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ISO 19906 - AN INTERNATIONAL STANDARD FOR ARCTIC OFFSHORE STRUCTURES

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ABSTRACT

In 2000, the International Standards Organisation (ISO) discussed the development of an international standard for the design of Arctic offshore structures. Canada, having active committees in place for such an activity, took the initiative to propose and coordinate the new work item to ISO. In response to the Canadian initiative, the ISO Technical Committee 67 (TC67), Sub-Committee 7 (SC7 - Offshore Structures) approved the development of a new standard entitled "Petroleum and natural gas industries - Arctic offshore structures". In addition, the developers of the new standard were tasked with the secondary objective of harmonising existing international offshore codes and standards related to Arctic structures.

SC7 established Working Group 8 (WG8) in response to this approval and WG8 started by holding its first meeting in July 2002. All countries with regions in ice covered waters, or with an interest in these regions, were requested to provide country representatives and technical experts to staff both WG8 and the Technical Panels formed by WG8 to actually prepare the document.

The technical work was initiated in 2003 and the completed document, ISO 19906 - Arctic Offshore Structures, was approved by the ISO member countries for distribution in December 2010.

The approved Standard specifies requirements and provides recommendations and guidance for the design, construction, transportation and installation of offshore structures, related to petroleum and natural gas activities in arctic and cold regions. The objective of the document is to ensure that offshore structures in arctic and cold regions provide an appropriate level of reliability with respect to personnel safety and environmental protection. While the document does not apply specifically to mobile offshore drilling units, the procedures relating to ice actions and ice management contained herein are applicable to the assessment of such units.

This paper provides a brief history of the document preparation as it relates to country and industry involvement, development of technical input, editing and review processes undertaken and acceptance of the document by ISO and its participating members.

INTRODUCTION - BACKGROUND & INCENTIVE

Previous papers on the development of 19906 (Blanchet, et al 2007), discussed factors emerged that together provided the incentive for the development of a new global standard for arctic offshore structures. These included the following;

1. Several regional and domestic codes and standards dealing with structures in ice environments were in existence. These did not necessarily provide the same guidance or the same ice load calculation methodology for the design of an offshore structure.

2. The Eurocodes, being developed by the European Union, were also planning to include ice actions and other subject matter related to offshore structures in ice environments. EU funded research and field data, obtained from lighthouses in the Baltic Sea from 1997 – 2002, and there was a strong incentive to ensure that these data were included in a standard for the oil and gas industry.

3. The effort required to maintain a variety of regional and national codes and standards was becoming a significant problem for the relatively small number of arctic engineering specialists worldwide.

4. A growing shift in energy demand had tightened supply and increased oil and gas prices, which in turn allowed exploration and development of Arctic resources to become economically feasible.

5. New license rounds, either held or announced, had created an interest in establishing a common basis for the design of structures and facilities to explore and produce hydrocarbons in these areas.

6. Oil and gas reserves found in the 1980s and 1990s were in the process of being, or had recently been, developed for production. These production developments (Figure 1 shows the Northstar facility) could have benefitted from an accepted international standard. This was especially true for international developments that could have avoided the development of Project Specific Design Codes (PSDC) and Technical Specifications (PSTS), which were time consuming and costly.

7. A number of structures designed and operated in one region had subsequently been deployed into another region. This had required design checks and regulatory approvals to different standards which would have been simplified by the worldwide adoption of a single International Standard.

8. Government regulators, the public and industry would benefit from the introduction of an internationally recognised standard.

Figure 1. Northstar Production facility. (Courtesy of D. Blanchet)

9. Newer research projects, such as the European Lolief and Strice projects, and measurement of ice loads in Bohai Sea in China, on the Confederation Bridge in Canada and the JOIA project in Japan provided new insights into ice loads and ice behaviour which could be implemented into the new standard.

10. The limit states reliability-based approach for design was gaining acceptance in offshore codes and there was increasing enthusiasm for an international standard incorporating this approach.

FORMATION OF WORK GROUP 8 (WG8)

Given these incentives the development of an Arctic offshore structures standard was made a priority by the oil and gas industry members working within ISO. Canada, having an active process and national committees in place for Arctic offshore structures, took the initiative to propose a new work item to ISO at the Milan meeting of ISO's Technical Committee 67 (TC67), Sub-Committee 7 (SC7 - Offshore Structures) in January 2002. This was approved and WG8 (Work Group 8) was established to develop a new standard and to harmonise existing international codes and standards within the series of standards for offshore structures.

