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ISO 19906:2019 – an International Standard for Arctic Offshore Structures

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ABSTRACT

In 2014, the International Standards Organisation (ISO) approved the proposal to update ISO 19906, the International Standard for Arctic Offshore Structures with focus on the areas of particular concern for design of offshore structures in arctic and cold regions.

ISO 19906 has been developed by an ISO working group (WG8) led by Canada. The first edition was published in 2010 and has been adopted nationally by most countries with arctic oil and gas interests. An update of ISO 19906 was initiated to incorporate new knowledge from offshore development projects, joint industry research projects, and address previous comments that were beyond the scope of the first edition.

The Draft International Standard (DIS) was published by ISO in August 2017 for international public comment and vote. Over 700 DIS comments were received and catalogued by ISO. WG8 and its Technical Panels addressed these comments and prepared a Final Draft International Standard (FDIS) which was balloted in late January 2019. Final publication is expected in May 2019.

This paper provides an overview of issues that have been addressed and improvements that have been made in the second edition. Separate technical papers cover the details of some key areas addressed by the Technical Panels. The second edition represents a best effort to incorporate a consensus on the latest knowledge and learnings, reflecting currently-accepted technology and practice.

This paper presents an updated international standard which is ready for adoption and use as one of the ISO 19900 series of standards for offshore structures.

KEY WORDS: ISO 19906; Arctic offshore structures; Cold regions; Design; Oil and gas

INTRODUCTION

ISO 19906 provides requirements, recommendations, and guidance, for design of offshore structures in the physical environment of arctic and cold regions, which include the Arctic and other locations characterized by low ambient temperatures and the presence or possibility of sea ice, icebergs, icing conditions, persistent snow cover, and/or permafrost. The provisions of ISO 19906 are incremental to other ISO standards in the 19900 series for common structure types, general requirements, and non-arctic specific requirements.

The objective of ISO 19906 is to ensure that complete structures, including substructures, topsides structures, floating production vessel hulls, foundations and mooring systems in arctic and cold regions provide an appropriate level of integrity with respect to personnel safety, environmental protection and asset value. Value includes value to the owner, to the industry and to society in general.

ISO 19906 provides design principles applicable to all phases of the life of the structure, including the successive stages of construction (i.e. fabrication, transportation, and installation), service in-place, and decommissioning.

The second edition of the International Standard for Arctic Offshore Structures ISO 19906 (2019) is expected to be published in May 2019. The first edition of the International Standard for Arctic Offshore Structures was published in December 2010 (ISO 19906, 2010). This standard, coordinated by Canada, was produced by Working Group 8 within subcommittee ISO/TC 67/SC 7 Offshore Structures. Background on ISO 19906 (2010) was outlined in Spring et al (2011) and the scope of the second edition (ISO 19906, 2019) was described in Muggeridge et al (2017).

This paper highlights some of the subject areas updated in ISO 19906 (2019), including those in response to the comments received from ISO member country organizations at the Draft International Standard (DIS) ballot stage.

ISO 19906 CONTEXT AND ORGANIZATION

The relationships between ISO 19906 (2019) and other ISO Standards for offshore structures and arctic operations are shown in Figure 1.

