24th International HISWA Symposium on Yacht Design and Yacht Construction
14 and 15 November 2016, Amsterdam, The Netherlands, RAI Amsterdam
ISBN / EAN: 978-94-6186-749-0

THE IMO POLAR CODE & LARGE YACHTS

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SUMMARY

In the interest of safety for ships and the people on board them, together with the environmental preservation of the polar waters, the International Maritime Organization (IMO) have adopted the International Code for Ships Operating in Polar Waters (Polar Code). The Polar Code will be applicable through the International Convention for the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL). It is expected that yacht owners and charters will become increasingly interested in polar tourism. Consequently this paper looks into the application and impact of the Code on large yacht design.

The paper summarises the various Polar Code Certifications available and highlights some aspects that could be difficult for a yacht to comply with or would have a significant impact on the design. Without understanding the ice environment that a vessel is expected to navigate in it is difficult to know how much of the Code is relevant when considering the design and naval architecture of a yacht. This paper aims to bring clarity to that based on the expected requirements of a typical superyacht owner/charterer. Through this work a recommendation for the appropriate Polar Ship Certificate and relevant regulations is made, and an assessment of the technical impact of these regulations on large yacht design has been carried out. The paper will offer naval architects and designers insight to ensure compliance with the Code and the necessary considerations for a polar yacht.

1. INTROUDCTION

This paper examines the application and consequences of the Polar Code on large yacht design. Three categories of Polar Ship Certificates are available depending on the intended ice operation. The relevant regulations for each category which will have a significant impact on yacht design are outlined and brief details of their effects on a Passenger Yacht Code (PYC) or Large Yacht Code (LY3) yacht are discussed. Operational requirements of the Code and regulations which do not have a substantial impact on the design of a polar yacht have not been considered. For a yacht intending to visit polar waters in the summer months when there is sunlight and opportunities to see wildlife, a recommendation for the appropriate Polar Ship Certificate and design considerations is provided.

2. HISTORY AND BACKGROUND TO REGULATION

In the interest of safety for ships and the people on board them, together with the environmental preservation of the polar waters, the IMO have adopted the Polar Code. The Polar Code will be mandatory under both SOLAS and MARPOL. The Polar Code and SOLAS amendments were adopted during the 94th session of IMO's Maritime Safety Committee, in November 2014. The environmental provisions and MARPOL amendments were adopted during the 68th session of the Marine Environment Protection Committee in May 2015. The Polar Code is expected to enter into force on the 1st of January 2017 and will apply to all ships constructed after this date. For ships constructed before this date and wishing to operate in polar waters, the relevant requirements must be met following the first intermediate or renewal survey after 1st of January 2018.

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3. APPLICATION AND CERTIFICATION

3.1 Application to Yachts

The Polar Code is split into two parts. Part I deals with safety and Part II deals with pollution prevention measures. Part I is applied through the SOLAS convention. "Pleasure yachts not engaged in trade" are exempt from SOLAS, so depending on the flag state's interpretation of this statement privately operated yachts may not need to consider Part I of the code. This would be the case with an Administration such as the Cayman Islands (CISR) for example. Additionally, as SOLAS does not apply to cargo ships less than 500GT, charter/commercial LY3 yachts of this size would not need to meet Part I either. However as discussed later in the paper compliance on a voluntary basis is likely to have significant benefits when visiting Polar Regions. Part II of the Code is applicable to all yachts greater than 400 GT (limit set within MARPOL).

3.2 Operational Limits

The intended area of operation and related ice conditions for a vessel plays a key role in the determination of what ice class is required. An ice class defines the operational limits to which the ship is designed to, based on the type and thickness of ice that it is intended to navigate in. Each Classification Society has different definitions and these are often vague because there is a vast amount of ice types and conditions. The main distinction is made into two groups; first year ice (ice of not more than one winter growth) and multi-year ice (ice which has survived at least one summer's melt). Multi-year ice has a lower salinity making it stronger, consequently operation in multi-year ice has a higher structural strengthening requirement. The Polar Code offers three Polar Ship Certificates. The intended ice operational limits are as shown in Table 1;

Table 1 [*Polar Code categories*]

Category	**Ice Description**
A	Medium first year ice (70cm to 120cm), which may include old ice inclusions (up to 3m or more)
B	Thin first year ice (30cm to 70cm), which may include old ice inclusions (up to 3m or more)
C	Open water (sea ice in concentrations less than 1/10) or ice conditions less severe than categories A & B

Although the Polar Code designates three categories of vessel, there are already many existing ice class standards. The Finnish-Swedish Ice Class Rules (FSICR) for example, have a proven service experience and are the de facto standard for vessels to be built to when operating in thin first-year ice. For this reason, Lloyd's Register (LR), a leading Classification Society with a substantial fleet of ice class vessels (including yachts), have aligned their rules with those of FSICR for operation in thin first-year ice (deduced by 'FS'). The intended operational limits for FSICR and LR are defined in Table 2 and Table 3 respectively.

