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Regulating Marine Safety in the Arctic

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This paper reflects the views of the authors and not the official position of the U.S. Coast Guard

ABSTRACT

The Coast Guard has yet to define a regulatory approach for the Arctic. This paper examines those risks, risk mitigation methods are proposed and the Canadian Arctic regulations are examined as a model for the U.S. Through an analysis of the risks, risk mitigation and the Canadian model, a course of action is proposed.

THE CURRENT COAST GUARD REGULATORY PROGRAM

The Coast Guard's regulatory philosophy has evolved in response to various marine disasters. These disasters tended to highlight shortcomings or inadequacies in existing laws and regulations. The most common response to disasters is the imposition of additional or different requirements designed to reduce or limit some aspect of risk brought to light by the disaster.[1] The majority of the regulations currently in effect are of the specific regulation category. This category reflects the "engineered" solution; the use of equipment and machinery design to lower the risk. This is seen throughout Title 46 CFR. The Coast Guard requires specific types of equipment, and has written detailed specifications for certain types of equipment,[2] while other standards are incorporated by reference.

The use of specific regulations as described above has a number of advantages when applied to situations involving established and static technology. In these areas the regulations simplify decision-making by limiting choices of equipment and methods while providing a fixed level of safety and quality. However, if the technology is new or rapidly changing, specific regulations may hamper progress and impede promising technologies. Specific regulations are time-consuming to draft and implement and can readily lag behind new technologies. This can result in two basic problems: (1) the regulation may be applied to a situation for which it was never intended[3] and (2) in the case of Outer Continental Shelf (OCS) activity, the specific regulation may well conflict with the requirement for Best Available Science and Technology (BAST).[4] If BAST differs from the regulation, the onus to prove the new technology provides an equivalent or greater degree of safety is on the user of the technology. The difficulties in proving the technology may be sufficient to discourage the use of new technology.

Offshore Arctic technologies are at the cutting edge of OCS activity. The state of the art of drilling technology is in contrast to the state of Coast Guard regulatory requirements. Advances in Arctic technologies have out-distanced Coast Guard regulatory efforts for several reasons. First, the Arctic represents a small, highly specialized, and extremely localized drilling theater that is overshadowed by areas like the Gulf of Mexico. Second, the technology is new and subject to rapid change. Also, standards for specific regulations have not been developed. Third, such standards may act to stifle development of new and useful technologies. These reasons combine to produce an attitude of wait and see what develops, then take appropriate regulatory steps. To date, specific regulation or policy for vessels operating in the Arctic has not been produced by the Coast Guard. Marine safety is provided by applying existing regulations and allowing the local Officer in Charge, Marine Inspection (OCMI), to impose local requirements on vessels operating in the Arctic. However, the Coast Guard's headquarters staff provides technical direction and support to the OCMI.

The Coast Guard is now at a point were a regulatory approach for the Arctic should be developed. This paper takes a look at what the risks are in the Arctic and the means of mitigating those risks. With an understanding of those risks the Canadian Arctic regulations are examined as a model for the U.S. The Canadians in 1972 adopted a regulatory regime for the Arctic known as the Arctic Shipping Pollution Prevention Regulations which is currently undergoing revision. This model combined with the risk analysis serves as a basis for a recommended U.S. Arctic regulatory policy.

RISK AND RISK MITIGATION

An effective regulatory framework must reflect an understanding of the issues, problems, and limitations imposed by the environment, technology, and fiscal constraints. In terms of regulating marine safety in the Arctic, this means first dealing with the risks, then examining the methods available to mitigate those identified risks. To that end, the following four areas frame the risk aspect of this paper:

1. A definition of risk
2. What's at risk
3. The origin of risk in the Arctic
4. The risks

With the risks identified, risk mitigation techniques will be reviewed.

Defining Risk

For the purpose of this paper, risk is defined as "a compound measure of the probability and magnitude of adverse effects."[5] The key concept in this definition is that risk has two planes: the first, probability, and the second, magnitude of the consequence. A high probability of occurrence may be acceptable if the magnitude of the adverse effect is negligible. Likewise, a low probability of occurrence may not be acceptable if the magnitude of the adverse effect is great. This latter scenario was played out in the case of the S.S. Titanic, when on April 14, 1912, the remote probability of striking an iceberg and sinking occurred. The probability was thought to be so low the Titanic carried lifeboatage for only 1,178.[6] Of the 2,227 on board the Titanic, 1,522 perished as a result of an encounter with ice and someone's miscalculation of risk.

As the Titanic case illustrated, despite low probability of occurrence, disasters of great magnitude occur. Historically, regulatory bodies like the Coast Guard react to such disasters by implementing new safety requirements (mitigaton techniques) to risks exposed by the disaster (risk analysis the hard way).

What's at Risk

The Coast Guard is committed to the preservation of life and property at sea. For this paper, the focus will be on the vessel and not the people on it. However, by ensuring the safety of the vessel, both the crew and the environment can be protected.

