7 Information about Navigation in Ice

Ice Navigation in Canadian Waters is published by the Canadian Coast Guard in collaboration with Transport Canada Marine Safety, the Canadian Ice Service of Environment Canada and the Canadian Hydrographic Service of Fisheries and Oceans Canada. The publication is intended to assist ships operating in ice in all Canadian waters, including the Arctic. This document will provide Masters and watchkeeping crew of vessels transiting Canadian ice-covered waters with the necessary understanding of the regulations, shipping support services, hazards, and navigation techniques in ice.

The nautical publication is available for download, free-of-charge, from
https://www.ccg-gcc.gc.ca/publications/icebreaking-deglacage/ice-navigation-glaces/page01-eng.html
(It is important to note that the paper version of the document is no longer available.)

7.1 General

Ice is an obstacle to any ship, even an icebreaker, and the inexperienced Navigation Officer is advised to develop a healthy respect for the latent power and strength of ice in all its forms. However, it is quite possible, and continues to be proven so, for well-found ships in capable hands to navigate successfully through ice-covered waters.

The first principle of successful ice navigation is to maintain freedom of manoeuvre. Once a ship becomes trapped, the vessel goes wherever the ice goes. Ice navigation requires great patience and can be a tiring business with or without icebreaker escort. The open water long way round a difficult ice area whose limits are known is often the fastest and safest way to port, or to the open sea when leaving a port.

Experience has proven that in ice of higher concentrations, four basic ship handling rules apply:
1. keep moving - even very slowly, but try to keep moving;
2. try to work with the ice movement and weaknesses but not against them;
3. excessive speed almost always results in ice damage; and
4. know your ship's manoeuvring characteristics.

7.2 Requirements for Ships Operating in Ice

The propulsion plant and steering gear of any ship intending to operate in ice must be reliable and must be capable of a fast response to manoeuvring orders. The navigational and communications equipment must be equally reliable and particular attention should be paid to maintaining radar at peak performance.

Light and partly loaded ships should be ballasted as deeply as possible, but excessive trim by the stern is not recommended, as it cuts down manoeuvrability and increases the possibility of ice damage to the more vulnerable lower area of the exposed bow. Engine room suction strainers should be able to be removed easily and to be kept clear of ice and snow. Good searchlights should be available to aid in visibility during night navigation with or without icebreaker support.

Ships navigating in ice-covered waters may experience delays and, therefore, should carry sufficient fresh water, supplies and manoeuvring fuel, especially vessels which use heavy bunker fuel for main propulsion.

7.3 Adverse Environmental Conditions

Ships and their equipment at sea in Canadian winters and in high latitudes are affected by the following:
- low surface temperatures;
- high winds;
- low sea-water injection temperatures;
- low humidity;
- ice conditions ranging from slush ice to solid pack;
- snow, sleet, and freezing rain;
- fog and overcast, especially at the ice/water interface; and
- superstructure icing when there is the great and dangerous possibility of heavy and rapid icing with consequent loss of stability.

7.3.1 Superstructure Icing

Superstructure icing is a complicated process which depends upon meteorological conditions, condition of loading, and behavior of the vessel in stormy weather, as well as on the size and location of superstructure and rigging. The more common cause of ice formation is the deposit of water droplets on the vessel's structure. These droplets come from spray driven from wave crests and from ship-generated spray. Ice formation may also occur in conditions of snowfall, sea fog (including Arctic sea smoke), a drastic fall in ambient temperature, and from the freezing of raindrops on contact with the vessel's structure. Ice formation may sometimes be caused or accentuated by water shipped on board and retained on deck.