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Table 2 [*FSICR operational limits*]

Ice Class	Operation in Ice
IA Super	Year round operation in the Baltic (ice thickness not exceeding 1.0m)
IA	Year round operation in the Baltic with an escort if necessary (ice thickness not exceeding 0.8m)
IB	Limited access to Finnish/Swedish ports for part of the year pending on ice conditions (ice not exceeding 0.6m)
IC	Limited access to Finnish/Swedish ports for part of the year pending on ice conditions (ice not exceeding 0.4m)
Category II	Not considered to be ice strengthened.

Table 3 [*LR ice class operational limits*]

Ice Class	Ice Description
1B FS	First-year ice conditions
1C FS	First-year ice conditions (close pack/drift ice concentration of 7/10)
1D	Light and very light ice conditions
1E	Very light first-year ice, such as brash ice (Fragments not more than 2m across) and small ice pieces

Due to the vast range of ice class rules, the International Association of Classification Societies (IACS) have developed the IACS Polar Rules to provide harmonisation between Classification Society requirements. Their ice class definition is defined in Table 4 below. Note that the Polar Code refers to IACS Polar Class (PC) 1-5 for a Category A ship and PC 6-7 for a Category B ship.

Table 4 [*IACS polar ice classes*]

Ice Class	Ice Description
PC 1 – PC 5	Year-round operation (See IACS Polar Class for each specific ice condition)
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

Table 5 below shows the approximate equivalence of the ice classes mentioned in Table 1 to Table 4 for first-year ice conditions only. Note that Polar Code Category A and IACS PC1-5 are for multi-year ice conditions.

Table 5 [*First-year ice class equivalence [1]. See reference for equivalence of other class societies*]

Classification Society	Ice Class				
Polar Code Certificate	Cat B	Cat B	Cat C	Cat C	Cat C
FSICR	IA Super	IA	IB	IC	Cat II
LR	1AS FS	1A FS	1B FS	1C FS	1D & 1E
IACS Polar Rules	PC6	PC7	-	-	-

The Polar Code categories defined in Table 1 provide an indication of the permissible operational ice range, however the actual ice limits will be defined by the ice class selected under the relevant Classification Society rules. The Polar Code category can then be assigned based on the selected ice class equivalence.

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3.3 Examples of Ice Class Vessels

Figure 1 and Figure 2 show typical examples of vessels with different ice classes. Their equivalent Polar Code category is also provided. These figures highlight the prominent difference of what is required from each Polar Code category.

Figure 1 [*Left: USCG Polar Sea (PC icebreaker, Cat A), Right: M/V National Geographic Explorer (DNV Ice Class 1A, Cat B)*]

Figure 2 [*Left: M/Y Luna (LR Ice Class 1D, Cat C), Right: M/V Sea Spirit (LR Ice Class 1D, Cat C)*]

3.4 Typical Yacht Operational Profile

An investigation has been carried out by BMT to identify the typical operational envelopes of commercial polar cruises. Polar cruises visit the most desirable locations in the Arctic and Antarctic and this is done during the summer months when there is sunlight and opportunities to see wildlife. Based on this it is anticipated that the operational profile of a polar yacht will be similar to that of a polar cruise ship.

3.4 (a) Antarctic

In general Antarctic cruises operate just at the tip of the Antarctic Peninsula and on some occasions cross the Antarctic Circle which is at a latitude of 66^0. Figure 3 shows an example of some common routes. The months of operation are between November and March. The vessel classes ranged between LR Ice Class 1D (equivalent to Category C) to LR Ice Class 1A (equivalent to Category B), however the ice class did not impact the route of operation. The ship with the lowest ice class (LR Ice Class 1D) is M/V Sea Spirit (see Figure 2). For operation further down the Antarctic Peninsula, as is the case with one vessel, the ice class notation is LR Ice Class 1A.