Further, only vessels subject to Coast Guard inspection and operating in the Arctic are considered. Additionally, if through prior agreement or arrangement the Coast Guard lacks authority to regulate certain aspects of vessel operations, those portions will not be considered.[7]

The Origin of Risk in the Arctic

The risks being addressed are a function of the Arctic environment. The following present those environmental factors that are both unique to the Arctic and the root cause of the risks addressed.

By understanding how the Arctic differs from other offshore drilling regions, it is possible to identify a set of risks that separate the Arctic from other environments for which marine safety regulations have already been promulgated. These include the following environmental factors:

Ice. This is the most dominant feature of the Arctic. It impacts nearly every aspect of marine operations, and its behavior and characteristics are complex.[8] This analysis considers the diversity of safety issues that could result from ice/vessel and ice/man interactions.

Polar-Climate. Ice is the physical manifestation of the cold which is the most apparent aspect of the Arctic climate. However, other aspects of the polar climate such as wind, darkness, reduced visibility, and upper atmospheric disturbances can have a profound impact on the systems discussed earlier. The climate of the Arctic generates a number of problems that are not readily apparent, yet can have a significant impact on the safety of a crew and vessel.

Remoteness. The physical remoteness of the Arctic from other centers of activity is compounded by the difficulty of access resulting from the first two factors.[9] It is therefore necessary for risk analysis to take proper account of the unique combination of remoteness, ice, and climate found in Arctic waters.

The concept of a vessel "being suitable for its intended service" is at the heart of the Coast Guard's commercial vessel safety program. This concept is also used in risk analysis for Arctic marine operations. If a vessel is to be "suitable" for Arctic service, it must be equal to the hazards encountered and risk analysis helps determine what those hazards are.

The Risks

The risks are expressed in terms of events. This format brings together what's at risk (vessel and personnel) with a set of risk factors "unique" to the Arctic environment. Further, both aspects are subject to magnitude constraints. Magnitude as used here is keyed to the threshold of Coast Guard involvement. If an event results in a reportable marine casualty, then it meets the magnitude criteria. The following describes the risks/events.

Damaging Vessel Ice Encounter. This is an event in which either damage to the vessel or personnel casualties are sufficient to warrant consideration as a reportable marine casualty. Two separate types of ice risks are considered. The first is sea ice and the second is superstructure icing associated with atmospheric conditions. Superstructure icing, albeit uncommon in much of the Arctic,[10] has the capacity to initiate a damaging ice vessel encounter. A 50 mm. (2 inch) ice buildup on a typical rig can add between 200 and 300 tons.[11] This can approach the typical design limit of a vessel. Vessels intended for Arctic use are normally designed to withstand significant icing.

The open water season (August to mid-October), when more vessel activity occurs, is also the time of greatest vulnerability to a polar ice invasion. A summer ice invasion is the shoreward advance of the edge of the "permanent" ice pack in response to wind and current. Large, thick icefloes up to 8.3 km. (5 miles) in diameter and 8 m. (25 feet) thick can be spun off the pack and blown about in the open ocean at speeds up to 2 knots.[12] These multi-year floes are generally composed of stronger (reduced salinity) ice, and may also contain old pressure ridges up to 21 m. (65 feet) thick.[13] Moving at summer velocities, they can be a serious threat to vessels and structures located in deeper waters.

Another ice feature that should be addressed is the ice island. Ice islands are the product of glaciers and are composed of fresh water ice, reflecting their origin. Such ice is both strong and brittle. The size of an ice island and the strength of its ice make mitigatory techniques such as ice management feasible.

A final point of interest in considering vessel-ice encounters is the subject of design and engineering. Sherman Wetmore stated: "The desired goal is designing an Arctic structure to induce ice failure (breaking up or dislocation) before structural failure occurs."[14] However, ice engineering has not yet reached the stage where management can rest assured that the numbers generated will ensure the safety of personnel and environment, yet produce a reasonably cost-effective project. This same thought appeared in a paper delivered at an oil industry conference:[15]

> Management must take part in understanding the limitations of the ice design criteria to help ensure that the design and operational philosophy takes into account the uncertainty of the iceload.

The uncertainty arises in part from the randomness of ice propagation, thickness, and trajectory through a particular location.

Damaging Polar/Climate Vessel Encounter. This is an event that results in a reportable marine casualty that is attributable to Arctic climatic conditions.

The extreme cold of the Arctic has a variety of impacts on vessels that, if not accounted for, can impact the safe operation of the vessel. Steel, if not specifically designed for use in extreme cold, can become brittle and suffer catastrophic loss of strength. Further, as in the case of Canadian Marine Drilling, Ltd.'s vessel, SSDC, extreme cold necessitates the daily movement of heated ballast to reduce the risk of ballast water freezing in the tanks.

The Arctic weather, with conditions such as whiteouts[16] and fog combined with limited aids to navigation, poor LORAN,[17] and questionable navigation charts, results in increased risk of navigational error. Ice, if present, will further complicate the navigational difficulties and risk.

Remoteness-Aggravated Damage/Disaster. This is a situation in which a marine casualty is either precipitated or made worse by the remoteness imposed by Arctic conditions.

