Safety Management MANUAL

7.8.8 Icing Conditions / Ice Operations

Originator:	Approved By:
Eric Benway	Timothy Twomey

1. Purpose

The purpose of this procedure is to establish guidelines to be followed when vessel encounters icy conditions or operations require the vessel to operate in ice conditions.

2. Responsibility

It is the responsibility of the master to monitor routine navigational, meteorological, and environmental data including ice data, ice charts and satellite images when navigating in colder regions or seasonal winter regions where ice formations could be possible.

RV Neil Armstrong has ICE Class D0. D0 is the lowest capability ABS Ice Class which corresponds to year-round navigation in water with very light or thin first-year ice. Typically, the RV Neil Armstrong will not operate or have missions intended for any interaction with ice.

First-year Sea Ice is ice that is thicker than young ice but has no more than one year growth. In other words, it is ice that grows in the fall and winter (after it has gone through the new ice – nilas – young ice stages and grows further) but does not survive the spring and summer months (it melts away). The thickness of this ice typically ranges from 0.3 m (0.98 ft) to 2 m (6.6 ft). First-year ice may be further divided into thin (30 cm (0.98 ft) to 70 cm (2.3 ft), medium (70 cm (2.3 ft) to 120 cm (3.9 ft)) and thick (>120 cm (3.9 ft)).

For Ice Class D0, the Design Service Temperature is 14 °F (-10 °C) for the external plating. Design Service Temperature is defined as the mean daily average air temperature in the area of operation (corresponding to the time of year if limited – such as “summer”).

RV Atlantis has Ice Class C Notation and therefore can operate in waters with ice conditions described as light compared to Armstrong’s very light. This light ice is still within first year ice category.

Neither of the vessels are compliant to Polar Code or have Polar Ship Certificate

If WHOI operated vessels transit North of 70 deg. or South of 70 deg. Special considerations are required and insurance providers also need to be informed**. Operations are typically only permitted in ice-free conditions.**

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IF THERE ARE SPECIFIC OPERATIONS OR A SUDDEN TURN OF THE WEATHER THAT LEADS INTO ICING OR TRANSIT THROUGH THIN SURFACE ICE CONDITIONS THE FOLLOWING PROCEDURES ARE TO BE TAKEN INTO CONSIDERATION:

Reference: ABS Guide for Vessels Operating in Low Temperature Environments
Guide for Vessels Operating in Low Temperature Environments (eagle.org)

3. General

Vessels operating in or near the Arctic, Antarctic, or extreme environments are exposed to risk of ice conditions. Cold temperatures may reduce the effectiveness of numerous components of the ship, ranging from deck machinery and emergency equipment to sea suctions. When ice is present, it can impose additional loads on the hull, propulsion system and appendages as well as navigational hazards.

Extreme caution must be taken and the utmost attention to the type of ice, thickness, and its exact location in navigable areas.

Masters must report as soon as practicable, to the Director of Ship Operations, when a vessel is expecting or experiencing a drop in air and/or sea temperature resulting in formation of ice on the sea.

Only vessels with ice class notation are permitted to operate and navigate in ice conditions.

Ice Charts can be requested from local agents and national agencies.

CREW FAMILIARIZATION WITH COLD AND ICE

Ship operations in ice and cold climates have special considerations and challenges for the crew and may include heavy manual work such as clearing snow and ice; long hours exposed to the cold, or extended periods of concentration for bridge and engine room staff when working in convoy with an ice breaker and other ships.

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The extended work hours may involve re-arranging the work patterns of the crew to provide less extensive hours exposed to the cold, or on duty, additional personnel may be required. The specific dangers of freezing temperatures and ice are to be explained to the crew and should include:

a. Frost bite - the fluids in the extremities of the body - fingers, toes, nose etc. - freeze

b. Hypothermia - loss of heat in the body core

c. Snow blindness - ultraviolet damage to the retina in the eye

d. Wind chill - the effect of the wind effectively lowering the temperature to the body

e. Slips and trips - slips and trips on ice, which may not always be visible

f. Fatigue - work in the cold is strenuous leading to fatigue

g. Loss of judgement - longer periods in the cold can lead to a loss or reduction in the powers of judgement leading to mistakes

h. Loss of productivity - work takes longer to carry out than in warmer climates. It has been demonstrated that the time taken to carry out a given piece of work can double for each 10°F the temperature drops below 32°F.

i. Long hours in darkness - cold tends to be experienced in the higher latitudes at the time of year when the hours of darkness greatly exceed the daylight hours, and this can have an effect on the personnel.