Figure 3 [*Common Antarctic routes. Left ≈ 3,500nm, Right ≈ 2,100nm*]

3.4 (b) Arctic

The Arctic cruise operational area is much more diverse than that of the Antarctic. Some of the most common routes are Franz Josef Land between July and August (See Figure 4), Greenland and/or Spitsbergen between May and September (See Figure 4), Baffin Bay and/or the Northwest Passage between August and September (See Figure 5). For Franz Josef Land, Spitsbergen and Greenland the lowest ice class vessel in operation is M/V Sea Spirit (LR Ice Class 1D). In the case of Baffin Bay and the Northwest Passage the lowest ice class vessel is M/V Le Boreal, with a Bureau Veritas Ice Class IC (equivalent to LR Ice Class 1C).

Figure 4 [*Greenland, Spitsbergen and Franz Josef Land illustrative route. Left ≈ 1,300nm, Centre ≈ 1,600nm, Right ≈ 1,600nm*]

Figure 5 [*Northwest Passage and Baffin Bay illustrative route. Left ≈ 3,800nm, Right ≈ 3,000nm*]

3.5 Low Air Temperature Operation

For ships intending to operate in low air temperature, a polar service temperature should be specified for that ship. The Polar Code defines operation in low air temperature as those voyages through areas where the lowest mean

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daily low temperature is below -10^{0}C. Figure 6 provides a definition of this. The polar service temperature should be 10^{0}C below the lowest MDLT of the intended area and season of operation.

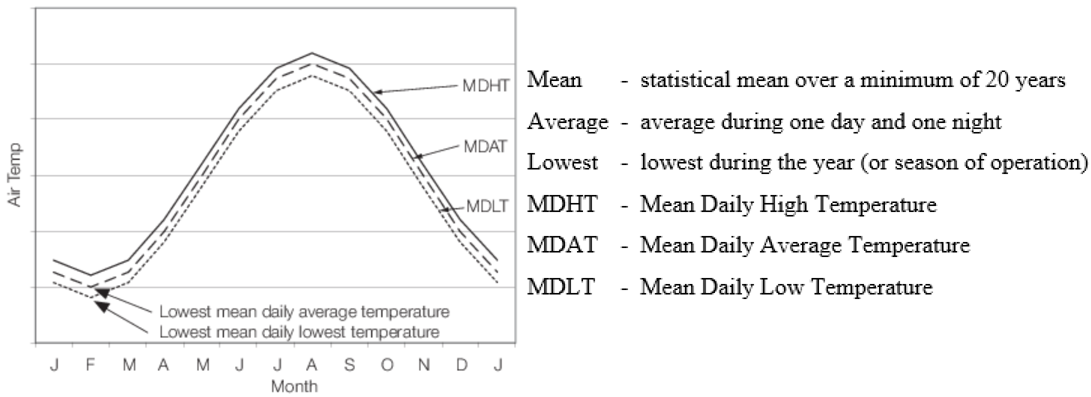

Figure 6 [*Temperature definition*]

Operation in low air temperature will have a significant impact on the materials for hull construction as well as equipment design. Protection measures and operational procedures are required to ensure that equipment is suitably protected to enable low temperature operation. Classification Societies often offer rules/guidelines for the winterisation of ships. It is the responsibility of the Owner and design team to determine the polar service temperature and whether a winterisation notation is required based on the intended area and season of operation. For a yacht engaging in polar tourism with a similar operational profile to that of the cruise ship industry in the summer months (Section 3.4), operation in temperatures below -10^{0}C will be uncommon. As low air temperature operation is unlikely this type of yacht will not need to specify a polar service temperature or require winterization of equipment and systems.

3.6 Operation in Ice Outside of the Polar Regions

The Polar Code is ultimately relevant to the Polar Regions and does not necessarily imply that a vessel with a Polar Ship Certificate can visit other ice covered waters such as the Baltics. Permission to visit other ice covered waters would require acceptance by the Administration and/or Port State Control, based on equivalency defined in Table 5. For ships intending to navigate in the Baltics, consideration may need to be given to the installed engine power such that it complies with the applicable FSICR.