Not only do Arctic conditions put heavy loads on vessels that make them more prone to mechanical failure,[18] but should a failure occur that necessitates the assistance of another vessel, be it for repair, resupply, or towing, then remoteness plays a role. Ice, limited use and cost of vessels, prior commitment, and distance all combine to restrict the availability of commercial assistance. This is a major aspect of working in the Arctic: realizing that, due to remoteness, many support services are not readily available, including search and rescue.

RISK MITIGATION

Each of the events presented above have causes (see figure 1) and effects (see figure 2). With these causes and effects it's possible to identify where and what type of regulatory actions would be effective and appropriate.

This approach is similar to an equation where CAUSE = CRITICAL EVENT = EFFECT. The causes can be categorized as one of the following:

1. Human factors
2. Environmental factors
3. Equipment failures
4. Inadequate design

The critical events that derive from the interaction of the above "causes" with one or more of the "unique" Arctic environmental factors can result in one or more of the following effects:

1. Hull failure
2. Mooring system failure
3. Blowout
4. Grounding/stranding

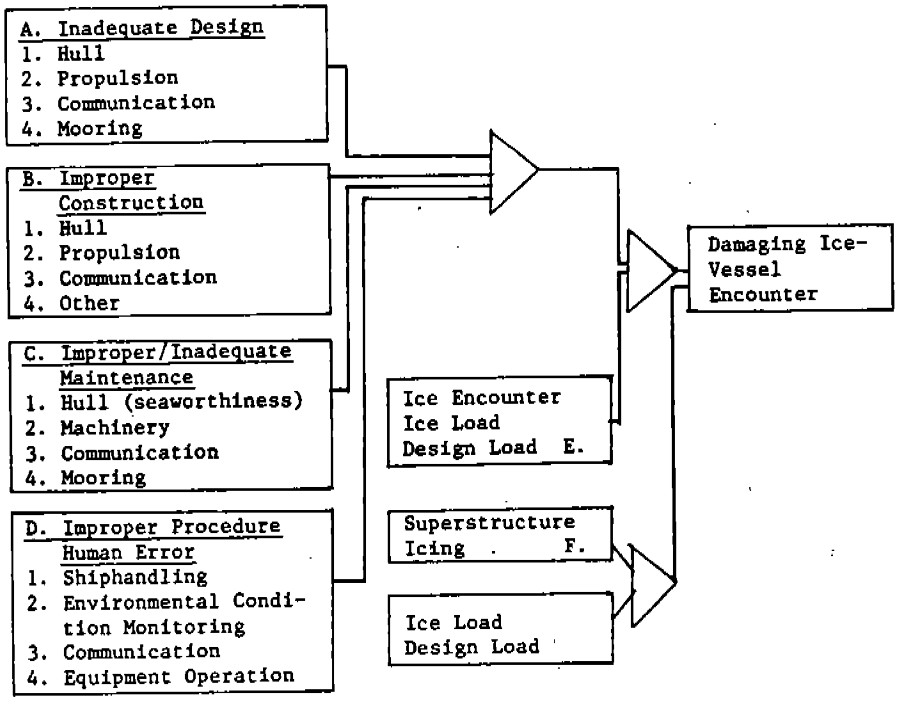

Fig. 1 Fault Tree Analysis
Vessel-Ice Encounter

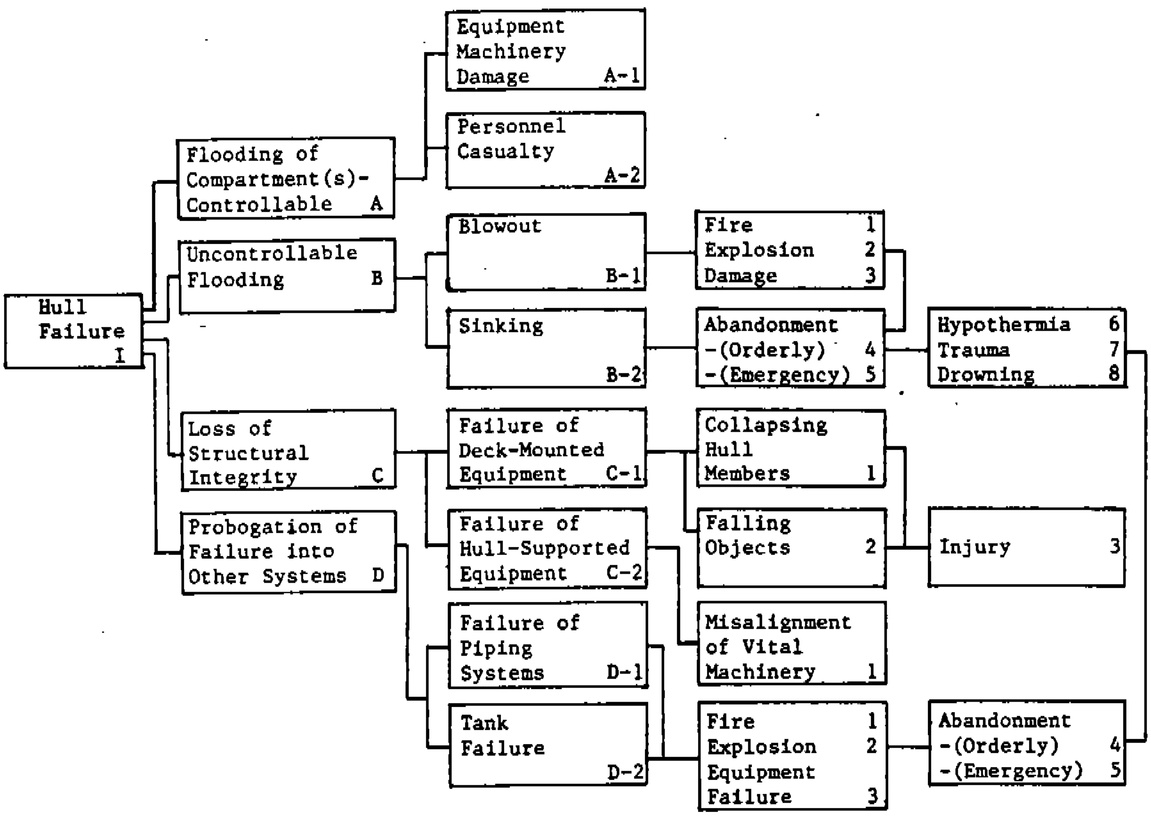

Fig. 2 Event Tree Analysis
Vessel/Ice Encounter--Hull Failure

System	Causal Factor	Consequence	Ultimate Outcome
Vessel	Inadequate design Human error Equipment failure	Hull failure Blowout Navigational failure	Abandonment (see personnel-emergency)
Personnel (Nonemergency)	Inadequate design Human Error	Slick decks Cold exposure Poor morale	Injury
Personnel (Emergency)	Inadequate design Human error Equipment failure	Difficulties during and after abandonment	Casualties

Table I
CAUSE / CONSEQUENCE RELATIONSHIPS

Term	Effectiveness
High	Likely to significantly reduce the potential adverse effects
Moderate	May reduce the potential adverse effects
Low	Unlikely to reduce the potential adverse effects

Table II
VALUES FOR EFFECTIVENESS

Term	Expense
High	Would be considered a major increase in costs to most Arctic operators or government agencies
Moderate	Would be considered a moderate increase in costs to most Arctic operators or government agencies
Low	An insignificant cost to most Arctic operators

Table III
VALUES FOR EXPENSE

5. Hypothermia

These effects, in turn, have other effects or could initiate one or more of the above. It is not difficult to see a blowout causing a hull failure which leads to hypothermia and possibly death. This relationship can be seen in Table I.

With an understanding of the cause and effect relationship associated with the specified risks/events it's possible to identify mitigatory steps and actions. To facilitate the review, mitigation techniques are grouped into the following categories:

1. Policies and procedures
2. Improved personnel procedures
3. Vessel design
4. Administration and enforcement of safety regulations

