

Research on Special Measures of Safe Abandonment of a Ship in Polar Waters

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Abstract: Ice melting in polar waters caused by global warming has been making it practicable for merchant ships to sail in polar area. Sailing distances from Far-east to West of Europe and East of North America are shortened by around 30% by selecting polar routes, therefore, polar routes are considered as the golden routes. However, polar water has its unique risks for ships sailing in the areas. Those unique risks may cause adverse impacts to the survival of seafarers in case of emergencies. To ensure the safe abandonment of a ship in polar waters, this paper analyzes and summarizes the potential risks associated with polar shipping with respect to safe escape, evacuation and survival for seafarers in case of emergencies. Based on the analysis of unique potential hazards and inquiry with experts and seafarers who have experiences in polar ship operation and management, this paper provides practical measures to safeguard crew's escape, evacuation and survival in extreme polar circumstances when abandoning a ship. The requirements as to Life Saving Appliances and Arrangements in Polar Code are also interpreted in this paper, and those practical measures provided will help the ship owners, ship operators, and ship masters and seafarers to better understand and comply with the requirements of the Polar Code.

Keywords: Polar Waters, Unique Circumstances, Safe Abandonment of a Ship, Polar Code

1. Introduction

With the trend of global warming up caused by Green House Effect, ice in polar water is melting dramatically, making it practicable for merchant ships to sail in polar area. Routes from Far East to West Europe and to East of North America through Arctic waters are the shortest of all the existing routes. Therefore, polar routes are considered as the golden routes. Polar shipping will undoubtedly grow in volume and diversify in nature over the coming years. Driven by an ever increasing global demand for commodities like energy and mining products, ship traffic is likely to increase dramatically in the near future -- a trend that will increase the pressure on this relatively pristine area.

Ships operating in the remote polar waters will face various unique risks including poor weather condition, extremely low air temperature, darkness, ice accretion, difficulties in search and rescue or environmental clean-up operations, etc. Poor weather conditions can compound the relative lack of good charts,

communication systems and navigational aids. Search and rescue or environmental clean-up operations can be extremely difficult and, as a result, potentially very costly. The cold temperatures and harsh weather systems can cause malfunctions of ship's machinery and equipment. Polar ice fields can impose additional loads on the ships' hull and propulsion.

To ensure the safety of shipping in polar waters, IMO has adopted the International Code for Ships Operating in Polar Waters (The Polar Code hereafter) and related amendments to make it mandatory under both SOLAS and MARPOL convention. The polar code entered into force on 1 January 2017. Due to the exceptional circumstances in polar waters, it is extremely hard for seafarers to survive in case of emergency and following ship abandonment. The polar code Chapter 8- Life Saving Appliances and Arrangements, regulates the basic requirements, provides for safe escape, evacuation and survival. However, those regulations are only the basic requirements. Based on the analysis of unique potential hazards and inquiry with experienced seafarers sailing in polar waters, this paper

this paper analyzes and provides practical measures to safeguard crew's escape, evacuation and survival in extreme polar circumstances in case of abandoning a ship.

2. Analysis of Hazards in Polar Shipping with Respect to Safe Escape, Evacuation and Survival

2.1. Potential Hazards Associated with Polar Shipping

IMO Sub-committee on Ship Design and Equipment

(DE 54/WP.3) presented on its 54th session, a hazard matrix identified on development of a Mandatory Polar Code. This matrix identified various hazards and their consequences in polar shipping. By referring to the matrix, a table of "Identified various hazards and their consequences in polar waters" is produced in this paper. These hazards uniquely endanger the seafarers in polar waters. To ensure the safe escape, evacuation and survival, those unique risks shall be fully taken into consideration. See table 1 below "Identified various hazards and their consequences in polar waters".

Table 1. Identified various hazards and their consequences in polar waters.