Note the publication 'A pocket guide to cold water survival' published by IMO should be made available to crew members.

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Wind Chill Chart

Wind (mph)

Temperature (°F)	Calm	5	10	15	20	25	30	35	40	45	50	55	60
40	36	34	32	30	29	28	28	27	26	26	25	25	
35	31	27	25	24	23	22	21	20	19	19	18	17	
30	25	21	19	17	16	15	14	13	12	12	11	10	
25	19	15	13	11	9	8	7	6	5	4	4	3	
20	13	9	6	4	3	1	0	-1	-2	-3	-3	-4	
15	7	3	0	-2	-4	-5	-7	-8	-9	-10	-11	-11	
10	1	-4	-7	-9	-11	-12	-14	-15	-16	-17	-18	-19	
5	-5	-10	-13	-15	-17	-19	-21	-22	-23	-24	-25	-26	
0	-11	-16	-19	-22	-24	-26	-27	-29	-30	-31	-32	-33	
-5	-16	-22	-26	-29	-31	-33	-34	-36	-37	-38	-39	-40	
-10	-22	-28	-32	-35	-37	-39	-41	-43	-44	-45	-46	-48	
-15	-28	-35	-39	-42	-44	-46	-48	-50	-51	-52	-54	-55	
-20	-34	-41	-45	-48	-51	-53	-55	-57	-58	-60	-61	-62	
-25	-40	-47	-51	-55	-58	-60	-62	-64	-65	-67	-68	-69	
-30	-46	-53	-58	-61	-64	-67	-69	-71	-72	-74	-75	-76	
-35	-52	-59	-64	-68	-71	-73	-76	-78	-79	-81	-82	-84	
-40	-57	-66	-71	-74	-78	-80	-82	-84	-86	-88	-89	-91	
-45	-63	-72	-77	-81	-84	-87	-89	-91	-93	-95	-97	-98	

Frostbite Times

- 30 minutes
- 10 minutes
- 5 minutes

CREW CLOTHING / FOOTWEAR

Cold weather clothing should be provided for the crew. In general, it is preferred to have a number of layers of clothing rather a single warm piece of clothing, as this allows layers to be removed as heavy manual work is carried out and prevents sweating. Note that sweat can freeze on the exposed parts of the body; it reduces the insulation effect of the clothing and leads to de-hydration.

The layers of clothing:

a. Thermal under clothing to absorb any moisture

b. Thicker garments to insulate the body and retain the heat, such as woolens

c. Waterproof / wind proof outer garments to keep the body dry and reduce wind chill effect

d. Head face and neck should be covered to prevent heat loss

e. Hands should be covered with lined gloves to protect against frost bite

f. Layers of socks and insulated boots should be worn on the feet

g. Sunglasses should be provided to protect against snow blindness if watch keeping in ice.

Safety Equipment

Lifesaving and fire extinguishing equipment when stored or located in an exposed location, should be of a type that are rated to handle -22 F.

For any instance Vessel is caught in ice and needs icebreaker support. The situation will be coordinated on a case by case basis with the Port Office and regional authorities.

4. Reporting

When operating in waters where ice is expected, it may be necessary or simply good practice to report ice seen visually by sight or radar to institutions established to promote the safety of navigation through icy waters.

