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Updating the Canadian Standards Association Offshore Structures Code

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ABSTRACT

In 1999 the Canadian Standards Association (CSA) embarked on an initiative to both revise the existing Offshore Standards that were adopted in the early 1990s and move forward to harmonize them with the ISO Offshore Structures Code. The updating process followed a consensus approach with care taken to ensure that due process was followed. Changes to CSA S471 General Requirements, Design Criteria, the Environment, and Loads, which sets the overall principles of the CSA Offshore Structures Code, were small, but there has been extensive revision of the *Annex E Determination of ice loads* as well as the addition of two new annexes, *Annex H Accidental loads* and *Annex I Ice accretion on offshore structures*. The revised CSA Code sets a basis for harmonization with the ISO Offshore Structures Code.

KEY WORDS: safety; limits states, reliability, offshore structures, environment, loads, accidents, fires, explosions

INTRODUCTION

The protection of human life and the preservation of environmental quality are fundamental goals of modern society. Developing offshore resources, often in hazardous environments, presents a challenge in meeting these goals of society while still providing economic solutions. The petroleum industry and governmental regulatory authorities have faced this challenge in the exploitation of offshore petroleum resources. Extensive experience was developed in the Gulf of Mexico and the North Sea in this regard, and codes of practice have been developed for these areas. With the advent of offshore exploration in Canadian waters in the 1970s and the potential for offshore production, a program to develop a Canadian offshore structures code was initiated by the Canadian Standards Association (CSA) in 1984. The CSA Offshore Structures Code was developed during the late 1980s, and was subsequently adopted in the early 1990s. The Code comprises five standards; namely CAN/CSA-S471-92 General Requirements, Design Criteria, the Environment, and Loads, CAN/CSA-S472-92 Foundations, CAN/CSA-S473-92 Steel Structures, S474-94 Concrete Structures, and S475-93 Sea Operations. These Standards have been used in Canada and elsewhere, particularly because of their treatment of extreme environments; i.e. sea ice, icebergs, and combinations of them with other environmental factors such as waves and earthquakes.

CSA has a requirement that every 5 years its codes be reaffirmed or revised in order to maintain their currency. By the late 1990s there was experience with the design and operation of the Hibernia offshore GBS, as well as with the design and procurement of systems for the Sable, Terra Nova and White Rose offshore field developments. While these systems are deployed off the East Coast of Canada, their design and procurement was international in scope. Given the international nature of the offshore petroleum industry, the desirability of harmonization between the CSA Offshore Structures Code and international codes was apparent. In 1999 the CSA Strategic Steering Committee on Offshore Structures, which had overseen the development of the original Standards, embarked on an initiative to both revise the Standards that were adopted in the early 1990s and move forward for harmonization with the International Organization for Standardization (ISO) Offshore Structures Code. This paper will present a general overview of the updating process and provide more detail on the changes to CSA S471 General Requirements, Design Criteria, the Environment, and Loads.

UPDATING PROCESS

The work for the updating of the Code was carried out under the direction of the CSA Strategic Steering Committee on Offshore Structures (SSCOS). The SSCOS set up two Technical Committees to review, revise and approve the five standards. One Technical Committee had responsibility for S471, S472 and S475, and the other Technical Committee had responsibility for S473 and S474. The

SSCOS oversaw the process, providing Terms of Reference for each of the Technical Committees, guidance on membership and secured financial support for the process. Responsibility for the technical review and balloted approval, however, rested solely with the Technical Committees. The Terms of Reference called for review and updating of the five existing CSA Standards, and participation in ISO offshore standards development, with the objective of harmonizing the CSA Offshore Standards with the ISO Offshore Standards. The scope of the CSA Standards review was to only correct what may be wrong or dangerous, and to ensure they are up to date.

To describe the process, some explanation of the context in which CSA operates is necessary. CSA is a Standards Development Organization (SDO), one of four such organizations in Canada. The Standards Council of Canada (SCC), the body which oversees Canada's National Standards System, sets terms and conditions that must be followed by SDOs for their standards to be accepted as National Standards. SCC is a Crown Corporation of the Government of Canada, and has a mandate to promote efficient and effective standardization. It is Canada's official representative to the International Organization for Standardization (ISO). To be approved as a National Standard of Canada SCC requires that the following criteria be adhered to in the development of a standard:

- follow a consensus with a balanced committee of producers, consumers and other interests,
- undergo a public review process,
- not restrain trade,
- be consistent with international standards as well as pertinent national standards.