Vessel icing is a function of the ship's course relative to the wind and seas and generally is most severe in the following areas: stem, bulwark and bulwark rail, windward side of the superstructure and deckhouses, hawse pipes, anchors, deck gear, forecastle deck and upper deck, freeing ports, containers, hatches, aerials, stays, shrouds, masts, spars, and associated rigging. **It is important to maintain the anchor windlass free of ice so that the anchor may be dropped in case of emergency.** Constant spray entering the hawse pipes may freeze solid inside the pipe, also anchors stowed in recessed pockets may freeze in place, both conditions preventing letting the anchor go. It is good practice in freezing spray to leave anchors slightly lowered in the hawse pipe in order to free them from ice accretion when needed. It is also advisable to maintain securing claws in place in case of slippery brakes, so that the anchors can be readily released in the event of a power blackout.

Superstructure icing is possible whenever air temperatures are -2.2°C or less and winds are 17 knots or more. It is very likely to take place when these conditions occur at the same time. In fresh water, such as the Great Lakes and the St. Lawrence River, superstructure icing will occur at 0°C and below, and accumulate faster than in salt water conditions.

Generally speaking, winds of Beaufort Force 5 may produce slight icing; winds of Force 7, moderate icing; and winds of above Force 8, severe icing.

Under these conditions, the most intensive ice formation takes place when wind and sea come from ahead. In beam and quartering winds, ice accumulates more quickly on the windward side of the vessel, thus leading to a constant list which is extremely dangerous as the deck-immersion point could easily be reached with a loaded vessel.

Vessel icing may impair the stability and safety of a ship.

The effects of freezing spray can be minimized by slowing down in heavy seas to reduce bow pounding, running with the sea, or seeking more sheltered sea conditions near-shore or in sea ice. Another option may be to head to warmer waters, although this is not possible in many Canadian marine areas.

Under severe icing conditions, manual removal of ice may be the only method of preventing a capsize. It is important for the Master to consider the predicted duration of an icing storm and the rate at which ice is accumulating on his vessel in determining which strategy to follow.

Several tips for minimizing icing hazards on fishing vessels are:

- head for warmer water or a protected coastal area;
- place all fishing gear, barrels, and deck gear below deck or fasten them to the deck as low as possible;
- lower and fasten cargo booms;
- cover deck machinery and boats;
- fasten storm rails;
- remove gratings from scuppers and move all objects which might prevent water drainage from the deck;
- make the ship as watertight as possible;
- if the freeboard is high enough, fill all empty bottom tanks containing ballast piping with sea-water; and
- establish reliable two-way radio communication with either a shore station or another ship.

Freezing spray warnings are included in marine forecasts by Environment Canada. However, it is difficult to provide accurate icing forecasts as individual vessel characteristics have a significant effect on icing. Graphs assessing the rate of icing based on air temperature, wind speed, and sea-surface temperature can provide a guide to possible icing conditions, but should not be relied on to predict ice accumulation rates on a vessel. Caution should be exercised whenever gale-force winds are expected in combination with air temperatures below -2°C.

7.4 Ships Navigating Independently

Experience has shown that non-ice-strengthened ships with an open water speed of about 12 knots can become hopelessly beset in heavy concentrations of relatively light ice conditions, whereas ice-strengthened ships with adequate power should be able to make progress through first-year ice of 6/10 to 7/10 concentrations. Such ships are often able to proceed without any assistance other than routing advice. In concentrations of 6/10 or less, most vessels should be able to steer at slow speed around the floes in open pack ice without coming into contact with very many of them.

7.4.1 Entering the Ice

The route recommended by the Ice Superintendent through the appropriate reporting system i.e. ECAREG or NORDREG, is based on the latest available information and Masters are advised to adjust their course accordingly. The following notes on ship-handling in ice have proven helpful:

a) Do not enter ice if an alternative, although longer, open water route is available.

b) It is very easy and extremely dangerous to underestimate the hardness of ice.

c) Enter the ice at low speed to receive the initial impact; once into the pack, increase speed gradually to maintain headway and control of the ship, but do not let the speed increase beyond the point at which she might suffer ice damage. Particular attention should be paid to applied power in areas of weak ice or open leads, pools, etc. where the speed might increase unnoticed to dangerous levels if power is not taken off.

d) Be prepared to go "Full Astern" at any time.