Several such institutions are:
Canadian Ice Service www.ice-glaces.ec.gc.ca

International Ice Patrol www.navcen.uscg.gov/IIP
U.S. National Ice center www.natice.noaa.gov

Engine Care

During ice and cold weather navigation, raw water suction and discharge pressures are to be monitored continuously by the watch. During ice transiting, snow, small ice pieces, and entrained air may accumulate in the sea chest**.** This accumulation may be of such a magnitude to cause overheating of the diesel engines and unscheduled shutdowns. To prevent clogging of the sea chests with snow and ice slush, utilize the raw water deicing systems equipped onboard as necessary. Monitor engine room ambient temperature that may affect machinery and personnel. Adjust supply and exhaust fans as necessary.

The use of winterized fuel is recommended to prevent the formation of wax or gelling of the diesel oil and possibly causing an unscheduled shutdown of engines. If winterized fuel is not available, there are additives that can be utilized to lower the floc point so that diesel does not crystallize. These should be brought on board prior to departure to an operations area where ice conditions are expected. Additionally, proper fuel management by allowing transfers of fuel oil to day tanks and allowing sufficient time for fuel to reach a temperature above the floc point should be followed. Be aware of the wax formations clogging fuel filters.

Monitor emergency diesel generators temperatures and add additional heat lamps or space heaters. Ensure that engine jacket water antifreeze concentration is sufficient. Ensure that, for battery start engines, that batteries are fully charged. Partial charge state moves the electrolyte towards more water and less acid and thus less freeze protection.

Protecting the Propeller

The propeller is vulnerable to ice damage, in particular the tips of the blades which may come into contact with the larger pieces of ice. The most hazardous time is when the propeller first starts and if moving stern first into the ice.

The principal protection for the propeller is to submerge the tips to a level below the ice or greater than the known ice thickness.

The propeller should be kept rotating at all times.

If the ship becomes stuck in ice the engine, thruster and propeller are to be kept in the ahead position to wash the ice clear of the propellers.

When first rotating the propellers in port, however, the thruster area is to be visually checked to confirm that it is free of ice, especially if the ship has been alongside for an extended period. If there is an accumulation of ice around the thruster, tugs or icebreakers, if available, are to be requested to clear the ice before the propellers are rotated.

It is preferable not to use the propeller in the astern mode, but if this is necessary then it should be done with care and in thinner ice.

Navigating and Maneuvering

An iceberg should be passed to its windward side, if sighted in poor visibility or at night, as there may be growlers present on the leeward side. Growlers, which are almost impossible to detect by radar, can be sufficiently large to cause serious damage to the ship. Icebergs should be given a wide berth due to the risk of them toppling due to wave motion.
If possible, course should be altered to afford a better attitude to the wind and reduce speed to avoid or minimize shipboard icing. Superstructure icing takes place whenever air temperatures are 28°F or less, and the winds are 17 knots or more, and when these conditions occur simultaneously. Winds of force 8 and above will cause severe icing. Stability can be compromised if severe icing occurs.

It is wise to make a detour and go around the ice if possible. If entry is unavoidable, maintaining freedom to maneuver is of utmost importance. Light and partly loaded ships should be ballasted as deep as possible.

Maintain minimum trim by the stern in order to prevent ice passing beneath the ship. Enter at right angles to the lee edge where ice is broken and loose and work with the ice, not against it. Avoid heavier, harder ice.

To ensure prompt engine response, the engine room must be manned at all times. If in ice, avoid going astern as the rudder/ thruster form the most vulnerable part of a ship unless specifically designed to take the excessive loading that impact with ice can cause. If going astern, the rudders / thrusters should be kept amidships.

If poor visibility restricts progress, consider heaving to while keeping the propellers turning slowly all the time, thereby making it less susceptible to damage. Keep a continuous radio

watch on frequency specified if you have requested icebreaker assistance. Experience has shown that vessels often have difficulty in establishing initial contact with the icebreaker.

Radars should be checked prior to approaching an area where ice might be encountered. The performance monitor should be used to achieve optimum tuning. Ice is a poor radar target beyond 3-4 miles range, areas of open water and smooth floes have a similar appearance on the radar display. Sometimes, the absence of sea clutter may also indicate that ice is present. A 3 cm radar is most beneficial if kept on a 6-mile range until the ice is detected. Thereafter, it should be on a 3-mile range. The presence of icebergs in ice covered seas may be indicated on the radar by distinctive straight lines of return on the display, the result of radar returns from the path the iceberg has made through the ice.

