant (G-MOC) 2100 Second Street, SW Washington, DC 20593-0001 Federal Communications Commission Wireless Telecommunications Bureau 445 12th Street SW Washington DC 20554		http://www.uscg.mil

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APPENDIX 13 List of Meteorological Organizations

1 Overview

Various government organizations provide readily accessible climatic, environmental and meteorological data sets and historic atlases. Appendix 13, Table 1 provides a list of these organizations along with their contact information.

TABLE 1
Meteorological Organization Contact Information

Country/	*Address*	*Contact/Telephone*	*Web Site Address*
All Russian Research Institute- of Hydrometeorological Information –World Data Centre	RIHMI-WDC, 6, Korolev St., Obninsk, Kaluga Reg., Russia	Tel: (7-495) 255-21-94 Fax: (7 495) 255-22-25 E-mail: wdcb@meteo.ru	http://www.meteo.ru/ index_e.html
Arctic and Antarctic Research Institute;	38 Bering str., St.Petersburg, Russian Federation, 199397	Tel: (7-812) 352 1520 Fax: (7-812) 352 2688 E-mail: aaricoop @ aari.nw.ru	http://www.aari.nw.ru/ default_en.asp
Argentine Navy Meteorological Service (SMARA) of the Naval Hydrographic Service	Av.Montes de Ocal 2124, 1217 Buenos Aires, Argentina	E-mail: cnhsmara@ rina.ara.mil.ar	
Australian Bureau of Meteorology	GPO Box 1289 Melbourne VIC 3001 (700 Collins Street Docklands) Australia	Tel: (61-(0)3) 9669 4000 Fax: (61-(0)3) 9669 4699 E-mail: webclim@ bom.gov.au	http://www.bom.gov.au/
British Antarctic Survey;	High Cross, Madingley Road Cambridge CB3 0ET United Kingdom	Tel: (44 (0)12) 2322 1400 Fax: (44 (0)12) 2336 2616 Email: basweb@ bas.ac.uk	http://www.antarctica.ac.uk/
Canadian Ice Service	373 Sussex Drive Block E, Third Floor Ottawa, Ontario K1A 0H3 Canada	Tel: (1-613) 996-1550 Fax: (1-613) 947-9160 Email: cis-scg.client@ ec.gc.ca	http://www.ice-glaces.ec.gc.ca.

TABLE 1 (continued)
Meteorological Organization Contact Information

Country/	*Address*	*Contact/Telephone*	*Web Site Address*
Climatic Research Unit, University of East Anglia	School of Environmental Sciences University of East Anglia Norwich NR4 7TJ, United Kingdom	Tel: (44-1603) 592722 Fax: (44-1603) 507784 Email: cru@uea.ac.uk	http://www.cru.uea.ac.uk/
Cold Regions Research and Engineering Laboratory- US Army	72 Lyme Road, Hanover New Hampshire, 03755-1290 USA	Tel: (1-603) 646-4582 Email: contactcrrel@ crrel.usace.army.mil	http://www.crrel.usace.army.mil/
Danish Meteorological Institute	DMI Lyngbyvej 100, 2100 København Ø Denmark	Tel: (45-39) 15 75 00 Fax: (45-39) 27 10 80 Email: vmarked@ dmi.dk	http://www.dmi.dk/dmi/index/
Environment Canada	Meteorological Service of Canada Atmospheric and Climate Science Directorate (ACSD) 4905 Dufferin Street Toronto, Ontario, M3H 5T4 Canada	Tel: (1-416) 739-4239 Email: firstname.lastname@ ec.gc.ca	http://www.climate.weatheroffice. ec.gc.ca/climateData/ canada_e.html
European Climate Support Network	EUMETNET Coordination Office 42, avenue Gaspard Coriolis 31057, Toulouse CEDEX 07 France	Tel: (33-5) 61 07 9947 Fax: (33-5) 61 07 9948 Coordinating Officer: Mr. Jean-Pierre Chalon (jean-pierre.chalon@ eumetnet.eu.org)	http://www.eumetnet.eu.org
Icelandic Meteorological Office	Bustadavegur 9 150 Reykjavík Iceland	Tel: (354) 522 6000 Fax: (354) 522 6001 Email: climate@ vedur.is	http://www.vedur.is/english/
International Oceanographic Data and Information Exchange (IODE)	IOC Project Office for IODE Wandelaarkaai 7 B-8400 Oostende Belgium	Tel: (32-59) 34 01 58 Fax: (32-59) 34 21 32 Email: Peter Pissierssens IODE Programme Coordinator (p.pissierssens@ unesco.org)	http://www.iode.org/
International Polarview Organization		Tel: (1-709) 737 3735 Email: info@polarview.org	http://polarview.org/project/ index.htm
National Snow and Ice Data Center, University of Colorado	449 UCB, University of Colorado Boulder, CO 80309-0449 USA	Tel: (1-303) 492 6199 Fax: (1-303) 492 2468 Email: nsidc@ nsidc.org	http://nsidc.org/data/ewg/index.html
Network of European Meteorological Services	*Refer to European Climate Support Network*		http://www.eumetnet.eu.org/

TABLE 1 (continued)
Meteorological Organization Contact Information

Country/	*Address*	*Contact/Telephone*	*Web Site Address*
Norwegian Meteorological Institute (DNMI)	PO Box 43 Blindern 0313 Oslo Norway	Phone: (47-22) 96 30 00 Fax: (47-22) 96 30 50 Email: met.inst@ met.no	http://www.met.no/english/ index.html
Norwegian Polar Institute	Norwegian Polar Institute, Polar Environmental Centre N-9296 Tromsø, Norway (Norsk Polarinstitutt, Polarmiljøsenteret, 9296 Tromsø).	Tel.: (47-77) 75 05 00 Fax. (47-77) 75 05 01 Email: postmottak@ npolar.no	http://npiweb.npolar.no/
Russian Federal Service for Hydrometeorology & Environment Monitoring	Novovagankovsky Per., 12 Moscow, 123995 Russian Federation	Tel: (7-495) 252-5504	http://www.mecom.ru/
Swedish Meteorological and Hydrological Institute	Folkborgsvägen 1 SE-601 76 Norrköping Sweden	Tel: (46-11) 495 8200 Fax: (46-11) 495 8350 Email: kundtjanst@smhi.se	http://www.smhi.se/en/index.htm
United States Government. Department of Commerce. National Oceanic and Atmospheric Administration, National Climatic Data Center	National Climatic Data Center Federal Building 151 Patton Avenue Asheville NC 28801-5001 USA	Tel: (1-828) 271-4800 Fax: (1-828) 271-4876 Email: ncdc.info@ noaa.gov	http://www.ncdc.noaa.gov/oa/ncdc. html
United Status Government. National Oceanic and Atmospheric Administration and the Cooperative Institute for Research in Environmental Sciences NOAA-CIRES - Climate Diagnostic Center	325 Broadway R/PSD1 Boulder, CO 80305-3328 OR CIRES/Climate Diagnostics Center University of Colorado 216 UCB Boulder, CO 80309-0216 USA	Tel: (1-303) 497-6188 Fax: (1-303) 497-6449 and (1-303) 497-7013 Email: cdc.webmaster@ noaa.gov	http://www.cdc.noaa.gov/
United States Government. United States Navy, the National Oceanic and Atmospheric Administration (NOAA), and the United States Coast Guard, National Ice Center	National Ice Center Federal Building #4 4251 Suitland Road Washington D.C. 20395 USA	Tel: (1-301) 394-3100 Email: liaison@ natice.noaa.gov	http://www.natice.noaa.gov/

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