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AN APPROACH FOR INCLUDING POLAR CLASS VESSELS IN THE CANADIAN ARCTIC SHIPPING REGULATIONS

G.W. Timco, A. Collins, I. Kubat
Canadian Hydraulics Centre
National Research Council of Canada
Ottawa, Ont. K1A 0R6 Canada

ABSTRACT

Transport Canada has indicated that they will be updating the Arctic Shipping Pollution Prevention Regulations (ASPPR) which are used to regulate shipping in the Canadian Arctic. There are several reasons for this. The Canadian Hydraulics Centre of the National Research Council of Canada (NRC-CHC) has performed significant research to evaluate the veracity of the two existing systems (Zone-Date System and Ice Regime System) that form part of these Regulations. The research clearly showed that neither system properly takes into account the ice conditions and the allowable areas for different vessels in Canada's Arctic waters. Further, these Regulatory Systems are based on various classifications for ice-strengthening vessels including Baltic Class, Arctic Class, and Canadian Arctic Class. Recently, the International Association of Classification Societies (IACS) has harmonized their classifications for Arctic vessels and has developed standards for seven Polar Class (PC) vessels. These vessel classes are not included in current Canadian regulations. Because of this, the Canadian government has investigated ways to update the Arctic shipping regulations to include the PC vessels by using a science-based approach. This paper presents an overview of the approach and highlights the results of the research to include the Polar Class vessels in the Canadian regulations.

INTRODUCTION

The Canadian Hydraulics Centre (CHC) of the National Research Council of Canada (NRC) has been investigating the scientific basis for Transport Canada's Arctic Shipping Pollution Prevention Regulations (ASPPR). The purpose of these Regulations is to minimize the likelihood that a ship will enter ice conditions that are beyond the ship's designed safe operating parameters. The Regulations are based on two completely different approaches for dealing with a vessel in different ice conditions at different times of the year. These systems are the Zone-Date System (ZDS) and the Ice Regime System (IRS).

The results of this research show that neither system is based on strong science. The NRC-CHC independently looked at the Ice Regime System and the Zone-Date System and, in a series of papers, outlined the strengths and weaknesses of each one (see e.g. Timco and Kubat, 2002; Timco et al. 2004; Kubat and Timco, 2008; Kubat et al. 2008). Transport Canada asked the NRC-

CHC to investigate some suitable methods for updating the shipping regulations. Timco and Kubat (2007) wrote a Discussion Report which outlined four possible options that would include Polar Class vessels, and may prove to be a more suitable means of pollution prevention in Canada's Arctic waters. This report was widely circulated to the Stakeholders through personal meetings, and at the CMAC-Northern meetings. The results of these discussions indicated that the Hybrid System was the best option to pursue. Timco et al. (2009a) presented a suggested Hybrid Control System for Type B vessels which was based on a detailed analysis of the ice conditions in the Canadian Arctic for the past 25 years (Timco et al., 2009b). This "Hybrid System" combines the ZDS and the IRS into an updated integrated system. The NRC-CHC spent considerable effort to disseminate the information on the Hybrid System to all Stakeholders. They did this through presentations at scientific conferences and committee meetings, individual meetings with stakeholders, and through a formal consultation meeting which was held in Montreal in March 2010. Timco and Kubat (2010) summarize these discussions and recommendations. This paper outlines the approach that is being used to update the Hybrid System to include the Polar Class vessels.

THE ZONE-DATE SYSTEM

In 1972, the Canadian Government drafted the Arctic Shipping Pollution Prevention Regulations (ASPPR) to regulate navigation in Canadian waters north of 60ºN latitude. These regulations include the Shipping Safety Control Zones, and the Date Table, made under the Arctic Waters Pollution Prevention Act (ASPPR 1989). Both of these are combined to form the "Zone/Date System" (ZDS) matrix that gives entry and exit dates for various ship types and classes. In this system, the ship types and classes, in descending order of ice capability are: Arctic Class: 10, 8, 7, 6, 4, 3, 2, 1A, 1 and Type Ships: A, B, C, D, E.

The Arctic Class was normally, but not accurately described as the thickness in feet of level ice that the vessel would have the power and strength to break. The Type ships represent the Classifications Societies' designation of ice-capable ships that are in turn equivalent to the Baltic Rules. The "Zone-Date System" is based on the premise that nature consistently follows a regular pattern year after year. It is a rigid system with little room for exceptions.