It is important that the vessel keeps moving in the ice even though the speed may be very slow. This will ensure that the ice along the hull does not compact and rotating the propeller / thruster will ensure that it is kept free of ice and the rotation will minimize the risk of damage to the thruster. Note that the propeller / thruster damage tends to occur when the propeller / thruster is first stared.

Work with the movement of the ice. It is important that the vessel avoids ice pressure particularly on the beam. Pressure on the beam will close the ice lead or ice channel between the ice breaker and the ship and possibly at a speed at which the ship cannot make headway. Similarly, the ship is most vulnerable to pressure on the beam, and this can lead to structural failure or ice overlapping the ship.

It may be beneficial to select a passage in the direction of the movement of ice or if not then it is preferable for the ship to head into the pressure as much as possible without trying to force a passage. In extreme cases the ship should await ice breaker assistance. Ice breakers are able to relieve the pressure by creating channels close to the ship.

The maneuverability of any ship in ice is greatly affected by the design such as length versus beam ratio, bow and stern design, midbody length and shape, as well as the structural ability to withstand contact with ice.

When maneuvering, navigators should be aware of the strongest areas of the ship, striking ice head on is more acceptable than striking with the less strengthened midbody, glancing blows should be avoided.

Speed
The safety of the ship in ice is very much related to the speed at which the ship moves in the ice. Selecting the safe speed will be a case of knowing the ice conditions - ice thickness, floe size and concentration - and taking these into account.

The ice will create friction on the hull of the ship which will naturally slow down the ship. The frictional loss due to snow, which tends to cover the ice, is even greater. The frictional losses due to the ice may well mean that the engine speed is greater than the speed of the vessel. It is important that when coming clear of ice and into open water that the engine movement is adjusted so that the ship does not speed up in the open water and attain a high speed when encountering the next ice floe.

Navigating at Night
If icebergs or growlers become visible call the Master and illuminate Ice Lights

Always avoid navigating near or into ice fields, especially at night. If area ahead of ship is unknown, call the master and “heave to” until conditions are assessed.

Heave to or stop the vessel along the edge of the ice and leave the vessel drifting along with the pack.

Be sure radars are adjusted to 6-nm and 3-nm and that they are properly tuned to the existing weather and sea conditions.

Anchoring
Both the R/V Neil Armstrong and R/V Atlantis are equipped with dynamic positioning and should utilize any combination of ship’s motion controls necessary to station keep and maintain readiness to leave the area if warranted. This should be the primary option for either vessel to maintain position in the proximity of ice. Anchoring in ice should be avoided except in an emergency. If it is unavoidable, a minimum amount of chain should be used. The windlass must be kept available for immediate use and engines maintained on standby or kept running at slow speed. If ice engulfs the vessel while at anchor, a similar precaution has to be taken with use of propeller or thruster movement from port to starboard to keep vessel's aft end clear and to resist ice movement from carrying vessel along with it. If

possible, use rudder movements to place the opposite side of the bow from which the anchor is deployed to protect the chain from contact with moving ice.

Anchoring positions should be selected using shore features as much as possible to provide a lee from prevailing ice drift.

If vessel is caught in sea ice pack, there are three basic principles that must be adhered to when navigating in ice and in no particular order are:
1. Keep moving – it is far better to move even very slowly than to be stopped in ice.
2. Work with the ice movement – do not try to force the ice.
3. Control the speed – excessive speeds will result in hull damage.

Lookout

Always keep vigilant lookout for growlers, burgs, and ice fields. Additional lookouts should be posted forward or at higher ends for safety concerns. Conning should be carried out from the ship's bridge to get a better view of the ice accumulation.