Led by Denis Blanchet (BP) and Ken Croasdale (KR Croasdale and Associates), WG8 held its first meeting in Toronto, Canada in July 2002. The initial task was to achieve a meaningful membership and commitment from countries with Arctic or sub-Arctic interests including Russia, Kazakhstan, Greenland, Japan and China that are outside the normal standard structure of Europe and North America.

Figure 2. WG8 members discussing ISO 19906 in Milan, June 2008.

Subsequent meetings were held at locations to ensure the country hosting the meeting could invite a wider audience of attendees. Typically these additional attendees were members of regulatory agencies, companies interested in offshore activities, national research organizations, academicians, and interested consultants and contractors. The intent was to not only inform these attendees of the activities of the WG8, but also to encourage participation in the Technical Panels formed to write the actual document. Figure 2 shows members at a meeting held in Milan in June 2008.

The first meetings were organizational in nature with discussions on a) ensuring all countries with an interest in ice covered waters participated, b) confirming the topics the document should (or should not) contain, c) structuring the Technical Panels (TPs) that would actually write the different parts of the document, d) appointing leaders and participants to the TPs, e) ensuring that all countries were represented on the TPs in which they expressed interest, and lastly f) developing a schedule to complete the document within the time frame provided by SC7.

Table 1 provides a list of countries represented in WG8 during the work activities and the main representatives and affiliation. As can be noted, all countries with immediate access to the Arctic were represented in addition to other countries that either have ice covered water coastlines, such as Finland, Germany and Kazakhstan, or countries with major companies active in ice covered regions, such as The Netherlands, Italy and the UK.

After careful deliberation by the WG 8 membership, the Technical Panels were formed to write the Standard. In topic areas with existing ISO standards, such as steel and concrete offshore structures, the new arctic standard was to refer to the existing standard and provide guidance only on arctic and ice related issues.

Table 1. List of WG8 Country members and their representatives during the development of ISO 19906.

Country	**Representatives**	**Affiliation**
Canada	D. Blanchet / K.R. Croasdale	BP / K.R. Croasdale and Associates
China	W. Dong / X Yang	Chinese National Offshore Oil Company
Denmark/Greenland	O. Pedersen	Department of Petroleum Bureau of Mines and Energy
Finland	M. Määttänen	Helsinki Univeristy of Technology
France	M. Vaché, M. Hamon	Doris Engineering
Germany	J. Schwarz / J. Berger	Consultant / Impac Engineering
Italy	A. Baryshnikov	ENI
Japan	K. Izumiyama / N. Nakazawa	NMRI / SEA System Engineering
Kazakhstan	K. Kaipiyev / S. Tuvtebaeva / Y. Smagulov	JSC Board of Oil and Gas Industry / AgipKCO
Norway	O. Gudmestad / M. Morland	Statoil / Norsk Hydro
Russia	D. Mirzoev / M. Mansurov	VNIIGAZ
The Netherlands	F. Sliggers / M. Winkler	Shell
United Kingdom	G. Thomas / D. Clare	BP / Arup
United States	W. Spring / D. Hinnah / J. Hamilton	Bear Ice Technology / MMS / ExxonMobil

The TPs, the TP Leaders and the countries that provided representatives to the TP are shown in Table 2.

TP activities started in 2003 and were mostly completed by 2008 when the ISO review process started. Each TP held meetings to review progress and contributions, but due to the international membership, most of their activities where completed through email and conference calls.
WG8 agreed upon a table of contents, shown in Table 3, for the final document. In agreement with ISO protocol, the Standard consists of three elements, a Normative part, an Informative part and Regional Descriptions.

As the use of language is very precise in ISO, a clear distinction was made as what could be contained within these elements. Specifically the use of “shall” denotes a requirement, “should” denotes a recommendation, “may” denotes a permission or option, and “can” denotes a possibility. The use of “must” is avoided because “must” is reserved for statutory issues, and such issues are outside the purview of an ISO Standard.

The main element, the Normative part, contains the provisions which the designer will have to follow in order to be compliant with the ISO standard. Therefore while it contains the “shall” and “should” provisions, “may” and “can” provisions are also included. Together, these normative provisions provide the user of the standard with requirements for conformity and guidance for expected or good practice.

Table 2. The WG8 Technical Panels, the TP Leader and the countries represented on the TP.