To simplify the review, Tables II and III present terms used to compare the mitigation techniques as applied to each system.

The following review of mitigation techniques addresses each category of mitigation technique applicable to each area of concern (vessel, personnel emergency/non-emergency).

Vessel

Policies and Procedures. Policies and procedure are moderately to highly effective, at a moderate to low cost. However, for policies to be effective they need to be clear, applicable to the subject they address, understood and accepted by those affected, and current with respect to the operating environment. If a policy or procedure is remiss in any of the above areas, effectiveness can easily become low or even detrimental.

The ice alert procedures developed by Canadian Marine Drilling Ltd. are an example of effective procedure. The document details roles and responsibilities and provides clear, easily understood standards and parameters, yet allows for competent decision-making by personnel charged with making decisions. The ice alert procedures are well understood by the crews and provide a major mitigation effort for operating in the Arctic.

Equipment. Items such as ice detection systems,[19] vessel monitoring systems for iceloads, and evacuation systems (lifeboats and life rafts) are examples of equipment used for risk mitigation. In general, this equipment is moderately effective with moderate to high costs, and primarily reduces initiating risk. Equipment's moderate rating reflects its susceptibility to human error, abuse, misuse, and other factors (such as environment) that tend to reduce its overall effectiveness.

Design. Design can be relatively cheap and effective in risk mitigation, but its cost impacts on construction and operation can also be prohibitively high. The challenge for both the regulator and the designer is to identify an appropriate level of engineered safety; which takes account not only of the available technology and operational requirements, but also of the capabilities and training of the personnel in the system. The acceptable level of risk should be linked to the probable severity of the consequences of accident or failure. For the Arctic, the problems involved in accomplishing this successfully are compounded by our relatively limited understanding of the physical demands which the environment may impose. However, the Canadian Coast Guard in its ongoing revision of the Canadian Arctic Shipping Pollution Prevention Regulations has explicitly recognized the interdependencies by forming parallel government/industry committees. These committees are developing complementary regulations for hull construction and for training and operations in order to strike an effective balance between these two areas.

Summary of Risk Mitigation

The most cost-effective mitigation techniques are policies, procedures, and training. This reflects the high percentages of failure associated with human error. Thus, by reducing the number and magnitude of human-related errors, overall risk can be reduced.