4. POLAR CODE REGULATION REQUIREMENTS & IMPACT, PART I – SAFETY MEASURES

This section discusses the relevant safety regulation requirements of the Code which will have an impact on the design of a large yacht wishing to obtain a Polar Ship Certificate. With reference to Section 3.1, Part I is not necessarily applicable to all yachts, however the impacts of the regulations with respect to both LY3 and PYC platforms are discussed.

4.1 Systems and Equipment

Machinery installations, fire safety systems and navigational equipment will need to provide functionality at the polar service temperature and under the anticipated environmental conditions. Means shall be provided to remove or prevent ice and snow accretion.

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Due to the harsh environment in the poles winterization of equipment and systems may be required, the level of this will be highly dependent on the polar service temperature of the ship. The list below provides some protection measures and requirements for low air temperature operation;

- Ice removal equipment
- Steam piping system and connections around the ship used for de-icing
- Covers to protect essential equipment (mooring & lifesaving)
- Working fluids suitable for low temperature
- Trace heating for piping and/or railings
- Heating for areas that are essential for safety (safety lockers, escape exits/routes & lifesaving launching area)
- Heating on safety and navigation equipment to prevent ice accretion
- Engine room & technical space heating (including emergency generator and Hi-Fog space)
- Tank heating in the form of heating coils for any tanks above the lower ice waterline and adjacent to the side shell
- Sea water inlet heating system to maintain ice free cooling water

The heating requirements above can have a significant impact on the vessel load balance and a higher load may lead to the requirement for larger generators. The capability of the HVAC system for temperature regulation of accommodation spaces will also need to be assessed against a lower design air temperature. If a polar yacht is not intended to operate in low air temperature many of the items above will not be required and the only major items to be considered will be the HVAC system capability.

4.2 Emergency Power Supply

The time required for the emergency source of power to supply electrical power to all services that are essential for safety in an emergency are 18 hours for an LY3 yacht and 36 hours for a PYC yacht. The Polar Code specifies a maximum expected time of rescue which should be no less than 5 days (120 hours). This requirement will have an impact on the emergency generator tank size and possibly the general arrangement. The additional fuel will also cause a small increase vessel weight and vertical centre of gravity (VCG).

4.3 Ship Structure

The selected ice class and subsequent Polar Code category will play a significant role in a yachts expedition capability. With a Category A or B vessel, operation in ice above 30cm is possible and this can give guests the opportunity to disembark the vessel right onto the ice (as shown in Figure 1). This will increase the vessel operational area, probability of seeing wildlife and attractiveness for charter or private guests. For a Category C vessel, the lower the ice class selected, the lower the expedition capability and a compromise on structure can lead to a compromise in vessel itinerary. In the Arctic, where ice concentrations vary significantly with season, a higher ice class will be able to operate for a longer time, which may be a significant benefit to the owner or charterer.

4.3 (a) Hull Scantlings Category A or B

For a Category A or B ship the structure shall be designed to resist the global and local structural loads encountered in the foreseen ice conditions. The code refers to the IACS Requirements concerning Polar Class, with varying ice classes as detailed in Table 4 (Category A; PC 1-5 and Category B; PC 6-7). The detailed requirements of the rules are not outlined in this report, however they will lead to a requirement for significant structural enhancement of the entire hull that will have a weight implication. The structural weight increases progressively from one polar class to the next (PC7 to PC1). Although the additional steel weight will have a cost implication this can be outweighed by the fact that fairing on the hull of a Category A or B yacht will be unlikely since this will get damaged during ice operation.

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4.3 (b) Hull Scantlings Category C

A Category C ship need not be ice strengthened if the Administration believe that the ship's structure is adequate for its intended operation, however this will significantly impact the permitted operational area. In which case there can be benefit to having some level of ice strengthening. If the vessel is ice strengthened the scantlings should be designed taking into account the expected ice types and concentrations encountered in the area of operation. The impact on scantlings will be largely dependent on the ice class selected. Considering that LR has a number of ice classed yachts, it has been taken as an example Classification Society. The LR ice classes that are suitable for a Category C Certificate are discussed below and are 1E, 1D, 1C FS and 1B FS.

For Ice Class 1E shell plating and framing strengthening in the forward region of the ship is required as shown in Figure 7. The scantlings of shell plating and framing are to comply with the requirements of Ice Class 1C FS using 0.9 times the ice pressure. The requirements for Ice Class 1D are strengthening of the forward region only, but with strength in line with the rules for Ice Class 1C FS below.