CSA follows these criteria so that CSA Standards may be accepted as National Standards of Canada. As a consequence CSA Technical Committees must comprise a balanced membership from four groups; owner/operator (oil companies), supplier/fabricators (engineering companies and contractors), general interest (universities, research organizations and general public) and regulatory authorities (governmental, classification societies). Each of the CSA Offshore Standards Technical Committees has a minimum of four and a maximum of six members from each group. Development of the technical content of the Standard follows the consensus process, which means "substantial agreement, that is much more than a simple majority, but not necessarily unanimity". Final adoption of a standard requires a recorded vote or a letter ballot with three options;

- Affirmative,
- Affirmative with Comments, or
- Negative with Reason.

Negative votes or ballots must be addressed by the Chair of the Technical Committee through consultation with the individual or individuals involved, and the disposition of them documented. Approval of a Standard requires that more than half of the Technical Committee vote in the affirmative, and of those voting at least two thirds are affirmative. Thus a Negative vote need not prevent adoption of a Standard.

The work of the Technical Committees leading up to the balloting was assisted by a number of working groups set up to examine specific areas. A series of meetings of the Technical Committees were held over the period 2001 through 2003, at which consensus was reached on the technical content of the revisions. By the time of presentation of this paper, it is likely all five CSA Standards will have been balloted and acceptance is expected for all of them. As can be seen there is a very deliberate process that must be followed for a standard to be accepted as a National Standard of Canada.

BACKGROUND TO S471 GENERAL REQUIREMENTS, DESIGN CRITERIA, THE ENVIRONMENT, AND LOADS

The CSA Offshore Structures Code uses limit states design procedures to accommodate the uncertainties in the environment and associated loads, as well as uncertainties in structure resistance. The fundamentals of the approach are set out in the S471 Standard (CSA, 1992). The following design objectives are indicated:

- structures and foundation can sustain all anticipated load and deformations with an acceptable level of safety,
- adequate measures are taken to mitigate consequences of accidents,
- there is sufficient durability for normal operations and to minimize material degradation,
- there is system ductility.

To meet these objectives it is often perceived that there must be a trade-off between cost and safety. The purpose of a code is to set adequate levels of safety and provide guidance on achieving them. The question is how to quantify these levels. The approach followed in the CSA code is well described by Jordaan and Maes (1991):

> The basic direction taken in the Canadian Standards Association (CSA) calibration was to use the simple premise of *consistent and adequate safety to the individual working on the installation*. The analysis of the cost and safety trade-off was *not* used as a calibration tool.

Thus in the CSA Standards there is no trade-off between safety and cost.

The design approach of the Standard defines two limit states:

- Ultimate limit states: limit states concerned with safety of life and environmental protection.
- Serviceability limit states: those that restrict the normal use or occupancy of the structure or affect its durability.

There is a further definition of two safety classes of the ultimate limit state for verifying the safety of the structure or any of its structural elements:

- Safety Class 1: for loading conditions where failure would result in great risk to life or a high potential for environmental damage.
- Safety Class 2: for loading conditions where failure would result in small risk to life and a low potential for environmental damage.

To meet the design objectives for safety, target reliability levels have been established that were subsequently used for calibrating the design limit states. The target reliability levels selected are outlined in Table 1. Setting such levels is not a trivial task. Jordaan and Maes (1991) presented arguments for these values, based on other risks encountered by individuals in society. For example, in Canada the annual risk of fatality from motor vehicle accidents is about 2×10^{-4}. It was proposed that a target value comfortably below this be selected, say $P_f = 10^{-5}$ for Safety Class 1 (reliability = $1 - P_f$). Less demanding levels were set for Safety Class 2 and serviceability. Other standards set similar reliability levels, e.g. NORSOK (1999) and the Joint Committee on Structural Safety (2001). Note that the CSA Standard and the noted standards use an annual probability of failure rather than a return period.

Table 1 Safety Classes and Reliability Levels

Safety Class	Consequence of Failure	Target Annual Reliability Level
Safety Class 1	Great risk to life or a high potential for environmental damage	$0.99999 = (1 - 10^{-5})$
Safety Class 2	Small risk to life and a low potential for environmental damage	$0.999 = (1 - 10^{-3})$
Serviceability	Impaired function	$0.9 = (1 - 10^{-1})$

Reliability considers both the uncertainty of loads, environmental and other, as well as the resistance or strength of the structure. Design to the prescribed reliability levels requires partial factors for both loads and the resistance. The values of the partial factors were calibrated for various loads and load combinations in a series of studies carried our by Maes (1986a and 1986b).