Vessel design, although potentially less cost-effective, provides substantial risk mitigation possibilities. Proper design that reflects the operating environment of the vessel can mitigate many serious as well as annoying problems.

THE CANADIAN MODEL

Background

The first impetus towards the development in Canada of specific regulations for Arctic operations came from the marine transportation industry, and was heavily influenced by the voyages of the *Manhattan*. It appeared that the development of U.S. and (potentially) Canadian hydrocarbon reserves in the high Arctic might lead rapidly into high volumes of commercial transportation, with risks to the ecology of the region and lifestyles of the native peoples. Accordingly, the Arctic Waters Pollution Prevention Act was passed in 1970 and provided the authority under which the Arctic Shipping Pollution Prevention Regulations (CASPPR) in 1972 laid down standards for the structural and mechanical design of all ships intended for operations at various times of the year in the 16 designated shipping safety control zones of the Canadian Arctic. Prior to this the design of Canadian icebreakers, and other ships making seasonal trips into the Arctic, had been largely based on the individual experience and expertise of the naval architects involved.

Although the anticipated trans-Arctic tanker traffic failed to materialize during the subsequent decades, there was an enormous increase in the volume of marine activity, including both ships and off-shore structures. These operate under different regulatory regimes, the ships being controlled by the Canadian Coast Guard (CCG), a branch of the Department of Transport (TC); while the Canadian Oil and Gas Lands Administration (COGLA) under the Department of Energy, Mines and Resources (EMR) has had control over off-shore development. Both departments, together and separately, sponsored a variety of large and small research projects aimed at establishing the knowledge essential to placing the early empirically-based rules onto a more scientific basis. The challenge posed by this objective has been increased by the variety of activities which have been undertaken in the Canadian Arctic. These range from the shallow water drilling in the Beaufort Sea through to subsea completions in the Arctic Archipelago; with community resupply, tourist cruises, bulk cargo shipments from mines, and numerous other operations complicating the picture.

Regulatory Approach

In order to keep this paper to a manageable length, and to highlight topics of particular interest to this forum, attention is focused on the current approach being taken to the revision of the Arctic Shipping Pollution Prevention Regulations. The Canadian Coast Guard formed a government/industry committee in 1985, and subsequently two subcommittees were mandated to look at design and training/operational issues respectively. Several members were common to all of these bodies, maintaining close liaison between them.

The design subcommittee members all shared the basic belief that all aspects of Arctic navigation are interrelated, and that no aspect could be treated in isolation from the others.[20] This principle is often accepted implicitly, but its consequences have rarely been addressed explicitly in the development of standards or regulations. In the CASPPR subcommittee, it was understood that the approach to structural regulation has to be set within a framework of training control, the provision of environmental information, and operator access, in order to provide an acceptably low level of risk without imposing undue economic burdens on ship-owners and their clients.

The key features of CASPPR include geographic access, structural design and monitoring, which are addressed in detail below.

Geographic Access

A very wide range of ice and weather conditions are found in the Arctic in different areas and at different times of the year. The weather can change with great rapidity. Ice, on the other hand, does not; though pressure fields can build or dissipate depending on the weather. It therefore seems possible in principle to regulate access by any ship to any part of the Arctic based on whether the ice present along its route is likely to consitute an unacceptable hazard to its structural integrity during the period of its voyage.

Several considerations are critical to the success of an approach such as this. First is the availability on a regular and timely basis of accurate ice data. This can now be provided by Environment Canada using technologies such as synthetic aperture radar (SAR), which can provide amazingly detailed information from aircraft overflights. This information can be provided to CCG and downloaded to the ships themselves, allowing both access control and accurate route planning. A second vital factor is that a finite (and relatively small) set of ice parameters have to be shown to correlate well to damage risk. Thirdly, ice "regimes" representing a given risk level have to extend over significant geographical areas. If none of these criteria are met, any access system would be unacceptably complex. However, considerable effort has been devoted to establishing that an effective system can be established; and that it will both reduce the damage risk and greatly increase the flexibility associated with the existing calendar date based access system used in the Canadian Arctic.[21]

Structural Design and Monitoring

The ice loads which a ship sees will depend on the types of ice it encounters and on the way in which it is operated. In certain conditions, some ships will be unsafe at any speed and should be denied access; others would be safe if operated with due caution, the inculcation of which into mariners is an objective of the training subcommittee's work. However, it was also agreed that unless a ship is designed to the highest strength class available under the revised CASPPR, it should be fitted with a hull stress monitoring system. This will assist its master in assessing his level of risk during operations such as ramming ridges and/or multi-year ice.

The 1972 CASPPR identified nine classes of Arctic shipping ranging from 1 (lowest) to 10 (highest) with some gaps. Implicitly, these were related to the requirements to break through various thicknesses (in feet) of level ice. This was not only because Canada has gone metric in the interim! As far as structural risk is concerned, it is now recognized that there are only four basic types of ice; one of which, glacial ice, should generally be avoided. Various gradations of thickness and strength within first year ice up to 1 meter (3 feet) thick are covered by the Finnish/Swedish regulations, which have controlled Baltic shipping acceptably for many years and are the basis for many Classification Societies' ice strengthening rules. The requirement for CASPPR is therefore to select strength standards for thick first year ice, second year ice, and multi-year ice that allow both transit and ice management operations (see Table IV). While transit can and should involve considerable caution, ice management can require the aggressive ramming of large ice features, for example to protect an offshore installation. Much of the data used in deriving both the loads and the strength requirements for the revised regulations is drawn from the Beaufort Sea icebreakers, which have now amassed many years of experience in just such operations.