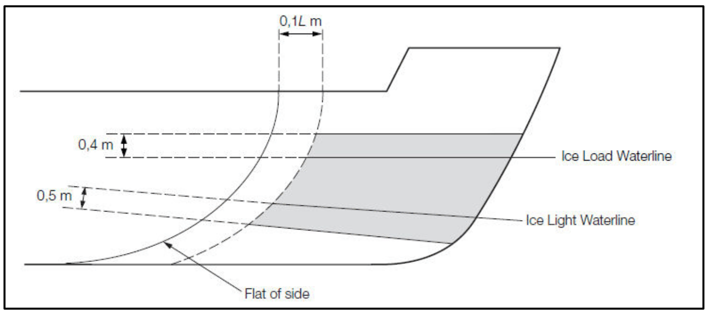

Figure 7 [*Extent of application of plating requirements for 1E & 1D (LR Ship Rules, Part 8, Chapter 2, Section 4, Figure 2.4.1)*]

Ice Class 1C FS requires compliance with the FSICR. The requirements are summarised below. The requirements for 1B FS are the same as those for 1C FS, however the ice pressures to be considered are higher.

- A minimum engine output is defined.
- An ice belt over the whole length of the ship is required as indicated in Figure 8.
- Shell plating in way of the ice belt requires ice strengthening. An abrasion and corrosion allowance of 2mm is included in the ice belt plate thickness.
- Framing in way of the ice belt requires ice strengthening and frame ends shall be attached to a deck or ice stringer.
- In the forward region, frames which are not at a straight angle to the shell shall be supported against tripping by brackets, intercostals, stringers or similar at a distance not exceeding 1300 mm.
- All welding in the ice belt is to be of the double continuous type.
- The web thickness of frames in the ice belt shall be at least one half the shell thickness and not be less than 9mm. Where there is a deck, tanktop or bulkhead in lieu of a frame, the plate thickness of this shall be as above, to a depth corresponding to the height of adjacent frames.
- Stringers within the ice belt require strengthening.
- The stem shall be supported by floors or brackets spaced not more than 0.6m apart and having a thickness of at least half the shell plate thickness.
- The connection of bilge keels to the hull shall be so designed that the risk of damage to the hull, in case a bilge keel is ripped off, is minimized.
- Deck drains are not to be located in way of the ice belt.

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In addition to the requirements above, when designing an ice strengthened yacht, underwater lights might need special consideration and shell doors might be within the ice belt which may have some considerable implications to the local structure.

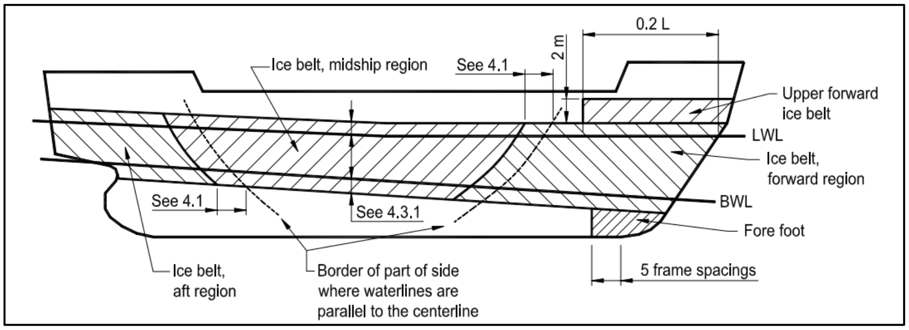

Figure 8 [*Ship ice belt regions for 1C FS & 1B FS (FSICR, Section 4.1, Figure 3)*]

4.3 (c) Materials of Exposed Structures

For ships intending to operate in low air temperature (see definition in Section 3.5), the materials of exposed structures shall be suitable for operation at the ships polar service temperature. For a Category A or B ship (based on the IACS Requirements concerning Polar), an alternative grade of steel for weather exposed plating is required in all cases when compared to a conventional ship. This could have an impact on the construction techniques and welding of steel. For Category C ships (based on IACS UR S6 Use of Steel Grades for Various Hull Members – Ships of 90 m in Length and Above), if the design temperature[1] is below -20^{0}C, the materials of exposed structures will require an alternate grade of steel. However it is highly unlikely that a Category C yacht will operate in such conditions.