In addition to general requirements for design, the Standard provides guidance on describing environment conditions and the use of environmental parameters in determining environmental loads and load combinations. Environmental conditions identified include

- ✓ wind,
- ✓ air and sea temperature,
- ✓ snow and ice accretion,
- ✓ waves,
- ✓ currents,
- ✓ water level,
- ✓ marine growth,
- ✓ sea ice and icebergs,
- ✓ seabed geology, and
- ✓ earthquakes.

These conditions have to be described, assessed and site-specific data assembled to quantify them.

The treatment of loads and load combinations addresses

- ✓ permanent loads,
- ✓ operational loads,
- ✓ accidental loads, and
- ✓ environmental loads.

Environmental loads are in turn sub-divided into those due to

- ✓ waves and current,
- ✓ wind,
- ✓ ice, and
- ✓ seismic effects.

Environmental loads can be *frequent*, such as wind or wave loads, or *rare*, due to earthquakes or iceberg impact. These two categories of environmental loads are treated separately in the Standard.

i. Frequent environmental processes produce many loads over the course of a year. For both Safety Class 1 and Safety Class 2, specified frequent environmental loads, E_f, shall have an annual probability of exceedance, P_E, not greater than 10^{-2}.
ii. Rare environmental events occur less than once a year. For Safety Class 2, specified loads shall have an annual probability of exceedance, P_E, not greater than 10^{-2}. For Safety Class 1, specified loads shall have an annual probability of exceedance, P_E, that lies in the range 10^{-4} to 10^{-3}. Rare environmental loads need not be considered for events have an annual probability of occurrence of less than 10^{-4}.

The concept of *companion frequent environmental processes* was introduced to provide guidance on specified loads for the simultaneous occurrence of the principal frequent environmental process or principal rare environmental event with another frequent principal environmental process. For principal processes or events such as waves, wind, current, sea ice, earthquakes or icebergs, *stochastically dependent*, *stochastically independent* and *mutually exclusive* companion frequent environmental processes were identified. Factors were given in Table 6.1(b) (CSA, 1992) to be applied to the specified frequent load, E_f, associated with stochastically dependent and/or stochastically independent companion frequent environmental process and added to the loads from the principal process of event.

Table 6.2 in S471 (CSA, 1992) identifies a total of 10 load combinations for Safety Class 1 and Safety Class 2 of ultimate limits states and the serviceability limit state. For each load combination, load factors are given to be applied to the specified loads, be they permanent, operational, environmental or accidental. These loads factors were derived from the aforementioned calibration studies.

The 1992 edition of S471 contained appendixes with information on safety classes, sources of environmental data, wind load determination, wave and current loads, determination of ice loads, earthquakes, and relevant standards, codes and recommended practice documents. The appendixes did not form a mandatory part of the Standard. Additionally there was a companion publication, CSA Special Publication S471.1, Commentary to CSA Standard CAN/CSA-S471,that provided clause-specific background and information.

REVISONS TO S471 GENERAL REQUIREMENTS, DESIGN CRITERIA, THE ENVIRONMENT, AND LOADS

As mentioned, the original Standard was published as CAN/CSA-S471-92 in 1992. The basic layout and structure of the revised version of the Standard, to be published in 2004, remains the same. In summary the significant changes include better definition of operational loads, additions to load combinations, revisions to the load factors, new requirements and guidance for accidental loads, and new guidance on ice loads, and ice accretion. Also the Commentary has been dropped, with significant parts of it incorporated as notes to the main body of the Standard. The changes will each be discussed in more detail in the following sub-sections.

Safety Classes and Reliability Levels

The relation between *target annual reliability levels* and Safety Class has been moved from an appendix where it was non-mandatory to the main body of the Standard, where it is mandatory. The values are those indicated in Table 1 of this paper.

System Ductility

The new Standard places additional emphasis on the potential benefits of system ductility in the assessment of system response to rare environmental and accidental loads. In this regard, the Standard is following terrestrial building standards for response to seismic excitation in which the capacity for a specified level of ductility is designed into the structural system. The Standard is not specific as to levels of ductility, but recognizes that, in the system response to rare environmental loads (seismic, icebergs, ice islands), and accidental loads, ductility and reserve strength should be considered. The corollary to this recognition, however, is the expectation that, in the damaged condition, the system maintains its integrity. To ensure this, the damaged structure or structural elements must meet the requirements of the appropriate damaged load case (Table 2), depending on the Safety Class of the structure. This is to ensure safety to personnel and limit damage to the environment, and subsequent inspection and repair, when in the damaged state.