Technical Panel Number	**Technical Panel Name**	**Leader**	**Countries Represented**
TP0	Editing	W. Spring	Canada, Finland, Germany, Norway, US
TP1	Environment	W. Spring	Canada, China, Finland, Germany, Norway, Russia, UK, US
TP2a	Reliability	F. Bercha	Canada, Norway, Russia, The Netherlands, US
TP2b	Ice Actions	T. Kärnä	Canada, China, Finland, Germany, Japan, Norway, Russia, US
TP2c	MetOcean	C. Shaw	Canada, France, Norway, The Netherlands, UK, US
TP2d	Seismic	F. Puskar	Canada, Japan, Norway, Russia, US
TP2e	Metocean Actions	P. Tromans	Canada, Denmark, Finland, Norway, Russia, The Netherlands
TP3	Foundations	D. Clare/P. Jeanjean	Canada, France, Norway, Russia, The Netherlands, UK, US
TP4	Artificial Islands	D. Mayne/ M. Metge / K. Been	Canada, France, The Netherlands, UK, US
TP5	Steel	T. Zimmerman / J. Berger	Canada, Germany, Japan, Russia, UK, US
TP6	Concrete	M. Vache	Canada, France, Norway, Russia, The Netherlands, UK
TP7	Floaters	C. Makrygiannis	Canada, Norway, The Netherlands, US
TP8a	Topsides	P. Sharma/O. Gudmestad	US
TP8b	EER	J. Poplin	Canada, Norway, The Netherlands, US
TP9	Ice Engineering	S. Løset	Canada, Germany, Kazakhstan, Norway, Russia, UK
TP10	Case Studies and Calibration	G. Thomas	Canada, Germany, Kazakhstan, The Netherlands, Norway, UK, US

The Informative part, contained in Annex A, contains informative text and commentary which assists the designer in following the Normative text. It contains the methodologies, equations, descriptive notes and references to be used in the design of the structure. It also contains additional “should” and “can” provisions. The organization of the Informative text mirrors the Normative in order to assist the designer.

Table 3. Table of contents for Normative and Informative parts of standard.

Clause Number	**Clause Title**
1	Scope
2	Normative References
3	Terms and Definitions
4	Symbols and Abbreviated Terms
5	General Requirements and Conditions
6	Physical Environmental Conditions
7	Reliability and Limit States Design
8	Actions and Action Effects
9	Foundation Design
10	Man-made Islands
11	Fixed Steel Structures
12	Fixed Concrete Structures
13	Floating Structures
14	Subsea Production Systems
15	Topsides
16	Other Ice Engineering Topics
17	Ice Management
18	Escape, Evacuation and Rescue

As ice features are the distinguishing characteristic for the standard, a description of the physical environment for each ice covered region in the Northern Hemisphere is contained within Annex B. Each regional description includes a brief narrative description of the metocean, seismic and ice environment found in that region and also provides indicative numerical values for the parameters that need to be considered in the design of an arctic offshore facility. If a parameter is not mentioned, it is because it is not found in the region. As an example, multiyear ice is not found in the Cook Inlet of Alaska and there is no mention of it in the ice parameter table for Cook Inlet. The parameter tables are meant to provide a list of features to consider, but the numerical values are generalised over a wide area and will not provide actual, site-specific design parameters. This lack of detail is intended to ensure that the owners and designers will develop, in conjunction with specialists, data sets for the region and site in question.

Table 4 provides a list of the Regional Descriptions that are contained within Annex B.

Although other offshore structures such as wind turbine substructures are outside the stated scope, it is considered that the ice action philosophy and analysis provisions can be applied.

DOCUMENT DEFINITION AND CONTENT

Under SC7, the emphasis of the new standard was on offshore structures for the petroleum and natural gas industries in ice covered waters. Notwithstanding this definition, it was recognised that the methodologies developed will be applicable to most structures in ice, whether they are for oil or gas or not.

Table 4. Table of Contents for Annex B - Regional Descriptions.

Annex Number	**Region**
B.2	Baffin Bay and Davis Strait
B.3	Labrador Sea
B.4	Newfoundland
B.5	Canadian Arctic Archipelago
B.6	Greenland
B.7	Beaufort Sea
B.8	Chukchi Sea
B.9	Bering Sea
B.10	Cook Inlet
B.11	Okhotsk Sea
B.12	Tatar Strait
B.13	Bohai Sea
B.14	North Caspian Sea
B.15	Baltic Sea
B.16	Barents Sea
B.17	Kara Sea
B.18	Laptev Sea
B.19	East Siberian Sea
B.20	Black Sea
B.21	Sea of Azov

By strict definition, a Standard for Arctic Offshore Structures would only apply to structures north of the Arctic Circle (67.5˚N). However, while retaining this simple title, ISO 19906 covers structures considered for installation in sea waters that may be partially or wholly covered with ice, whether seasonally or year-round.