4.4 Appendage Scantlings

4.4 (a) Appendage Scantlings Category A or B

The scantlings of propeller blades, shaftline, steering equipment and other appendages shall be designed to resist the loads imposed by ice interaction. The code refers to the IACS Requirements concerning Polar Class, with varying ice classes as detailed in Table 4 (Category A; PC 1-5 and Category B; PC 6-7). The full detailed requirements of the rules are not outlined in this report, however they will lead to a requirement for significant structural enhancement that will have a weight implication.

4.4 (b) Appendage Scantlings Category C

If the ship is ice strengthened the scantlings should be designed taking into account the expected ice types and concentrations encountered in the area of operation. The impact on a Category C vessel will be largely dependent on the ice class selected. Taking LR as an example Classification Society, the requirements are discussed below. Note that if the vessel is not ice strengthened there will be no impact on appendage scantlings.

For Ice Class 1E the following is required;

- The shafting and propeller blade thickness as required by the rules for open water service are to be increased as follows;

    Screwshaft, increase in diameter – 5%
    Propeller, increase in blade thickness at root and at 60% radius – 8%

[1] Note that the design temperature is to be taken as the lowest MDAT in the area and season of operation. See Figure 6 for reference and note that this is different to the polar service temperature, defined in Section 3.5.

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Keyless propeller fitting, increase in mean torque – 15%

- There is a minimum propeller blade tip thickness requirement.
- Arrangements to assist in maintaining the cooling water system suction pipes free from ice.

For Ice Class 1D the requirements are as per Ice Class 1E. In addition to this, the rudder and steering arrangements should be strengthened in line with the rules for Ice Class 1C FS below.

For Ice Class 1C FS & 1B FS the following is required;

- Scantlings of rudder post, rudder stock, pintles, steering gear etc. as well as the capability of the steering gear shall be determined according to the rules of the Classification Society.
- Propeller, shafting and gearing scantlings are to be determined taking into account the impact when a propeller hits ice.
- The cooling water system shall be designed to ensure supply of cooling water when navigating in ice.

4.5 Subdivision and Stability

Due to vessel interaction with ice and the likelihood of ice accretion on board, the Polar Code introduces additional stability requirements over and above those of the usual regulations.

4.5 (a) Intact Stability (Applicable to all Categories)

All ships are to have sufficient stability in the intact condition when subject to ice accretion. When operating in areas and during periods where ice accretion is likely to occur, the following icing allowances shall be considered in the stability calculations:

1. 30kg/m^2 on exposed weather decks and gangways.
2. 7.5kg/m^2 for the projected lateral area of each side of the ship above the water plane.
3. The total projected area of continuous surfaces shall be increased by 5% and the static moment of this area by 10%.

For both LY3 and PYC yachts, the icing allowances above will impact the loading conditions. For each loading condition the displacement as well as VCG will increase, resulting in a loss of GM and reduced margin to the limiting VCG curve. A study has been carried out by BMT on four yachts of lengths between 70m and 160m to investigate the impact of the icing allowances. The yachts were selected based on having a beam, profile area, and gross tonnage in relation to length that was representative of the trends seen in the industry to date. The results showed that the VCG increase is significant and can range between 120mm to 180mm. This will cause a notable reduction in the margin to the limiting VCG curves, and is best considered at the start of a design project.

4.5 (b) Damage Stability (Only applicable to Category A and B ships)

Category A and B ships shall have sufficient residual stability to sustain ice-related damages. The Polar Code specifies additional damage extents to be considered which are focussed on damage by ice around the waterline, and across watertight bulkheads. For an LY3 yacht, Section 11.3 of LY3 is still applicable however the additional damage extents of the Polar Code effectively requires a change from a one compartment standard of subdivision to two. This will result in a significant increase in subdivision compared to a non-polar yacht. The PY code has a significant variety of stability requirements depending on the vessel length and PY Category. In summary, vessels complying with the deterministic aspects of the PYC (Part VI and Part VII) will already meet a two compartment standard.

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For yachts complying with the probabilistic requirements (Part II) the Polar Code specifies criteria and a damage extent which are an enhancement to the standard SOLAS requirements. With regard to 'SOLAS Regulation II-1/8 - Special requirements concerning passenger ship stability', the Polar Code requires s_i to be 1.0 (as opposed to 0.9 in SOLAS) and damage across watertight bulkheads must be considered (not necessary under SOLAS). This is likely to have an impact on the subdivision of large PY-U, PY-P and PY-2 yachts.