Accidental Loads

Substantial improvements were made to the treatment of accidental loads (i.e. fires, explosions, ship collisions, dropped objects, etc.) in the Standard. Requirements for prevention of accidental events have been added to mitigation and control of their consequences. Annex H has been added to the Standard to provide additional guidance for the determination of accidental loads and the response of the structure to these loads.

The accidental loads revisions have drawn upon guidance from the North Sea community developed primarily as a result of the learnings from the Piper Alpha disaster in1988. Following Piper Alpha the North Sea community undertook numerous initiatives to improve the guidance for accidental loads, and in particular, that for fires and explosions. These efforts are on going however significant advancements to date have been reflected in guidance including that from the Steel Construction Institute (1993), NORSOK (1998, 1999) and ISO (1999). The update to the S471 standard incorporates these advancements bringing the CSA S471 requirements more in-line with those of the North Sea.

Among the new advancements in the standard is the requirement for the protection of structure, safety critical systems, pipework, and communications from the effects of accidental loads including, but not limited to, explosions, fire, projectiles and strong vibrations. With respect to projectiles and strong vibrations, these are effects that can follow the initial accidental event, such as an explosion or ship collision, and it is important to appropriately address these effects to prevent escalation of the event. For example, equipment exposed to an explosion may possibly become a projectile if the mounting arrangement cannot withstand the loads generated from an explosion. The projectile may then possibly cause escalation of the event by damaging other equipment, safety critical systems, piping, etc. For the case of strong vibration, this effect may be generated by explosions or ship collisions and may cause damage to critical components such as control systems and communications away from the vicinity of the event.

The new guidance in S471 includes reference to standards such as NORSOK (1998, 1999) for assessment of loads and resistance, respectively. As well, the guidance on fire and explosions published by the Steel Construction Institute (1993) under the Fire and Blast Information Group (FABIG) is also cited. The reference to the FABIG documents includes reference to the original Interim Guidance Notes (IGN's) and also the Technical Notes (TN's) that update the IGN's. Numerous TN's have been published since the IGN's were first published in 1992 and provide additional guidance in areas such as the response of structure against fires and explosions and the design of joints to resist explosions. For the control and mitigation of the topsides to fires and explosions, the recently published ISO 13702 standard is also referenced.

The work performed under CSA to update the standard in the area of accidental loads has been used as input to other recent initiatives in the area of fire and explosion loading including initiatives under the American Petroleum Institute (API), United Kingdom Offshore Operators Association (UKOOA) and the Health & Safety Executive (the UK offshore regulator). The S471 guidance has also been an important input into the new ISO standards through Canada's direct participation on the ISO Accidental Actions Technical Panel responsible for drafting the provisions in the new ISO Offshore Structures Standards (under ISO TC 67 SC7).

Annex H, like all the other annexes is not mandatory, however, part of it is written in normative language. This has been done to facilitate its adoption by users of the Standard or regulatory authorities as an additional requirement of the Standard.

Operational Loads

During the course of the revision of the Standard, corresponding ISO Standards were also reviewed. While reviewing ISO/CD 19901-3 Topsides (ISO, 2002), it became apparent that the partial load factors on operational loads in Table 6,2 were unsafe in certain circumstances. All operational loads were treated as being in one category, however modern practice is to divide operational (or live) loads into (i) operational loads of long duration and (ii) loads associated with short-term operational activities. Different partial load factors apply to each category of operational load. It was deemed that a re-calibration exercise would be needed to establish load factors for the two categories of operational loads. Subsequently it was decided to extend the re-calibration exercise to all loads. The results of this exercise will be discussed in the next section.