ISO 19906 specifies requirements and provides guidance for the design, construction, transportation and installation of offshore structures in arctic and cold regions environments. ISO 19906 does not contain specific requirements for the operation, maintenance, service-life inspection, repair or decommissioning of arctic offshore structures nor does it cover pipeline related issues. The only exception is where active measures such as ice management and disconnection are implicit in the design philosophy, in which case details relating to such operations have been included.

ISO 19906 does not apply to Mobile Offshore Drilling Units (as ISO 19905-1 is intended to cover these facilities), but the procedures relating to ice actions and ice management contained herein are applicable to the assessment of such units

DOCUMENT PREPARATION

All TPs completed the first draft of their Normative sections in early 2006 and TP0 was formed to review the submissions and ensure that only suitable normative clauses were included. The TPs completed their first draft of the Informative sections late in 2006 and these were reviewed to ensure completeness and uniformity in language, methodology, and technical guidance. A technical editor (R.F. McKenna) was appointed in late 2006 and included in the editing process of TP0.

In November 2007, the Committee Draft (CD) of the document was issued for country and member comments. This was the first complete draft issued for external comment and Table 5 shows how the 992 comments from member countries were distributed by the TPs to which the comments were addressed. The greatest number of comments was editorial in nature (i.e., grammar, spelling, etc) and the next largest number of comments was related to the ice actions section as is to be expected in an Arctic Standard.

Table 5. Comments received on the CD and DIS versions of ISO 19906.

TP to which Comments were Addressed	**Number of Comments Received**	
	CD	**DIS**
0	56	42
1	53	154
2A	92	64
2B	162	187
2C	3	2
2D	4	0
2E	6	8
3	37	24
4	22	30
5	33	21
6	15	36
7	78	54
8A	50	23
8B	36	25
9	40	42
Editor	274	205
WG8	17	6
Total	**992**	**995**

The comments were all acted upon and by November 2008 the document (now called the Draft International Standard or DIS) was ready and reissued for country and member comments. A total of 995 comments were received as summarized in Table 5. As in the CD comments, the majority were editorial in nature and handled by the Editor. The second largest number was again related to the ice actions section of the document.

CALIBRATION AND CASE STUDIES

Concurrent with the DIS review, two additional initiatives were undertaken; calibration and case studies. The calibration of ice action factors and return periods was undertaken to ensure that the intended reliability was achieved. The case studies initiative was undertaken to see how the document was used by those not familiar with it and to identify what was missing or needed change. TP10 was formed to initiate and monitor these activities.

Details of the calibration effort are provided in Maes and Thomas, 2011. Action factors for gravity loads, variable actions, earthquakes and resistance were obtained from the appropriate ISO standard. The calibration accounted for ultimate and abnormal limit states as they affected action factors, specified annual probabilities of exceedance, companion factors involving extreme level actions, abnormal level actions, or both, and the inclusion of system robustness/energy dissipation capacity for the abnormal limit states.

The case studies to be performed were determined by TP10 and were selected to ensure that each type of facility and each type of environment (i.e., an iceberg environment, a multiyear ice environment, etc.) was investigated. Eight different cases were defined and a request for proposals was issued after industry funding was raised by the International Association of Oil and Gas Producers (OGP). The accepted proposals were from a combination of contracting firms, design institutes and academic researchers from Europe, Russia/CIS and North America. A member of TP10 was assigned to provide technical input, as requested by the study contractor, and to report upon the finding back to TP10.

Table 6 – Structure types, regions and ice environment considered in Case Studies.

Structure Type	**Region**	**Ice Environment**
GBS – Vertical Sides GBS – Conical Sided	Beaufort Sea	Multiyear (MY) and First year (FY)
GBS – Vertical Sided	Labrador	MY and FY / Icebergs
GBS – Multi-leg	Sakhalin (Sea of Okhotsk)	FY – rafted and deformed
Jacket Structure	Cook Inlet / Bohai Sea	FY – highly mobile
Floating FPSO	Barents	Icebergs / FY rafted and ridged
Gravel / Fill Island	North Caspian / Perchora Sea	FY – pile-up and encroachment
LNG Dock	Melville Island, Canada	MY and FY
Small diameter vertical structure (e.g. wind turbine support)	Baltic Sea	FY

Significant learnings resulted from the studies and details can be found in Thomas, et al, 2011. In addition, the case studies yielded a total of 263 comments on the ISO/DIS 19906 text that were submitted as OGP comments and were acted upon by the TP responsible for the section in which the comment was received.