It is not the intention of this paper to provide any details of either the loads or the strength requirements proposed by the CASPPR subcommittee; these have been described in some detail in various papers presented at SNAME's Ice Tech '90 in Calgary. However, a number of points are worth emphasizing. As noted earlier, strength is only one component of a situation which includes personnel knowledge and capabilities, the provision of appropriate environmental and ship response data, and an understanding of the extent to which other existing rules, regulations, criteria, etc. can be utilized and/or require to be supplemented. Within the structural regulations themselves, an equally integrated approach has been followed. The way in which loads have been derived is linked to the way in which structural strength is established, and material requirements are specified to provide ductile behavior under the temperatures and load rates characteristic of the operating scenarios (see Table V). This, together with the requirements for certain standards of subdivision, provides additional margins against catastrophe.

CASPPR AS A MODEL FOR THE U.S. ARCTIC

The draft revision of the Canadian regulatory model links design criteria to specific ice conditions. Additionally, the proposed changes to CASPPR would incorporate human factors into the regulatory process. This approach to regulation has a number of advantages including:

1. I tspecifies what construction standards are applicable to a vessel based on recognized ice conditions. These conditions are in turn based on real world experience in both the Baltic Sea and the Arctic. Hence, the standards to be adopted reflect current standards versus some new or radically different standard.
2. By working within the constraints of the revised categories recognized by the draft CASPPR, both the design and the review of that design should be quicker and easier.
3. Enforcement action would be able to focus on the operator as well as the designer. The revisions to CASPPR more clearly place responsibility on both the corporate operator (operating procedures) and the master for proper operation of the vessel. Not unlike loadline regulations that combine season and geography to limit draft among other things, CASPPR provides the regulatory body similar ease in determining if the vessel is operating within certain design criteria.
4. Since the implementation of CASPPR the regulations have succeeded in their intended purpose. The revisions are an evolutionary process and can be expected to yield continued improvements.

As with any complete set of regulations, there are disadvantages. This is especially true when the regulations are viewed from a perspective different from those who framed the original. In this case Canadian rules are being examined from the perspective of a U.S. regulatory body whose agenda is driven by different forces. Before delineating the disadvantages, it may be helpful to point out differences that separate the U.S. and Canadian view of Arctic affairs. It is in part these differences that shape the recommendations. The significance and value placed on Arctic issues determines the level of attention paid by the political establishment, the resources made available to resolving problems, and the priority of those issues. Some of the differing factors that bear on the recommendations include:

1. The Canadian Arctic is a predominant feature of the Canadian geography, much of which is an archipelago that is rich in geographical and climatic diversity. This contrasts the U.S. whose Arctic holdings are by comparison small, geographically simple (a straightforward coastline vs. an archipelago), and not viewed as a significant part of the nation.
2. Resource development in the Canadian Arctic is far more dependent on marine transportation than in the U.S. Arctic. This fact has been demonstrated both by past activities and also in the serious proposals to construct icebreaking LNG carriers and tankers to carry crude which have been put forward and reviewed.[22]
3. The political visibility and perceived importance of the Arctic is a key factor in driving the development of design standards. In Canada, the Arctic is politically visible and important enough to drive Arctic-related legislation through to adop-

CATEGORY	LIMITING ICE TYPE	NAVIGATION LIMITATION	PRINCIPAL FUNCTION	GENERAL MODE OF OPERATION ENVISAGED
CAC1	MULTI-YEAR	NONE	ICEBREAKER	In M/Y ice proceeds continuously or by ramming to owner's requirements.
CAC2	MULTI-YEAR	NONE	TRANSIT	Takes easiest route. Proceeds in M/Y ice continuously or by ramming to owner's requirements. May be an icebreaker of lesser capability than CAC1.
CAC3	SECOND YEAR	BY ICE REGIMES	TRANSIT	Takes easiest route permitted under ice regime system. Unrestricted in second year ice. Avoids M/Y ice. When not possible proceeds by controlled ramming. May be an icebreaker with capability limited by category and structural strength. Escorts ships of lesser category.
CAC4	ALL FIRST YEAR	BY ICE REGIMES	TRANSIT	Takes easiest route permitted under ice regime system. Unrestricted in first year ice including F/Y ridges. Avoids M/Y ice. When not possible proceeds by cautious ramming or by pushing. May be an icebreaker with capability limited by category and structural strength. Escorts ships of lesser category.