Re-Calibrations

The original calibration studies for the Standard were done in 1986 (Maes, 1986a and 1986b). Since that time there have been significant advances in the stochastic load models used for the offshore. Therefore a re-calibration of all the partial load factors in S471 was carried out (Maes, 2003). Recalibrations were carried out at target annual reliability levels for Safety Class 1 and Safety Class 2 and a number of load combinations. Guidance for the selection of stochastic models for the various parameters came from sources such as JCSS (2001). Because the re-calibration was done against target annual reliability levels, the nature of distributions of resistance or strength parameters as well as distributions of the various load parameters was considered. Complete details on the re-calibration exercise, the characteristics of the distributions used for the parameters, the load combinations specified and the selection of the corresponding partial load factors is given in detail in Maes (2003). Based on this exercise a new Table 6.2 was prepared for the Standard, this one comprising 12 load combinations and providing load factors for the associated loads. Load parameters include the following:

- Permanent, G
  - Dead, G_D
  - Deformation, G_R
- Operational, Q
  - Short-term, Q_1
  - Long-term, Q_2
- Environmental, E
  - Specified frequent, E_f
  - Specified rare, E_r, and
- Accidental, A.

In the 1992 edition of Table 6.2 there were three load combinations with load factors that were structural material dependent. It was seen to be inappropriate to have "material-dependent" load factors, so these cases were removed and reference made, as appropriate, to S473 Steel Structures and S474 Concrete Structures. The load combinations and load factors in the revised Table 6.2 are presented in abbreviated form in Table 2. The 2004 edition of S471 contains extensive guidance notes on the use of Table 6.2, so Table 2 presented here should not be used without reference to the whole Standard. It should also be noted that these load factors are much closer to those in other modern standards.

Table 2 Load factors and load combinations

Load combination	Load factors
Ultimate limit states – Safety Class 1	
1	$1.25\ G_D + G_R + 1.45\ Q_1 + 1.2\ Q_2 + 0.7\ E_f$
2	$1.25\ G_D + G_R + 1.15\ Q_1 + 1.7\ Q_2 + 0.7\ E_f$
3	$1.05\ G_D + G_R + 1.15\ Q_1 + 1.35\ E_f$
4	$1.05\ G_D + G_R + 1.15\ Q_1 + E_r$
5	$1.05\ G_D + G_R + 1.15\ Q_1 + A$
6 damaged	$(1.05 \text{ or } 0.9)\ G_D + G_R + Q_1 + E_f$
Ultimate limit states – Safety Class 2	
7	$1.05\ G_D + G_R + 1.1\ Q_1 + 0.75\ Q_2 + 0.85\ E_f$
8	$1.05\ G_D + G_R + 0.9\ Q_1 + 1.1\ Q_2 + 0.85\ E_f$
9	$1.05\ G_D + G_R + 0.9\ Q_1 + E_r$
10 damaged	$(1.05 \text{ or } 0.9)\ G_D + G_R + Q_1 + 0.7\ E_f$
Ultimate limit states – Fatigue	
11	$G_D + G_R + Q_1 + E_f$
Serviceability limit states	
12	$G_D + G_R + Q_1 + 0.7\ E_f$

Annex E - Determination of ice loads

The past 10 years have seen substantial advancement in the understanding of ice loads as a result of a number of research projects. This has been primarily due to the analysis of data collected from numerous field measurement projects (Timco et al, 1999), with Beaufort Sea experience being most valuable, plus the addition of new data from measurements of ice forces on the Confederation Bridge (Brown, 2001). The new insights and knowledge gained have been used in revising this Annex (CSA, 2004).

More guidance is given on application of probabilistic methods to determine ice loads for the annual probability levels called for in the Standard. Better environmental data are now available. Probabilistic methods have moved into the mainstream of design. More guidance is given on characterizing frequent environmental processes and rare environmental events.

For ice loads a clearer distinction is now made between pressures for global load and local load determination. This clears up confusion that arose in the older editions. Global and local pressures will be explained in turn.

a. Ice pressures for global design of stability of structures are now broken into two categories, depending on aspect ratio (width of structure/ice thickness).

   i. Low aspect ratio (narrow structure)
   Pressure, p, is given by

$$p = C_p\, A^{D_p} \tag{1}$$

   A = the nominal contact area
   C_p = a coefficient
   D_p = a negative exponent
   C_p and D_p can be either deterministic values or normally distributed values that can be found in Table E.1 of Annex E.

   ii. High aspect ratio (wide structure)
   Pressure, p, is given by

$$p = C_{p'}\, h^{D_{p'}}\, (W/h)^{E_{p'}} \tag{2}$$

   W = nominal contact width
   h = nominal ice thickness
   $C_{p'}$, $D_{p'}$ and $E_{p'}$ = constants from measurement, see Table E.2 of Annex E.