Kubat et al. (2005, 2006, 2007) has been investigating the veracity of the Zone-Date System for Transport Canada. They found that there are very large variations in the ice conditions from year-to-year. An examination of several years of data has shown that the Zone-Date System allows vessels into ice regimes which have a high potential to damage the vessel and it often restricts vessels from entering regions where the ice conditions are favourable for a safe passage. The large annual variations are not taken into account by the ZDS - it has fixed (rigid) entry dates that often do not reflect the severity of the ice.

THE ARCTIC ICE REGIME SHIPPING SYSTEM

Transport Canada, in consultation with stakeholders, made extensive revisions to the Arctic Regulations through the introduction of the Ice Regime System (ASPPR 1989; Canadian Gazette 1996; Equivalent Standards 1995; AIRSS 1996). The changes were designed to reduce the risk of structural damage in ships which could lead to the release of pollution into the environment, yet provide the necessary flexibility to ship-owners by making use of actual ice conditions, as seen by the Master to determine transit.

The Arctic Ice Regime Shipping System (AIRSS) is based on a simple arithmetic calculation which produces an "Ice Numeral" that combines the ice regime and the vessel's ability to navigate safely through that ice regime. The "Ice Regime" is a region of generally consistent ice conditions. The Ice Numeral (IN) is based on the quantity of hazardous ice with respect to the ASPPR classification of the vessel. The Ice Numeral is calculated from

$$IN = [C_a \, x \, IM_a] \quad + \quad [C_b \, x \, IM_b] \quad + ... \qquad [1]$$

where IN is the Ice Numeral, C_a is the concentration in tenths of ice type "a", and IM_a is the Ice Multiplier for ice type "a" and Ship Category (ASPPR 1989; Timco and Johnston, 2003). The term on the right hand side of the equation (a, b, c, etc.) is repeated for as many ice types as may be present, including open water. The ice types are based on the World Meteorological Organization classifications. The values of the Ice Multipliers reflect the capability of the vessel class to operate in different ice conditions without damage. The multipliers are adjusted to take into account the decay or ridging of the ice. The Ice Numeral is therefore unique to the particular ice regime and ship operating within its boundaries.

The vessel class is defined in terms of vessels designed to operate in severe ice conditions for both transit and icebreaking (Canadian Arctic Class - CAC) as well as vessels designed to operate in more moderate first-year ice conditions (Type Ships). In this system, the vessel classes, in descending order of ice capability are Canadian Arctic Class: CAC1, CAC2, CAC3, CAC4 and Type Ships: A, B, C, D, E.

The Ice Regime System determines whether or not a given vessel should proceed through that particular ice regime. If the Ice Numeral is negative, the ship is not allowed to proceed. However, if the Ice Numeral is zero or positive, the ship is allowed to proceed into the ice regime. Responsibility to plan the route, identify the ice, and carry out this numeric calculation rests with a qualified Ice Navigator (ASPPR, 1989) who could be the Master or Officer of the Watch. Due care and attention of the mariner, including avoidance of hazards, is vital to the successful application of the Ice Regime System. Authority by the Regulator (Pollution Prevention Officer) to direct ships in danger, or during an emergency, remains unchanged.

Transport Canada funded the NRC-CHC to perform a considerable amount of research to investigate the scientific veracity of the Ice Regime System using a seven Task approach (Timco et al. 1997). Based on the research results and discussions with Stakeholders, a Discussion Paper was produced (Timco and Kubat 2002). This led to a Workshop of Stakeholders in Montreal in 2003 with the final outcome of a suggested modified Ice Regime System that better fit the empirical data (Timco et al. 2004).

FOUR ICE REGIME OPTIONS

The inadequacies of the Zone-Date System and the existing Ice Regime System combined with the new changes in international harmonization of Polar Class vessels indicate that changes to the Shipping Regulations for Canada's Arctic are required. However, the best approach to do this is not clear. The Regulations would have to have the following features:

- Have a strong scientific basis (i.e. not be based on *ad hoc* approach).
- Allow the operators sufficient opportunity to operate safely in the Arctic.
- Facilitate a means for operators to manage risk in a systematic way.

- Develop a quantifiable system that will allow improvements and innovation in rule making.
- Include the new IACS Polar Class vessels.