TABLE IV
SHIP CATEGORIZATION
ARCTIC CLASSES

ITEM	STURCTURAL MEMBER INCLUDING ANY ATTACHED STRUCTURE FOR A DEPTH OF 740 mm	STEEL GRADES FROM 0.2L AFT TO 0.3L FORWARD OF MIDSHIPS	FROM 0.2L AFT TO 0.3L FORWARD OF MIDSHIPS	OUTSIDE 0.2L AFT TO 0.3L FORWARD OF MIDSHIPS	OUTSIDE 0.2L AFT TO 0.3L FORWARD OF MIDSHIPS
	THICKNESS-------->	<=25.5 mm	>25.5 mm	<=25.5 mm	>25.5 mm
1	Sheerstrake at strength deck	E	F	DH	E
2	Strength deck plating exposed or in unheated deckhouses	E	EH	DH	E
3	Strength deck plating in heated deckhouses	B	B	B	B
4	Side shell plating from lower edge sheerstrake to waterline at half the lightest operating draft	E	E	E	E
5	Remainder of side shell to flat of bottom	DH	DH	DH	DH
6	Flat of bottom and keel	B	B	B	B
7	Exposed non-strength deck plating	B	B	B	B
8	Continuous longitudinal members above strength deck	E	EH	DH	E
9	Upper strake of longitudinal bulkhead at strength deck	E	E	DH	E
10	Upper strake of top wing tank longitudinal bulkhead	E	E	DH	E
11	Lower strake of longitudinal bulkhead at bottom shell	DH	DH	DH	DH
12	Sternframes, rudder horns, rudders, ice horns, shaft brackets, bossings	-	-	DH	DH

TABLE V
MIMIMUM STEEL GRADES FOR STRUCTURAL MEMBERS OF ARCTIC CLASS SHIPS

tion. In the U.S., awareness of the Arctic is now being focused by the debate over whether the Arctic National Wildlife Refuge (ANWR) should be open to exploratory drilling. Regardless of the attention, it is not likely the outcome will impact the development of design standards for vessels operating in the Arctic. However, the increased interest in the Chukchi Sea could spur development standards on par with Canada if commercial quantities of hydrocarbons are found[23] or a disaster occurs a la Exxon Valdez.

In light of these and other considerations, the broad nature of the draft revision of CASPPR would require either statutory or regulatory initiatives that are not supported by the current political climate in the U.S. However, many portions of CASPPR could serve as a basis for a NVC or another regulatory approach including:

1. Hull Requirements: As discussed earlier, CASPPR represents a workable set of standards for evaluating the adequacy of the hull and its appurtenances.
2. Machinery: The machinery provisions, like the hull requirements, would serve well as a basis for U.S. Arctic requirements.
3. Operational Procedures: Review of these procedures allows the operator flexibility in how the vessel operates and provides the regulatory body a means to set standards within flexible guidelines.
4. Navigation Equipment: The basic navigation equipment in CASPPR is already addressed in current U.S. regulations. However, from CASPPR the U.S. should include the requirement for communication equipment to facilitate the transmission of weather and ice information.
5. Radiotelephone: The requirement for a fully operational radiotelephone located at the conning position.
6. Ice Navigator: Although this position could represent some administrative difficulty in implementing, the concept is important enough to justify the effort to adopt this position.
7. Fuel and Water: The 120 day minimum requirement for fuel and water provides designers and the USCG with a standard that provides flexibility as to how it is attained while assuring a specified level of safety.

RECOMMENDED MODEL FOR REGULATING MARINE SAFETY IN THE ARCTIC

The complexity of work in the Arctic has been well established. Likewise, regulating marine safety in the Arctic will reflect the complexity of the work. As with most complex issues, a single answer or approach does not always produce the results that are sought.

Implicit in the analysis of risk and risk mitigation is the interaction of people with an engineered structure or system. If the goal is to improve safety in the Arctic and protect the environment, a regulatory program can focus on: (1) the vessel, (2) human factors, or (3) a combination. The original approach of CASPPR was heavily focused on design standards. The current work on CASPPR is broadening its scope to incorporate more of the human factors while making qualitative improvements in the design standards and eliminating the objectionable geographic/seasonal limitations.

The proposed revision to CASPPR provides a workable model for the U.S. The holistic approach embodied in the proposed revision of CASPPR recognizes that improved safety comes from the interaction of trained and qualified personnel with properly designed and constructed equipment. Additionally, any U.S. regulatory scheme should embrace a degree of flexibility. This flexibility recognizes the understanding that operations in the Arctic are very much dependent on the vessel's intended service, and that the rapidly evolving technology requires a regulatory approach with a degree of flexibility. The flexibility needed would start by using the NVC as the initial vehicle to spell out the policy. A NVC does not have the force of law or regulation. However, when flexibility is needed, laws and regulations are not always the best tools. A NVC could be drafted to reflect the appropriate aspects of the CASPPR model discussed earlier. The NVC is a short to medium term fix. Such a document would provide designers, builders, operators and the Coast Guard inspector with a uniform set of standards to use. If and when that elusive elephant field is found in the Arctic, then the Coast Guard will probably have the incentive to pursue the long term regulatory "solution," which like the NVC should reflect the influence of the proposed revision of CASPPR.

REFERENCES AND FOOTNOTES

1. Such as the S.S. Titanic and the need for adequate lifeboatage, and with the Ocean Ranger, recognition that survival suits could have significantly reduced the number of casualties.