Hazards	Consequences of the hazards	Affecting the seafarers' safe abandonment of a ship?
Low air temperature	Loss of performance of material, exposed to low temperature	Yes, survival boats
	Malfunction of machinery	Yes, boat engines
	Freezing of fluid/cargo	No
	Thicker viscosity fluid/cargo and machinery	Yes, boat engine fuels
	Effect of cold cargo to hull materials	No
	Loss of functionality of operating and emergency equipment	Yes, emergency escaping equipment
	Loss of functionality of doors and closing appliances	Yes, escape routes
	Reduced survival time/hypothermia	Yes, coldness and less survival time
	Reduced human performance, physical and cognitive functions	Yes, human performance
	Ice on deck and superstructure	Yes, escape route blocked
Low water temperature	Freezing of ballast	No
	Limitation of SAR capabilities	Yes, SAR operations
	Reduced maneuverability	No
	Reduced survival time	Yes, coldness and less survival time
	Malfunction of fluid systems	Yes, boat engine fuels
Extreme and rapidly changing weather condition	Clogging of inlets and outlets	Yes, boat engine cooling system
	Difficult to prepare for or avoid dangerous weather conditions	Yes
	Propulsion and/or manoeuvring difficulties	No
	Reduced survivability/hypothermia	Yes, coldness and less survival time
	Increased risk of human error	Yes
	Injuries due to ice flow/falling on deck	Yes
	Capsize and operational threats to smaller vessels, auxiliary boats and tenders	Yes, survival boat
	Limitation of SAR capabilities	Yes, SAR operations
	Structure failure due to impact with ice or pressured ice	Yes, survival boats
	Hull penetration and structure deformation	Yes, survival boats
Presence and variability of sea ice	Disturbance in navigation due to icebergs	No
	Propulsion and/or maneuvering difficulties/failure	Yes, survival boats
	Different stability characteristics in ice	Yes, survival boats
	Damage to anti-collision systems	No
	Reduced propulsion system capacities	No
	Inability to operate evacuation systems due to surrounding ice	Yes
	Reduced stability	No
	Mal or no function of equipment and systems (including LSA and FP) on deck	Yes
	Malfunction of navigational aids	No
	Injuries to personnel	Yes
Ice on deck and superstructures	Blocking of air intakes, air ventilation and pressure release valves	Yes, survival boats
	Exposure of personnel to de-ice (chemicals)	Yes
	Possibility of damage to equipment during de-icing	No
	Malfunctioning of deck machinery	No
	Overload due to ice	Yes, survival boats
	Restrictions of human activities	Yes
	Hypothermia	Yes
	Grounding, stranding, trapped in ice	No
Reduced navigational aids	Impact with ice or other structures	No
	Lack of signals/disturbance DGPS	Yes
	Unstable gyro	No
Varying availability of charts/hydro-graphical information	Grounding, stranding	No
	Voyage planning	No
	Anchoring	No
Varying availability	Voyage planning	No

Hazards	Consequences of the hazards	Affecting the seafarers' safe abandonment of a ship?
meteorological information/Ice data	Difficult to prepare for or avoid dangerous weather conditions/ situations	Yes
	Insufficient clothing and supplies (optimistic planning)	Yes, hypothermia
	Insufficient actions to incidents and accidents	Yes
	Insufficient spill preparedness	No
Variable infrastructure	Limited compliance and enforcement (local infrastructure, waste reception facilitation)	No
	Potential for incidences to escalate	No
	Loss of possibility to send distress messages/contact SAR	Yes
Interference with long-range electronic communications	No weather/ice forecast	Yes
	Loss of communication possibilities	Yes
Variable communication capabilities	Communication difficulties	Yes
Limited search and rescue capabilities	Insufficient response to incidents and accidents	Yes
	Lack of medical support	Yes
	Capability of emergency source of electrical power	Yes
	Insufficient response to spills	No
Limited availability of oil spill preparedness	Damage to ecological systems	No
	Damage to flora and fauna	No
	Potential for incidences to escalate	No

Note: The Table 1 above gives 13 types of hazard faced by ships when sailing in polar waters, and the possible consequences for each hazards are listed in column 2. Not all the hazards in the table pose a danger to the crew abandoning the ship in an emergency. Therefore, in column 3 whether the danger and consequences affecting the abandonment of the ship is given, If yes, a short explanation is followed to indicate the effects.