Based on these criteria, Timco and Kubat (2007a, 2007b) and Kubat et al. (2008) presented four different potential approaches: Modified Ice Regime System, Regimes Ice Chart System, Hybrid System, and the Arctic Certificate System. A consultation meeting was held in Montreal with all key Stakeholders to decide the general approach to take for the revision. It was decided that the Hybrid System, and perhaps the Arctic Certificate System, is the best path forward (Kubat and Timco, 2008).

The Hybrid System approach would make use of both the Zone-Date System and the (Modified) Ice Regime System in a direct manner. In this case, the existing Zones and Dates would be re-evaluated and updated based on the historical data from the last twenty years or so. This would provide a framework for allowable entries into the zones.

THE HYBRID SYSTEM

The NRC-CHC conducted a very thorough analysis of the ice conditions in Canada's Arctic and used this analysis to develop the Hybrid System. The NRC-CHC approach tried to ensure that the system was relatively simple to understand and apply, yet based on strong science. As a starting point, they developed the system and applied it to a Type B vessel. This type of vessel was chosen since most present day Arctic operators use Type B vessels and so they are familiar with them and their operating range. (This vessel class normally corresponds to a Baltic 1A vessel).

It is important that the best available information was used to develop this system. The authors considered various approaches but felt that making use of the Ice Charts supplied by the Canadian Ice Service (CIS) was clearly the best choice. The CIS have archived information on the ice conditions in the Arctic for a considerable length of time and this information forms the background for the analysis. The information is supplied for different geographic regions and represents the integration of information interpreted from satellite imagery, as well as on-ice observations. The conditions are summarized in terms of Egg Codes based on the WMO ice types (see e.g. MANICE 2005). This system is used internationally by all ice service organizations. The Ice Chart is subdivided into regions of more-or-less consistent ice conditions (or ice regimes). Each of these regions has a unique Egg Code associated with it. It is possible to use the ice information and the Ice regime system to define the regions where the vessel would be allowed and restricted for each Ice Chart (i.e. each geographic region and date). Since there is considerable variation in the ice conditions from year-to-year, this must be included in the analysis. This was done by overlapping the Ice Charts throughout the year for all regions of the Arctic for the past 25 years. This method integrates all of the information from the Ice Charts in a coherent manner. The approach, which was developed by one of the authors (AC), is described in Timco et al. (2009).

The analysis showed that the existing zone boundaries of the ZDS were actually quite representative of the ice conditions in the Arctic. However there were a few proposed changes. The main change was related to the western section of the Canadian Arctic in the Beaufort Sea region. Here it was found that the ice conditions could, in some years, become relatively severe if

the polar pack moved down into this region. Thus, this necessitated proposed changes to the boundaries in this region. Figure 1 shows a map with the existing ZDS boundaries and the new proposed boundaries for the Hybrid System outlined in Red. Zone 4 was the principal zone affected by this analysis but changing its boundaries also influenced Zones 1 and 12.
The NRC-CHC Ice Chart analysis was applied for all zones to determine the severity of the ice for each vessel class throughout the year. One method for showing the results is to present the percentage of the positive Ice Numerals versus the time-of-year for the vessel class. Figure 2 shows this plot for all zones for a Type B vessel. This plot, although it appears to be complicated, contains a wealth of information. It shows the percentage of positive regions in each zone throughout the year. For example, for Zone 1, the percentage of positive numerals is quite low throughout the year for a Type B vessel. This would be expected since the Type B vessels are not designed for multi-year ice and Zone 1 has a high coverage of this type of ice. On the other hand, the analysis shows that Zone 16 has virtually all positive numerals from about Week 30 to about Week 48.

Based on this type of analysis, the results can be used to generate the dates for vessel operations in each of the zones in the Arctic. In the Hybrid System, the dates for operation are based on two different types of definitions:

> Open Dates (OD) – Historically, when ice conditions were shown to be very light in a zone, vessels could operate without any formal reporting or record keeping of the ice conditions. Operation was controlled by due care and diligence of the Master.
>
> Modified Ice Regime System Mandatory Dates (MIRSMD) – When ice conditions were historically shown to be more severe, the modified ice regime system must be used to determine the allowable regions of navigation for the vessel. Of course due care and diligence of the Master was still required. In this case, the NRC-CHC proposed that Mariners would not have to seek approval from the NORDREG office for operating in this region. However, they would have to keep records of the ice conditions and the calculated Ice Numerals. The ability of an Operator to operate outside of either of these date regions would still be possible by using the Ice Regime System and the approval of the NORDREG office.