2. Subchapter Q, Title 46 CFR, specifies design criteria for certain lifesaving and firefighting equipment.

3. An example is Title 46 CFR I, which specifies equipment and supplies for lifeboats and life rafts. How ever, the supplies required are not usable in the Arctic.

4. Outer Continental Shelf Lands Act amendments require the use of BAST on systems covered by the law.

5. W. Lowrance, Of Acceptable Risk, William Kaufman, Inc., 1976.

6. National Geographic, Vol. 170, No. 6, December 1986.

7. In the case of MODU's, the Coast Guard and Minerals Management Service (MMS) have entered into a Memorandum of Understanding, dated 18 December 1980, which states MMS regulates "mineral exploration, drilling, and production activities," while the Coast Guard regulates "to promote the safety of life and property on OCS facilities and vessels engaged in OCS activities." This means on MODU's the MMS regulates those operations and equipment directly concerned with the drilling for and production of hydrocarbons; with respect to such equipment and operations the Coast Guard lacks authority to act.

8. The complexity of ice is seen in the Alaska Oil and Gas Association's (AOGA) publication, Ice Engineering Nomenclature, which has five pages of ice-related terms. Additionally, the Canadian Marine Drilling, Ltd. publication Ice Alert Procedures, 1984 has 18 pages describing ice, ice symbology and ice definitions.

9. The two largest and most powerful U.S. ice breakers (the Polar Star and Polar Sea) would in all probability not be effective in the U.S. Beaufort Sea in the dead of winter (from Captain W. Moncreif, Commanding Officer, CGC Polar Sea on 22 January 1987).

10. Icing is more common in the subarctic (Navarin Basin, Norwegian Sea, etc.).

11. Joseph T. Lonsdale and Thomas Norby, "Electric Heat Tracing Designed to Prevent Icing," Offshore, November 1985: 25.

12. Sherman B. Wetmore, "Arctic Offshore Drilling: A New Challenge," Offshore, November 1985: 144.

13. Ibid. Undocumented reports indicate ice floes 26 m. (80 feet) in depth.

14. Wetmore, Op. cit., 146.

15. David G. Stenning and John Smith, "Project Management of Beaufort Sea Development, the Unique Challenge," Proceedings of the Arctic Offshore Technology Conference and Exposition, October 28-31, 1986, Calgary, Alberta, Canada.

16. Intense wind-driven snowstorms during which visibility is reduced to feet.

17. LORAN, Long Range Aid to Navigation, is a worldwide navigational system operated by the U.S. Coast Guard.

18. Ice-related damage to rudders, propellers, shafting, and the hull result from direct contact with the ice, while ice-vessel induced vibrations can impact many other systems, from electronics to internal hull strength members.

19. Using equipment such as Side Looking Airborne Radar (SLAR), computer, shipboard radar, etc., ice movement can be plotted and ice threats assessed.

20. J. McCallum, "Overview and Summary of the Proposed Revisions to CASPPR, SNAME Ice Tech '90, Calgary.

21. D. Lapp, M. Lowings, and M. Luce, "A Revised Navigation Control System for CASPPR Based on Ice Regimes," SNAME Ice Tech '90, Calgary.

22. The Arctic Pilot Project would transport liquified natural gas from the Drake Point gas field on Melville Isl. to southern markets via two LNG tankers. Dome Petroleum (now Amoco-Canada) planned to transport Beaufort Sea crude to market utilizing Arctic Class 10 tankers. APOA Review, Marine Transportation of Oil and Natural Gas, Spring/Summer 1983, Alberta, Canada.

Walter Maclean

It seems to me that what you've done is opened up the system quite tremendously, but I see placing this responsibility on management and on the ship's staffing is a very large change. The question in my mind is in what way are you going to act to see that these people implement proper management systems and have trained personnel?

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The training of the personnel and implementation is difficult. To fully implement these, we're possibly going to need statutory changes, definitively regulatory changes. However, the Coast Guard is trying to recognize these other aspects in terms of regulating. To implement with licensing, that's where it would be, licensing that said that you have to have so much experience in the ice, so many trips, and we've also, with respect to licensing, have the ability to provide tradeoffs. If you take this course instead of having to make 20 trips through an ice condition you can do it with 15, that provides the incentive to get education. Or we can actually require that you take mandatory courses which are reviewed and approved by the Coast Guard. This is a system we already have in place.

We already approve, on the offshore industry, the operations manuals. We go through the operations manuals; the difficulty is and will always be ascertaining how well the crew has been informed in this. One approach to take is something that we have - it's enforcement. It could be, granted, after the fact, but if you go into a casualty investigation and you find that the operations, the approved procedures, were not communicated to the necessary people you take action against the owners in terms of fines. Likewise, for many companies, especially oil companies in Alaska in such a harsh environment, it is extremely expensive to drill. The cost of litigation is also high, as we've seen with the 1.2 billion dollar Exxon Valdez settlement. If the Coast Guard writes an investigation and it says you are liable, the lawyers will see it as a real incentive for the next guy to make sure that's not the basis for litigation against them.