2.2. Potential Hazards with Respect to Safe Escape, Evacuation and Survival

Based on the specific hazards and consequences above, this paper analyzed and selected all potential hazards associated closely with seafarers' safe escape, evacuation and survival in case of emergency when sailing in polar waters, and grouped them into five categorizes as follows.

1) Low temperature affecting the stowage and deployment of life-saving appliances

For ships sailing in polar waters, coldness is one of the greatest dangers. The temperature of polar region can reach to below -50°C . Low temperature increase the viscosity of oil products, decrease the self-priming capacity of oil pump and the pressure of hydraulic system, thus causing the hydraulic system fail. The low temperature effect on all liquids in the lifeboats should be taken into consideration when installed, e.g. special fuel, lubrication oil cooling water for the engine.

2) Ice built-up hampering life-saving appliances

It is possible that sub-zero temperatures would cause ice accretion. The life-saving appliances may malfunction when covered by ice. All the life-saving appliances should be designed or protected against ice accretion so that it is operable in case of abandoning the ship.

3) Launching of survival craft on ice-covered waters

The standard free-fall lifeboat in accordance with IMO provisions includes arrangements that allow only a lowering aft of the ship. It is impossible for a vessel to launch free-fall life boat onto ice. If a lifeboat should be lowered onto ice, the slope of the bottom of the boat hull must be considered and

equipment for limiting the heel must be provided.

4) Threats to survival in polar waters after abandonment

Survivors in lifeboats and life rafts, after a casualty in polar waters, may be expected to spend longer time on board such survival craft than is considered normal for survivors in most other parts of the world. Additionally, they will be exposed to climate conditions that are much more demanding and which require specific mitigating measures such as proper clothing, immersion suits or heating appliances in order to prevent hypothermia.

5) Limited search and rescue capabilities

In the remote polar waters, due to the sparse population along the polar coast and less vessel traffic, few rescue forces are stationed. Once a ship disaster take place, even if the distress signal could be sent immediately, it may take several hours or even a few days for the rescue force to arrive. Seafarers in distress will face the threats of drifting at sea and waiting for rescue resources for much longer time than that in normal shipping waters.

In addition to those identified hazards above, there may be some other hazards that are not identified for lack of resources and experiences in polar shipping. Further work should be continued and further resources related to polar shipping should be gathered.

3. Requirements of Polar Code Chapter 8 - Life Saving Appliances and Arrangements

The influence of polar environment on life saving and communication equipment is mainly manifested in four aspects: low temperature, ice and snow accumulation, abandonment of ships in ice area and lack of rescue resources. Low temperature may cause some life-saving and communication equipment to fail, such as the lifeboat releasing device, machinery, the batteries, etc.; Ice and snow accumulation snow may cause the escape route and access to

muster station blocked; In case of abandoning a ship in the ice area, it may be difficult to release the survival rafts, and even the rafts can be launched, it may quite difficult to operate them in ice; Lack of rescue resources may lead to longer awaiting time for the survivors.

In view of the adverse effects of polar environment on marine survival, to ensure the life safety of seafarers during

and after abandonment, the Polar Code provides mandatory provisions on the life-saving appliances and arrangement of polar vessels in Chapter 8, Part I-A. In brief, those requirements/regulations are divided into three sections: Escape, evacuation and survival. To make it more clear, a table interpreting the requirements is created in this paper. See Table 2 below.

Table 2. *Requirements of Life Saving Appliances and Arrangements in Polar Code.*