Using these definitions, the regions for a vessel can be proposed by using the analysis results from Figure 2 for a Type B vessel. Figure 3 shows the results of this analysis for a Type B vessel. It shows the proposed operational dates for all zones for a Type B vessel.

It should be borne in mind that this Hybrid approach and the proposed dates and zones are not official Transport Canada proposals. This was a system proposed by the NRC-CHC. Nevertheless, Transport Canada and the Canadian Hydraulics Centre were interested in receiving feedback from stakeholders of the Arctic regulations on this proposed system. This was actively pursued using four different approaches discussed below:

1. Distribution of the Report - The NRC-CHC printed and distributed 130 copies of the report describing the Hybrid System (Timco et al., 2009a). Also, about 100 copies of the electronic report were distributed through email. The report was also available on the NRC-CHC website (www.chc.nrc.ca) in the section on CRT papers and reports.

2. Formal Presentations - Presentations were made at the CMAC-Northern meetings in both Quebec City and Yellowknife. Scientific papers were presented at four international cold regions conferences (Kubat and Timco, 2008; Kubat et al., 2008; Timco et al., 2009b; Timco et al., 2009c).
3. Individual Consultations - A series of individual meetings were held between the NRC-CHC and a number of stakeholders. Also, feedback was supplied directly to the NRC-CHC through several written comments submitted to them.
4. Consultation Meeting - A consultation meeting was held in Montreal on March 10, 2010 to discuss direct feedback on the Hybrid System. The meeting was chaired by Victor Santos-Pedro of Transport Canada and was structured to allow ample time for participants input. There were seven formal presentations made at the meeting.

The NRC-CHC wrote a summary report that documents all of the comments and the results of this consultation process (Timco and Kubat, 2010). The results are too lengthy to report here and the interested reader is asked to consult the mentioned document. Basically, it was concluded that there was very good interest in this approach but there was a wide variation in opinion on several aspects. There was not a strong desire to change the zone boundaries except for the Zone 4-1-12 region discussed above. Further, clarification was needed on the reporting mechanism in terms of the frequency and amount of information required. Finally it was noted that although there was initial resistance to the Ice Regime System, most active shippers in the Canadian Arctic now use this approach on a very regular basis.

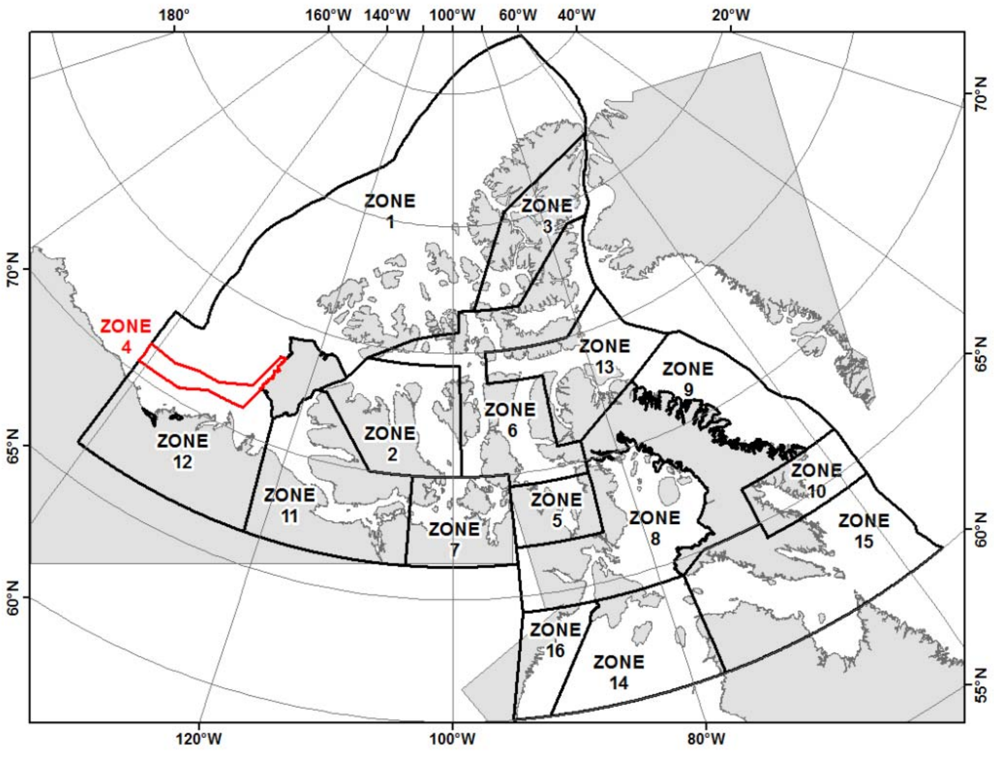

Figure 1: Map showing the existing boundaries of the Zone-Date System including the proposed changes in the Hybrid System for Zone 4.