e) Navigation in pack ice after dark should not be attempted without high-power searchlights which can be controlled easily from the bridge; if poor visibility precludes progress, heave to in the ice and keep the propeller turning slowly as it is less susceptible to ice damage than if it were completely stopped, blocks of ice will also be prevented from jamming between the blades and the hull.

f) Propellers and rudders are the most vulnerable parts of the ship; ships should go astern in ice with extreme care, and always with the rudder amidships. If required to ram ice when brought to a halt, ships should not go astern into unbroken ice, but should move astern only in the channel previously cut by their own passage.

g) All forms of glacial ice (icebergs, bergy bits, growlers) in the pack should be given a wide berth, as they are current-driven whereas the pack is wind-driven. Large features of old ice may be moving in a direction up-wind or across wind according to the direction of the current.

h) Wherever possible, pressure ridges should be avoided and a passage through pack ice under pressure should not be attempted. The ship may have to be stopped in the ice until the pressure event is ended.

i) When a ship navigating independently becomes beset, it usually requires icebreaker assistance to free it. However, ships in ballast can sometimes free themselves by pumping and transferring ballast from side to side, and it may require very little change in trim or list to release the ship, especially in high-friction areas of heavy snow-cover.

The Master may wish to engage the services of an Ice Navigator in the Arctic.

7.5 Main Engine Cooling Systems

There is potential for ice and slush to enter sea bays or sea inlet boxes, blocking sea-water flow to the cooling system. This problem is encountered by a majority of ships entering ice-covered waters, especially when in ballast at light drafts. If water cannot be obtained for the cooling system, the main engines will not perform properly and may overheat causing the engines to shut down, or to be seriously damaged. The design of ships that operate in ice must prevent the cooling system from becoming blocked by ice.

Warning: Blockage of the sea boxes can cause the main engine cooling system to overheat, requiring reduced power to be used or the engine to be shut down completely.

Means must be provided to clear the sea bays if they do become blocked by ice. There are several design features which can ease operation or eliminate these problems:

a) High and low inlet grilles can be provided as far apart as possible.

b) Weir-type sea inlet boxes will overcome the problem of suction pipe clogging. The principle is commonly used by icebreakers in the Baltic Sea. The suction is separated from the sea inlet grilles by a vertical plate weir. Any ice entering the box can float to the top and is unlikely to be drawn back down to the suction level.

c) De-icing return(s) can be arranged to feed steam or hot water to the sea inlet box top, where frazil ice may have accumulated, or directly to the cooling system suction where a blockage may have occurred.

d) Ballast water recirculation through the cooling water system allows ballast tanks to be used as coolers, alleviating any need to use blocked sea inlet boxes. It should be noted that, while this solution is effective, it is usually a short-term solution unless vast quantities of ballast water are available or if the ship is fitted with shell circulation coolers because the recirculated ballast water will become too warm for effective cooling.

e) Means should be provided to clear the systems manually of blockage by ice.

The navigators and engineers should be aware of these potential problems and the solutions available to them on their ship.

7.6 Hull Fractures

Over the last several winter seasons, a number of bulk carriers and tankers developed fractures in their hulls while navigating in ice, off the East Coast of Canada or in the Gulf of St. Lawrence. The Load Line Regulations require that the master of every ship be supplied with a loading manual to enable him to arrange for the loading and ballasting of his ship in such a way as to avoid the creation of any unacceptable stresses.

Masters should be aware, while navigating in Canadian East Coast Waters and in the Gulf of St. Lawrence during the winter season, that low temperatures increase the brittleness of steel. This fact may be aggravated by wind force, sea conditions, and load distribution, temperatures of heated cargoes or oil fuels and length/beam ratio of vessels. Therefore, when there is a combination of:

(a) gale force winds;
(b) short, steep seas;
(c) very cold temperatures, and
(d) high length/beam ratio in vessels in ballast or in part-loaded condition.

Masters should minimize longitudinal stresses by reducing speed and maintaining the most advantageous ballast distribution as long as is necessary.

Authority: Canadian Coast Guard