Note that these changes to the definition of global ice loads, taking into account aspect ratio, lead to greater commonality with Russian codes for ice loads. The constants in the two tables mentioned, E.1 and E.2, used for calculating global loads depend on the severity of the sea ice regime being considered. Three regimes have been defined, Zone 1 for the Arctic (annual freezing degree days 3000 to 4000 °C-days), Zone 2, Labrador Coast (annual freezing degree days approximately 2000 °C-days), and Zone 3, temperate regions such as Newfoundland and Gulf of St. Lawrence (annual freezing degree days 1200 °C-days or less). Average pressures are reduced by about a factor of 2 from Zone 1 to Zone 2 and another factor of 2 from Zone 2 to Zone 3.

b. Ice pressures for local design

Separate specification of local ice pressures within contact areas less than 5 or 10 m^2 are required for design of shell or stiffening elements. What is being defined here are pressures on smaller areas within the nominal contact area, termed "design area", a_L, see Figure 1. Local ice pressure, z_e, is defined by

$$z_e = x_0 + \alpha\{-\ln[-\ln F_Z(z_e)] + \ln \mu\} \tag{3}$$

where
x_o is offset of distribution,
α represents the dependence of pressure on contact area, and
μ is an exposure factor.

For annual pressures at probability levels 10^{-2} and 10^{-4}, $F_z(z_e)$ is 0.99 and 0.9999, respectively. Based on measurements from ships,

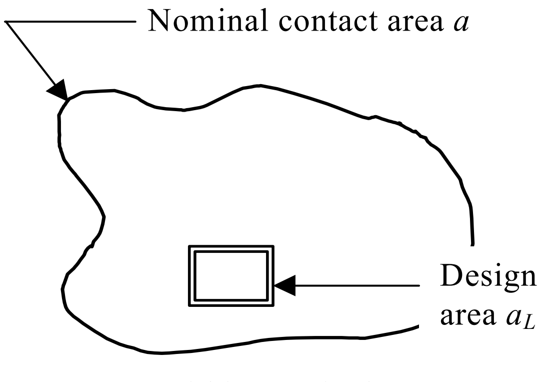
$$\alpha = B_p\, a_L^{-0.7} \tag{4}$$

where
a_L is the "design" area, and
B_p is an empirical constant.

Further, the exposure is given by

$$\mu = 1.4\, nt \tag{5}$$

where
n is the annual average number of interactions, and
t is the average duration of impacts, s.



Area within nominal contact area

Figure 1 Schematic illustrating design area, a_L.

Quantitative information on pack ice driving forces has been added in Annex E. Such information helps set an upper limit on the force that can be transmitted through pack ice to a structure. Pack ice forces often correspond to ridge building, but can also relate to floe splitting, rafting or other out of plane mechanisms. Based on extensive field measurements and an analysis of them by Croasdale et al (1992), the following expression is proposed

$$F_{DF} = \begin{cases} 0.6fh^{1.25} & 50m < W \le 100m \\ f\left[0.6 - 0.00125(W - 100)\right]h^{1.25} & 100m < W \le 500m \\ 0.1fh^{1.25} & W > 500m \end{cases} \quad (6)$$

where

F_{DF} is the limiting force condition, MN/m,

W is the width over which the pack ice forces are acting, m,

h is the ice thickness, m, and

f is a coefficient defining the probability distribution for F_{DF}.

Annex I - Ice accretion on offshore structures

he new edition of S471 has added Annex I, providing guidance on ice accretion on fixed or floating offshore structures. It notes that ice accretion represents not only a load and stability hazard, but also an operational concern; e.g. slippery decks, ladders and handrails; ice encasing winches, derricks and valves; ice on radar antennas; and ice can interfering with life saving and fire-fighting equipment. This annex provides the designer with some up-to-date references pertaining to ice accretion on offshore structures, but is not intended to give detailed methods for estimating ice accretion loads. The information is provided on the following topics:

- ✓ explanation of ice accretion sources,
- ✓ generation of sea spray,
- ✓ ice accretion,
- ✓ Canadian offshore icing climatology, and
- ✓ references to other relevant standards.

It refers to NORSOK N-003 (1999) as the only standard that provides guidelines for ice accretion on offshore structures.

CONCLUSIONS

The consensus process, as implemented by CSA, has been followed to produce new edition of S471. It contains a number of improvements over the 1992 edition, including better definition of operational loads, additions to load combinations, revisions to the load factors, and new guidance on ice loads, accidental loads and ice accretion. The revised S471 is a good basis for moving forward to harmonizing with the ISO Offshore Structures Code.

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