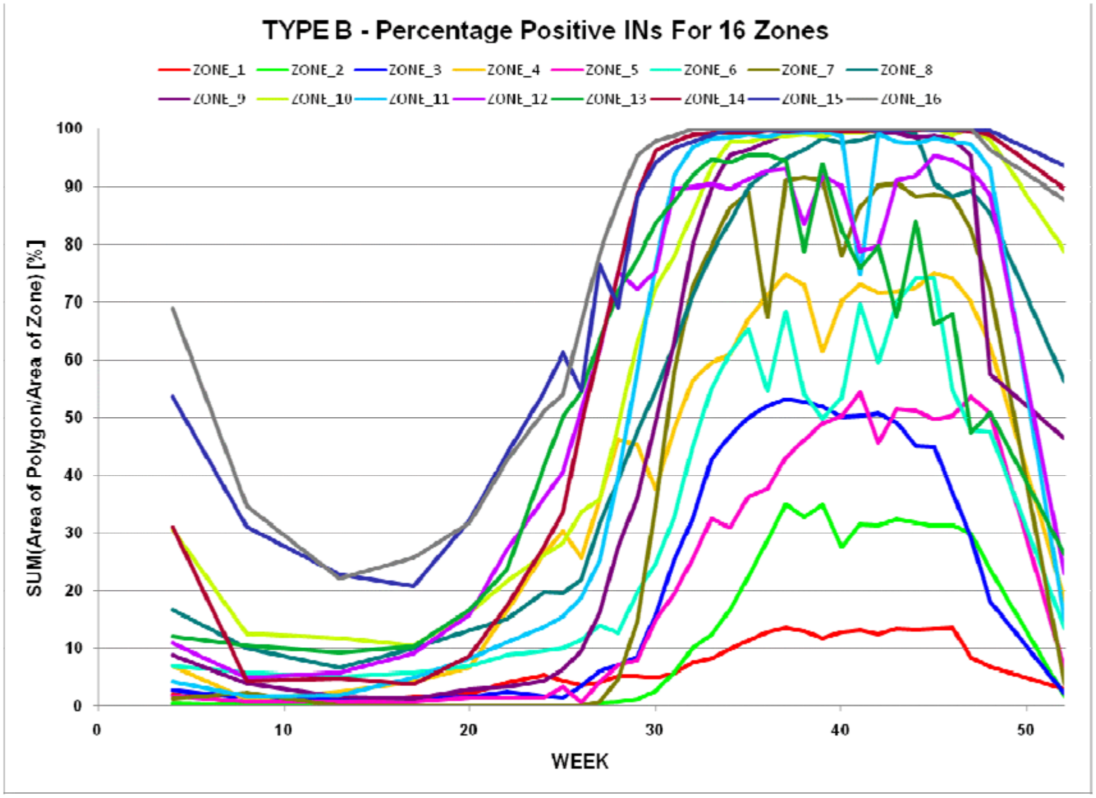

Figure 2: Plot showing the percentage of positive Ice Numerals as a function of date throughout the year for all 16 zones for a Type B vessel.