Keep in mind that at all times the stern must be observed for rudders' movement so as to avoid a floe from actually moving the stern towards it. In such cases, it is advised to post a lookout right aft with flashlights, whistles, UHF radios, etc. to make sure that the bridge is informed immediately in case the propellers/thrusters are in any kind of danger. Reduce speed if the ice goes under the ship.

De-Icing

The most effective method for preventing accumulations of ice and snow on equipment and fittings is to protect them with canvas covers and ensure operation of heating systems if equipped.

Any canvas covers that are fitted to Fire Fighting or Life Saving appliances must be capable of being easily removed so that the equipment can be accessed and brought into operation when required.

Ballast Tanks and Vents
Proper inspection and preparation for cold / icy weather needs to be done ahead of time for all ballast tanks and vents. Ballast tank vents may become frozen if not protected by canvas covers. This could lead to over/under pressurization of ballast tanks. The use of covers on these vents should be strictly supervised to ensure that the covered vents can still operate as designed. It is recommended that covers be removed prior to the commencement of ballast operations. Frequent removal of any accumulated ice will be required.

Exterior Water Lines
If the ship is expecting to encounter weather near or below freezing temperatures (32F/0C) all exterior water lines and fire stations should be secured and drained to prevent their water lines from freezing. A ruptured water line could represent anything from a minor inconvenience to a potential flooding hazard and steps should be taken to avoid this preventable situation from occurring.

Accommodation & Machinery Space Air Vents and
Effective measures must be taken to ensure that accommodation and machinery space air supply and exhaust vents remain clear of accumulations of snow and ice, so that they are able to operate correctly, this is particularly important with respect to remotely operated and self-closing vent flaps.

A ship specific procedure will be written to ensure that for regular inspections of supply and exhaust vents are carried out and that all build-up of snow and ice are removed remotely operated and self-closing vent flaps should be tested at more frequent intervals depending on expected ambient temperatures and weather forecasts.

Post Navigation Inspections
After completion of navigation in ice the following inspections should be carried out and applicable equipment tested:

- Upper deck Fire Fighting and Lifesaving Appliances
- Deck machinery and fittings
- Visual inspection of the external hull plates and inside from Engine Room.

- Inspection of steering gear parameters.
- Visual inspection of empty ballast tanks, cofferdams and void spaces.
- Visual inspection of all watertight spaces below the waterline.

The condition of ballast systems should be tested for any defects due to ice navigation and are to be reported to the Ship's Operator for further actions (additional survey, repair, arrangements for P&I Club Correspondents, logging a Sea Protest, additional safety measures for the next ice navigation, hiring of the Ice Advisor and so on).

Results of the inspections should be recorded into a Bridge / Engine Log book and reported to Port Office.

5. Icing conditions

Icing of the ship’s superstructure represents a significant hazard to the stability of the vessel. A heavy build-up of ice on the super structure will add excess strain to the foundations of the structure and equipment, potentially causing failure if left unchecked. The addition of ice on deck and on the superstructure adds a significant amount of weight onto the vessel above the center of gravity, potentially causing a loss of positive stability and the vessel overturning or taking on an angle of loll. All care should be taken to avoid this by altering course and/or removing ice from the vessel whenever possible.

Icing conditions are present when the air temperature falls below 28F and the wind is blowing 17 knots or greater. Severe icing will occur when winds are Beaufort force 8 or greater. If severe icing is occurring, the Master if practicable, will alter course to decrease the amount of freezing spray the vessel is taking on until such time that the crew can clear ice from the superstructure.

When icing conditions are present, it shall be the responsibility of the Master to work with the crew to remove as much ice on the superstructure as quickly and safely as possible, preventing any significant mass of ice to build above the ship’s center of gravity. The crew will use mallets and shovels to break ice off of the house, taking care not to damage equipment, to maintain footing and be ever cognizant of the fact that ice may fall off the

superstructure above them at any time. Smaller pieces of ice may travel far from their point of origin due to wind or ship motion. In addition to warm clothing that is appropriate to the weather conditions, the crew should consider wearing hard hats if there is a danger of ice falling from the superstructure.