LSA and arrangement		Requirements in Polar Code
Escape	Escaping routes	1. For ships exposed to ice accretion, means shall be provided to remove or prevent ice and snow accretion; 2. For ships constructed on or after 1 January 2017, exposed escape routes shall be arranged so as not to hinder passage by persons wearing suitable polar clothing.
	Muster stations	1. For ships exposed to ice accretion, means shall be provided to remove or prevent ice and snow accretion; 2. Adequacy of embarkation arrangements shall be assessed, having full regard to any effect of persons wearing additional polar clothing.
	Embarkation areas	For ships exposed to ice accretion, means shall be provided to remove or prevent ice and snow accretion;
	Survival craft, its launching appliances	1. For ships exposed to ice accretion, means shall be provided to remove or prevent ice and snow accretion; 2. Have sufficient capacity for additional equipment.
Evacuation	Access to survival craft	For ships exposed to ice accretion, means shall be provided to remove or prevent ice and snow accretion;
	Survival equipment	ships shall have means to ensure safe evacuation of persons, including safe deployment of survival equipment, when operating in ice-covered waters, or directly onto the ice, as applicable
	Source of power	Where the regulations of this chapter are achieved by means of adding devices requiring a source of power, this source shall be able to operate independently of the ship's main source of power
	Immersion suit or a thermal protective aid	1. for passenger ships, a proper sized immersion suit or a thermal protective aid shall be provided for each person on board; 2. shall be of the insulated type.
Survival	Searchlights	For ships intended to operate in extended periods of darkness, searchlight suitable for continuous use to facilitate identification of ice shall be provided for each lifeboat.
	Life boats	Shall be partially or totally enclosed type Appropriate survival resources shall be provided as follows: 1. life-saving appliances and group survival equipment that provide effective protection against direct wind chill for all persons on board; 2. sufficient thermal insulation to maintain the core temperature of persons; 3. personal survival equipment that provide sufficient protection to prevent frostbite of all extremities.
	Personal survival equipment and Group survival equipment	Whenever there exist a potential of abandonment onto ice or land, the following apply: 1. group survival equipment shall be carried, unless an equivalent level of functionality for survival is provided by the ship's normal life-saving appliances; 2. when required, personal and group survival equipment sufficient for 110% of the persons on board shall be stowed in easily accessible locations, as close as practical to the muster or embarkation stations; 3. containers for group survival equipment shall be designed to be easily movable over the ice and be float-able; 4. whenever the assessment identifies the need to carry personal and group survival equipment, means shall be identified of ensuring that this equipment is accessible following abandonment; 5. if carried in addition to persons, in the survival craft, the survival craft and launching appliances shall have sufficient capacity to accommodate the additional equipment; 6. passengers shall be instructed in the use of the personal survival equipment and the action to take in an emergency; and 7. the crew shall be trained in the use of the personal survival equipment and group survival equipment.
	Emergency rations	shall be provided, for the maximum expected time of rescue.

4. Recommended Measures Taken by Polar Ships

The Polar Code is a mandatory code enforced by SOLAS and MARPOL convention to ensure the safe operation of ships in polar waters. All the ships sailing in polar region shall comply with the requirements. However, those regulations provide only the basic requirements, and those clauses usually do not give specific measures, and the specific measures are usually realized by the ship itself, as long as it meets the mandatory requirements.

By inquiry to and/or questionnaires feedback from various experienced mariners and experts engaged in polar shipping, and based on the potential risks along with polar shipping, preventive measures are extracted and recommended to be

taken to ensure the safe operation in polar shipping.

- 1) In addition to the equipment stated in the Code, extra protective clothing is recommended to carry on board such as winter hats, winter gloves, winter socks, face and neck protections, and make them ready for use in case of cold weather encountered.

Sufficient de-icing tools should be provided such as long handle axes, glue bars, round strong wood, spanners, pneumatic guns, and machinery tools to remove ice accretion near the survival rafts and escape routes.

- 2) When evacuating in polar waters, crew members may need to wear bulky thermal clothes, and ordinary escape routes may not allow them to pass through quickly and smoothly. Therefore, Escaping routes should be designed as wide as possible to ensure the safe passage by persons wearing suitable polar clothing

- and should not be blocked by any obstruction;
- 3) For exposed liquids e.g. fuel oil and cooling water for boat engines, if possible, arrange the piping systems in covered spaces with heating protections. Otherwise, protect them with insulating lagging to prevent from frozen or other protective measures;
 - 4) When considering resources to be included with the personal and group survival equipment, reference can be made to Polar Code Part I-B Chapter 9 - Additional

guidance to Ch 8 (Life-Saving Appliances and Arrangements). See table 3 “Suggested Equipment for group survival equipment”. Shelter e.g. tents or storm shelters or equivalent, thermal protective aids or similar, sleeping bags or foam sleeping mats or similar, and stove and fuel as listed in table 3 are considered as essential equipment, and are recommended to be provided on board, as they can provide effective protections to survivors in extremely code atmosphere.