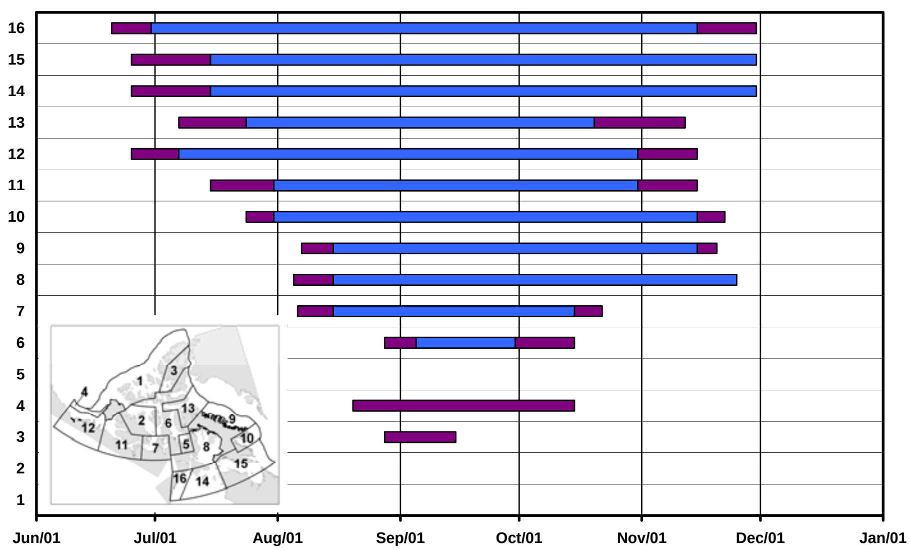

Figure 3: Operating Dates for a Type B vessel in the proposed Hybrid System. Here the maroon regions relate to the dates where use of the Modified Ice Regime System would be mandatory. The blue bars refer to the Open Dates where operation is allowed without any formal approval or record keeping. In all cases, due care and diligence of the mariner would, of course, be in effect.

THE POLAR CLASS VESSELS

The International Association of Classification Societies (IACS) has recently agreed to harmonize their classifications for Arctic vessels and have developed standards for seven Polar Classes (Kendrick 1999; IMO 2002; Santos Pedro 2003: IACS 2007). These are not taken into account in the current Canadian Regulations. The analysis described above and developed for the Type B vessels can be extended to the PC vessels. To do this, the Ice Multipliers for the PC vessels must be used. Although these have not been finalized or approved by Transport Canada, the authors used the Ice Multipliers suggested by Kendrick (2010). Table 1 presents these values for the Type E, B and A vessels as well as the PC7,6,5,4 and 3 vessels.

Table 1: Ice Multipliers suggested by Kendrick (2010)

Ice Types	Ice Multipliers for each Vessel Category							
	Type E	Type B	PC7	Type A	PC6	PC5	PC4	PC3
Old / Multi-Year Ice	-4	-4	-4	-4	-4	-4	-2	-1
Second-Year Ice	-4	-4	-3	-3	-2	-2	-1	1
Thick First-Year Ice	-3	-2	-1	-1	0	1	2	2
Medium First-Year Ice	-2	-1	0	1	1	2	2	2
Thin First-Year Ice - 2nd Stage	-1	1	2	2	2	2	2	2
Thin First-Year Ice - 1st Stage	-1	1	2	2	2	2	2	2
Grey-White Ice	-1	1	2	2	2	2	2	2
Grey Ice	1	2	2	2	2	2	2	2
Open Water	2	2	2	2	2	2	2	2

The NRC-CHC is currently applying the results of the Ice Chart analysis with these proposed Ice Multipliers to develop similar curves to Figure 2 and Figure 3 for each of the Polar Class vessels. The results of this analysis are available in a NRC-CHC report (Timco et al., 2011).

SUMMARY AND CONCLUSIONS

This paper has briefly outlined the procedure being developed to include the Polar Class vessels into the Canadian Arctic shipping regulations. The information from this analysis will be provided to Transport Canada for use in developing updated regulations which include the PC vessel classes.

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REFERENCES

AIRSS 1996. Arctic Ice Regime Shipping System (AIRSS) Standards, Transport Canada, June 1996, TP 12259E, Ottawa. Ont., Canada.

ASPPR, 1989. Proposals for the Revision of the Arctic Shipping Pollution Prevention Regulations. Transport Canada Report TP 9981, Ottawa. Ont., Canada.

Canadian Gazette, 1996. Regulations Amending the Arctic Shipping Pollution Prevention Regulations. p 1729, Ottawa, Ont., Canada.

Equivalent Standards for the Construction of the Arctic Class Ships, 1995. Transport Canada Report TP-12260, Ottawa, Ont., Canada.

IMO MSC/MEPC Circular on Guidelines for Ships Operating in Arctic Ice Covered Waters. 2002. *in* Annex 10 of the forty-fifth session of the Sub-Committee (DE 45/27) - reference Chapter 11 of the Circular. Draft Guidelines submitted to MSC76, December 2002.

IACS 2007. International Association of Classification Societies Requirements Concerning POLAR CLASS, Jan. 2007.