DOCUMENT ACCEPTANCE

After resolution of all DIS comments, the document was forwarded to the WG8 parent organization, TC67/SC7, for approval in January 2010 as being ready for final ballot. Concurrently, the document was also forwarded to the ISO Secretariat to ensure that it met the requirements, format and language of that organization.

The ISO Secretariat provided an edited version of the revised document to TP0 in June 2010 and in a joint meeting between the two groups, the document was reviewed and major issues were resolved. A revised version was provided by the ISO Secretariat to TP0 in August for a last check before being issued to ISO member countries in September for a yes/no vote on acceptance. The ballot result was positive with no negative replies and the standard was published in mid-December 2010.

In Europe the final document was adopted without modification throughout the European Economic Area (the European Union plus Norway and Iceland). In the US, API has stated that they would withdraw API RP-2N and recommend ISO 19906, while in Canada; CSA has stated that it would withdraw CSA S-471 in favour of ISO 19906. In Russia, the document is being translated into Russian for use. Its adoption in other jurisdictions is imminent and it is expected that existing standards of other countries will either be withdrawn or be revised to reference ISO 19906. ISO allows country specific Annexes containing additional or different technical requirements and geographical information. These Annexes will be a useful indicator for future revision of ISO 19906 in order to provide consistency in the methods used to design Arctic offshore structures.

AWARENESS INITIATIVE

To inform the industry of the availability of this document and to elaborate on the technical content of the document, an information initiative was undertaken by TP0 on behalf of WG8. This initiative consists of dedicated sessions at the Arctic Technology Conference (ATC) held in Houston in February 2011 and the Port and Ocean Engineering Conference (POAC11) in Montreal in July 2011. At each of these sessions, various papers will be presented by TP Leads and activity organizers related to the preparation of the document.

At the ATC Conference, in addition to those already referenced, three other papers were presented. The first, by T. Kärnä, et al, discussed the results of TP2b and their activities related to ice load/action determination methodologies. The second, by Fuglem et al, discussed the ice criteria, structure types and ice loads/actions that were used in the calibration of the ice action factors. Finally, McKenna, et al 2011 discussed the use of the standard.

SUCCESS FACTORS

Factors which led to the successful completion of this document included;

- A Convenor (D. Blanchet) with international recognition and support. This ensured that TPs had leading world experts to call upon to help write the document.
- A professional Secretariat, the Canadian Standards Association, which provided two very competent staff to work with WG8, L. Fogwill and J. Walker.

- The formation of an Editing TP (TP0) which coordinated all activities and became a de facto Management Team.
- A very competent Editor (R. McKenna) who worked well with the TP Leaders to ensure that changes were acceptable and reflected the intent of those making them.
- Support from the OGP which funded not only the Editor, but also the Calibration and Case Studies initiatives.
- Collaboration with SC7 to ensure that no issues would cause delays
- Collaboration with ISO Central in Geneva to make sure document changes were acceptable and made in a timely manner.

CONCLUDING REMARKS

- This International Standard, ISO 19906, specifies requirements and provides guidance for the design, construction, transportation and installation of offshore structures, related to the activities of the petroleum and natural gas industries, in arctic and cold regions environments.
- The document was written with the assistance of over 150 of the world's leading experts in Arctic and structural design. It was estimated that over 1,000,000 man-hours went into the development of the first draft. Industry, through direct funding of certain contractors, travel contributions for academicians and research institute personnel and funding for the calibration and case studies, provided almost $500,000 to the writing of the Standard. This does not include the labor and travel costs associated with personnel for the document preparation.
- The document is the result of the analysis of the best available data as relates to ice loading on a structure. The methodologies developed to calculate ice loads are considered to be the best available.
- The objective of the ISO 19906 document is to ensure that arctic and sub-arctic offshore structures provide an appropriate level of reliability with respect to personal safety and environmental protection.
- ISO 19906 does not contain specific requirements for the operation, maintenance, service-life inspection, repair or decommissioning of arctic offshore structures.
- While ISO 19906 does not apply specifically to Mobile Offshore Drilling Units (see ISO 19905-1), the procedures relating to ice actions contained herein may be applicable.

While the document is now available for use, there are identified areas, such as ice loads on floaters, where additional work can be performed. WG8 will investigate these areas and if approaches with global consensus can be identified, work will be started for inclusion in the next version of the Standard. In accordance with ISO directives, each Standard will need to either be ratified as still valid or updated after the initial 3 years.

Even if no additional work is approved, WG8 and the Technical Panels will continue to exist in order to address errata as they are found. In the future, errata should be brought to||the attention of any national standards body which will forward the information to ISO and WG8.

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