For both an LY3 and PYC yacht, subdivision for a Category A or B Certificate should be considered from the start of a project. In many cases there will be a requirement for an increased level of subdivision or equivalent voids the size of the damage extent in way of watertight bulkheads. Both these options will have a significant impact on the subdivision, general arrangement and steel weight compared to a non-polar yacht.

4.6 Life-Saving Appliances and Arrangements

All life-saving appliances and associated equipment shall provide safe evacuation and be functional under the possible adverse environmental conditions during the maximum expected time of rescue. In addition to this the following is required;

- Safe evacuation and deployment of survival equipment should be possible when operating in ice-covered waters or directly onto the ice.
- For passenger ships (PYC yachts) an immersion suit or thermal protective aid shall be provided for each person on board.
- Additional personal and group life-saving equipment is required (in easily accessible locations). The survival craft and launching appliances shall have sufficient capacity to accommodate this additional equipment.
- If lifeboats are present they shall be of partially or totally enclosed type.

Heating arrangements as discussed in Section 4.1 may be required depending on the polar service temperature. It is likely that the additional personal and group life-saving equipment will have an impact on the general arrangement. Additional space in the safety locker on the embarkation deck will be required to accommodate this equipment. The size of the survival craft may be impacted by the fact that it is required to have sufficient space for the additional life-saving equipment.

4.7 Safety of Navigation

Ships shall have the following additional navigational equipment;

- Two non-magnetic means to determine and display their heading.
- Ships proceeding to latitudes over 80^0 shall be fitted with at least one GNSS compass or equivalent.
- Two remotely rotatable, narrow-beam search lights.
- Flashing red light visible from astern.
- Means to prevent the accumulation of ice on antennas required for navigation and communication.

In Category A and B ships, the bridge wings shall be enclosed or designed to protect navigational equipment and operating personnel. Enclosed bridge wings can have a notable impact on the exterior styling of the yacht.

4.8 Manning and Training

When operating in polar waters, masters, chief mates and officers in charge of navigational watch shall be qualified in accordance with chapter V of the STCW Convention and the STCW Code, as amended in Table 6.

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Table 6 [*Manning and training requirements*]

Ice Conditions	PYC	LY3
Ice Free	Not applicable	Not applicable
Open waters (Cat C)	Basic training for master, chief mate and officers in charge of a navigational watch.	Not applicable
Other waters (Cat A & B)	Advanced training for master & chief mate. Basic training for officers in charge of navigational watch.	Advanced training for master & chief mate. Basic training for officers in charge of navigational watch.

5. POLAR CODE REGULATION REQUIREMENTS & IMPACT, PART II – POLLUTION PREVENTION MEASURES

This section discusses the relevant pollution prevention regulation requirements of the Code which will have an impact on the design of a large yacht wishing to obtain a Polar Ship Certificate. With reference to Section 3.1, these requirements are applicable to all yachts greater than 400 GT.

5.1 Prevention of Pollution by Oil

Discharge of oil or oily mixtures into polar waters is prohibited. For Category A and B ships with a fuel oil capacity less than $600m^3$, all fuel tanks shall be separated from the outer shell by a distance of not less than 0.76m. However this provision does not apply to individual tanks with a capacity less than $30m^3$. This also applies to oil residue (sludge) and oily bilge water holding tanks. Note that for Category A, B and C ships with a fuel oil capacity greater than $600m^3$, MARPOL Regulation 12A applies in the usual manner.

For Category A and B ships the regulation can be achieved by limiting all fuel tanks to $30m^3$. This will drive up the number of fuel oil tanks resulting in a more complex, heavier fuel transfer, bunkering and supply system. If fuel oil tanks larger than $30m^3$ are desired there will be a significant impact on the vessel. Protected tanks can be incorporated into the design by either using accommodation space or alternatively, the protected tanks can be incorporated into the double bottom. However this will require the tank top height to be increased, which will have the following knock on effects [2];

- Other decks will increase in height
- Increase in lightship and deadweight VCG (which will have an impact on stability)
- Increase in structural weight
- Increase in Gross Tonnage

Polar expedition trips can be very long as shown in Figure 3 and Figure 4. An increased fuel capacity in comparison to a conventional yacht may be required. Careful attention to this should be exercised at the start of a design project when considering the fuel tank options above.