Kendrick, A. 2010. AIRSS Ice Numerals for Polar Class Ships. BMT Fleet Technology Report 6722.FR, Kanata, Ont., Canada.

Kendrick, A., 2005. Integration of Polar Classes and Arctic Ice Regime Shipping System. BMT Fleet Technology Report 8319C.FR, Kanata, Ont., Canada.

Kendrick, A. 1999. The Harmonization of Polar Shipping Requirements. Marine Technology, Vol. 36, no 4, pp. 232-237

Kubat, I. and G.W. Timco. 2008. Ice Regimes Options for the ASPPR: The Way Forward. Proceedings Arctic Shipping North American Conference, Lloyds List Events Conference, Montreal, PQ, Canada.

Kubat, I., Timco, G.W. and A. Collins, 2008. Examination of Shipping Regulations in the Canadian Arctic – Time for Revisions. Proceedings ICETECH’08, paper ICETECH08-138-RF, Banff, AB, Canada.

Kubat, I., Collins, A., Gorman, B. and Timco, G. 2006. Impact of Climate Change on Arctic Shipping: Vessel Damage and Regulations. NRC Report CHC-TR-038, Ottawa, Ont., Canada.

Kubat, I., Collins, A., Gorman, B. and Timco, G.W. 2005. A Methodology to Evaluate Canada’s Arctic Shipping Regulations. Proceedings 18th International Conference on Port and Ocean Engineering under Arctic Conditions, POAC’05. Vol. 2, pp 693-703, Potsdam, NY, USA.

Kubat, I., Gorman, B., Collins, A. and Timco, G.W 2007. Climate Change Impact on Canadian Northern Shipping Regulations. Marine Technology, Vol. 44, No. 4, pp 245-253.

Santos-Pedro, V.M. 2003. Ice-Covered Waters Navigation: The Regulatory Regime. Transport Canada Report TP14057, Ottawa, ON, Canada.

MANICE, 2005. Manual of Standard Procedures for Observing and Reporting Ice Conditions, Ninth Edition, Canadian Ice Service, Ottawa, On, Canada.

Timco, G.W., Collins, A. and Kubat, I. 2009a. Proposed ASPPR Hybrid System for Type B Vessels. Report CHC-TR-063, Ottawa, Ont., Canada.

Timco, G.W., Collins, A. and Kubat, I. 2009b. The Approach for Revising the Canadian Arctic Shipping Regulations. Proceedings 20th International Conference on Port and Ocean Engineering under Arctic Conditions, Paper POAC09-57, Luleå, Sweden.

Timco, G.W., Collins, A. and Kubat, I. 2011. Ice Severity for Polar Class Vessels: Input into the ASPPR Arctic Shipping Regulations. NRC-CHC Report CHC-TR-079, Ottawa, Ont., Canada.

Timco, G.W. and Johnston, M.E. 2003. Arctic Ice Regime Shipping System Pictorial Guide. NRC-CHC Report TP14044E, Ottawa, Ont., Canada.

Timco, G.W. and I. Kubat. 2010. Feedback on the ASPPR Hybrid System for Type B Vessels. NRC Report CHC-TR-071, Ottawa, Ont., Canada.

Timco, G.W. and Kubat, I. 2007. Regulatory Update for Shipping in Canada’s Arctic Waters: Options for an Ice Regime System. NRC Report CHC-TR-045, TC Report TP14732E, Ottawa, Ont., Canada.

Timco, G.W. and Kubat, I. 2002. Scientific Basis for Ice Regime System: Discussion Paper. NRC Report CHC-TR-002, TP13916E, Ottawa, Ont., Canada.

Timco, G.W., Kubat, I. and Collins, A. 2009c. Update on the Ice Regime System: Development of the Hybrid System for Shipping in Canadian Waters. Proceedings 2009 Lloyd’s List Arctic Shipping North America Conference, St. John’s NL, Canada.

Timco, G.W., Kubat, I. and Johnston M. 2004. Scientific Basis for Ice Regime System: Final Report. NRC Report CHC-TR-020, Ottawa, Ont., Canada.

Timco, G.W., Frederking, R.M.W. and Santos-Pedro, V.M. 1997. A Methodology for Developing a Scientific Basis for the Ice Regime System. Proceedings ISOPE’97, Vol. II, pp 498-503, Honolulu, USA.