Table 3. *Suggested Equipment for group survival equipment.*

Suggested Equipment
Shelter---tents or storm shelters or equivalent---sufficient for maximum number of persons
Thermal protective aids or similar-sufficient for maximum number of persons
Sleeping bags---sufficient for at least one between two persons
Foam sleeping mats or similar---sufficient for at least one between two.
Shovels---at least two
Sanitation (e.g. toilet paper)
Stove and fuel---Sufficient for maximum number of persons ashore and maximum anticipated time of rescue
Emergency food--- Sufficient for maximum number of persons ashore and maximum anticipated time of rescue
Flashlights---one per shelter
Waterproof and windproof matches---two boxes per shelter
Whistle
Signal mirror
Water containers & water purification tablets
Spare set of personal survival equipment
Group survival equipment container (waterproof and float-able)

- 5) Sufficient emergency food ration and fresh water shall be provided more than that of ships sailing in ordinary waters for the expected longer waiting periods, e.g. double the amount.
- 6) For ships intended to operate in extended periods of darkness, each lifeboat needs to be provided with additional searchlights suitable for continuous use to facilitate identification of ice.
- 7) SOLAS requires that ships built after 1 July 1986 shall be equipped with partially or fully enclosed lifeboats. In general, it is expected that such lifeboats provide a good protection against the harsh environmental conditions. Therefore, only ships with partially or fully enclosed lifeboats should operate in polar waters. This requirement has been included in Guidelines for Ships Operating in Polar Waters (resolution A. 1024 (26)). However, due to the harsh environment, both partially enclosed and enclosed lifeboats will operate with doors closed, thus with very low ventilation. It may cause lack of oxygen and concentration of CO₂ in the life boats. In view of this, bottles containing sufficient oxygen are recommended to be included in the group survival equipment for emergency use in case that the ventilation is not practicable due to extreme coldness.
- 8) For individual ships operating in ice-covered waters, LSA should be provided in such a way that e.g. lowering of a lifeboat onto the ice is possible. The standard free-fall lifeboat in accordance with IMO provisions includes arrangements that allow only a lowering aft of the ship. Another means of launching may need to be required since the area aft of the ship will be closed again by drifting ice. Alternatively to the

installation of a davit system, the shape of lifeboat could be optimized and the hull strengthened so that the lifeboat can withstand the ice interaction. If lifeboats should be lowered onto the ice, the slope of the bottom of the lifeboat hull must be considered and equipment for limiting the heel must be provided. To solve these problems proposed by Germany to DE Subcommittee on its 56th session, a complete modification shall be done to lifeboats, e.g. bottom of lifeboat hull shall be modified to be flat for polar ships.

- 9) Any other measures that are deemed helpful in polar operation should be actively promoted.

5. Conclusions

The anticipated growth in polar traffic for a variety of shipping sectors brings a number of challenges to mariners and ship operators, of which safety is of vital importance, especially when a ship is in disaster followed by its abandonment.

The unique characteristics in polar water e.g. remoteness, high latitude, harsh weather condition, darkness, and existence of ice, impose great dangers to safe polar shipping. It will be even much more dangerous in polar waters than that in other waters for ship's crew to escape and survive in case of emergency. To enhance the safe abandonment of a ship in polar waters, this paper identifies a variety of potential hazards, and provided targeted solutions for the hazards faced by mariners. However, there may be some hazards that are not identified due to lack of resources and experiences in polar shipping, and further work should be continued and further resources related to polar shipping should be gathered

so as to make continuous amendment to polar and related conventions and codes, thus enhancing constant improvement in safe shipping in polar waters.

These measure serves only as a guidance for operators. Alternative measures can be introduced and encouraged, as long as the measures implemented can meet the requirements of the Polar Code and helps to cope with the expected dangers in polar shipping.

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