5.2 Prevention of Pollution by Sewage and Garbage

The regulations for prevention of pollution from sewage or garbage are in line with the general requirements that a yacht should already adhere to. However for the purpose of polar expedition it may be desirable to increase the black and grey water system tank capacities and garbage handling/storage for extended periods of navigation.

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6. RECOMMENDATION

Although there will be some clients who want a purpose built yacht focussed on polar expedition with a winterization notation, ice breaking capabilities and a Category A or B Certificate, this type of yacht will be unusual. It is more likely that Owners will wish to have the ability to visit Polar Regions if desired, but whilst avoiding compromise to a design which may be more focussed on traditional warmer cruising grounds. For this type of yacht Owner, operation in the Polar Regions will only happen during the summer months when there is sunlight, good weather and opportunities to see wildlife. This trend is reinforced by the months of operation of commercial polar cruises discussed in Section 3.4. In addition to this, operation in temperatures below -10^0C will be unlikely. Consequently a Category C Certificate would be the most common requirement, without low air temperature operation.

The Code does not specify ice strengthening for a Category C ship, however wildlife is usually present on the floating ice, especially in the Arctic. Therefore to allow owners and guests access to these sights some form of ice strengthening should be specified so that the yacht can operate in waters with floating ice. Based on the investigation of polar cruises discussed in Section 3.4, and assuming that a yacht will have a similar operational profile, ice strengthening to the forward region of the vessel is advised. Table 7 shows a summary of what should be considered from a technical design point of view when thinking of applying for a Category C Polar Ship Certificate for a yacht.

Table 7 [*Summary of impacts for a Category C polar yacht not operating in low air temperature*]

Regulation		**Category C Certificate Impacts**
Systems & Equipment		HVAC system capability for operation up to -10^0C should be considered
Emergency Power Supply		Increased size of emergency generator fuel tank
Structure Scantlings		Ice strengthened forward region
Appendage Scantlings		Ice strengthened appendages
Intact Stability		Reduction in margin to limiting VCG curves should be considered
Life-Svaing	PYC	Additional locker space for personal & group survival equipment and immersion suits
	LY3	Additional locker space for personal and group survival equipment
Safety of Navigation		Additional navigation equipment
Manning & Training	PYC	Additional training for master, chief mate and officers in charge of navigational watch
	LY3	No additional requirement

Although the Polar Code may not be applicable to many yachts, operating in polar waters will still require permission/permits from the relevant national governing authorities. Obtaining these permits is a deeply intricate process and involves lengthy risk assessments to prove that the voyage is safe and poses minimal risk to the environment. Compliance with some or all of the Code and Classification requirements will make this process easier. Alternatively, for any responsible yacht expedition, other ways to mitigate the risks will have to be established.

Note that this paper is focused on the impact on some of the design aspects imposed by the Polar Code. When considering the design of a polar yacht there will be many other points to consider not covered by the Polar Code which could also have a notable impact on the design of a yacht.

ISBN / EAN: 978-94-6186-749-0

7. CONCLUSIONS

The Polar Code starts the process of setting an international benchmark to ensure the safety of ships and the people on board them, together with the environmental preservation of the polar waters. In addition to the regulations of the Polar Code there will be many other items to consider when visiting the Polar Regions (these have not been considered in this paper).

In many cases the Polar Code will not be applicable to yachts, but where it is applied the impact to design is highly dependent on the intended operational profile, both in terms of ice conditions as well as air temperature. It is up to the Owner to decide which destinations he wants to take his yacht and guests, and based on this the design team can determine what Polar Code category, class notation and operating temperature range is most suitable to meet his aspirations.

When considering a polar yacht two types of vessel are foreseen. The first would be in line with today's understanding of what a yacht is and does, but also has the capability to visit the Polar Regions occasionally if desired. In this case a Category C certificate is sufficient and the implications of the Polar Code are not onerous. The extent to which this vessel is ice strengthened (or not) will impose the limit of its expedition capabilities. The second type of yacht could be a purpose built polar explorer which may spend the majority of its time between the Arctic and Antarctic. For this yacht a Category A or B certificate is more appropriate. Although the Polar Code regulations imposed on such a yacht are considerable, they will be justified by the extended operational season and the 'no limit' capability to exploit the full potential of polar exploration. For this type of yacht the design requirements of the Polar Code will need to be assessed from the outset of the design and will form some of the core objectives of the platform.

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