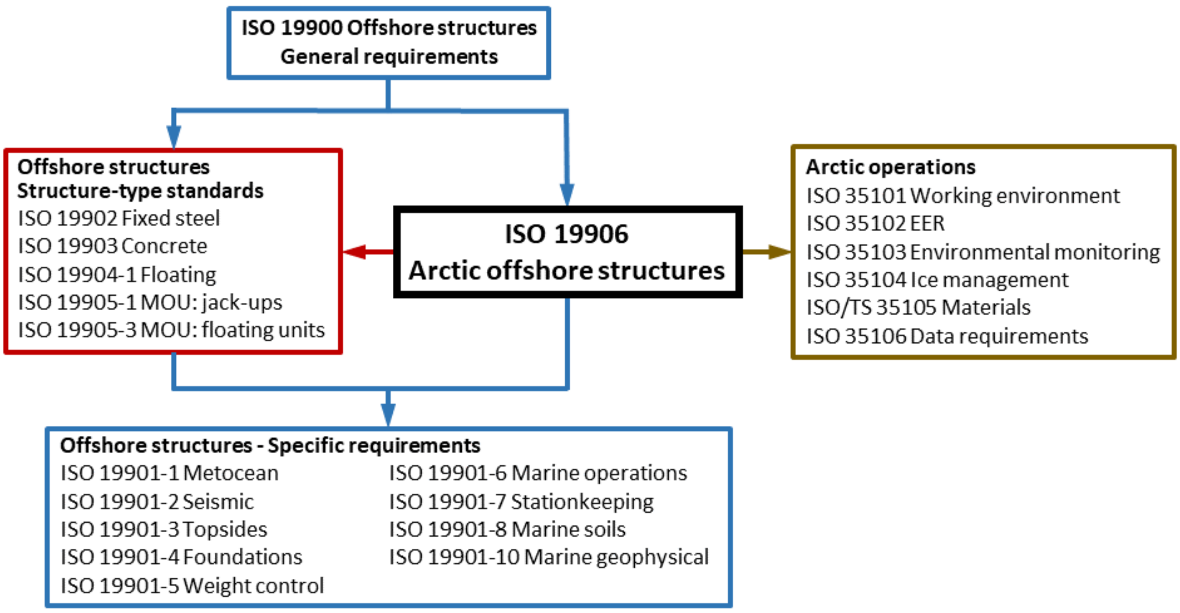

Figure 1. ISO 19906 relationships to other offshore structures and arctic operations standards

From a facility design perspective, ISO 19906 is incremental to the ISO 19900 series of standards dealing with offshore structures, prepared by ISO/TC 67/SC 7 (ISO 19900 to ISO 19906). It is complemented by the series of International Standards on arctic operations, prepared by ISO/TC 67/SC 8 (ISO 35101 to ISO 35106). While the arctic structure standard does not deal explicitly with mobile offshore drilling units (MODUs), its provisions are referenced in ISO 19905-1 and ISO 19905-3. ISO 19906 is also referenced for offshore wind turbines in ISO/FDIS 61400-3-1.

The draft ISO/DIS 35102 document, expected to be published by 2020, deals with evacuation, escape and rescue (EER) and incorporates many of the provisions of ISO 19906 (2010). ISO 35104 provides a full set of ice management requirements. ISO 19906 (2019) retains only those EER and ice management issues that influence the overall design of the offshore structure and references the EER and ice management documents for details. ISO 35106 dealing with metocean, ice and seabed data requirements also complements ISO 19906 (2019). Details on ice gouges, strudel scours and permafrost that were in ISO 19906 (2010) were moved to ISO 35106.

The clauses in ISO 19906 (2019) are listed in Table 1. The title of clause 8 has been changed to “Events and actions”, so as to better describe the contents of clause 8 which is to calculate actions from identified events. Action effects (in the previous title) arise after the structure is modelled and analysed.

Table 1. List of clauses in the newly revised version of the ISO 19906 (2019) standard

Clause	Title
1	Introduction
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	Events and actions
9	Foundation design
10	Man-made islands
11	Fixed steel structures
12	Fixed concrete structures
13	Floating systems
14	Subsea production systems
15	Topsides
16	Other ice engineering topics
17	Ice-specific operations
18	Emergency response
Annex A	Additional information and guidance
Annex B	Regional descriptions

The titles of clauses 17 and 18, dealing with ice-specific operations and emergency response have been revised to reflect the new content and the interface with the SC8 documents. Clause numbering in Annex A, the informative commentary, mirrors that for the normative clauses 1 through 18. Annex B provides descriptions for ice-covered regions in the northern hemisphere with existing or potential oil and gas developments.

KEY UPDATES FROM ISO 19906 (2010)

Operational procedures

One of the significant changes in the revision is the introduction of some key principles for safety requirements when operational procedures are involved. An ice alert system and emergency response plans should be considered for any facility, if

- operational procedures related to ice hazards are contemplated, or
- unlikely but high consequence events for which abnormal-level (AL) ice actions do not apply can occur (i.e. that annual probability of interaction is less that 10^{-4} for high consequence facilities).

For floating structures, the revision highlights emergency response plans and operational responses used to mitigate ice hazards under the ice alert system. Ice hazards can involve sea ice, icebergs, and icing. Ice conditions can be assessed in terms of proximity to facility, ice floe size, velocity, direction, ice concentration, ice pressure and other characteristics.

An ice alert system consists of a series of barriers, involving the definition of:

- a set of ice conditions or scenarios requiring operational responses related to different ice alert levels, which can include vigilance or preparedness (e.g. ice monitoring, ice detection, threat assessment), initiation of ice management activities (e.g. towing, icebreaking), and activation of emergency response plans for ice hazards;
- lead times and clear designation of roles and responsibilities associated with declaring different ice alert levels or status.

Performance requirements and recommendations to ensure timely identification of ice hazards and their mitigation through ice management, if necessary, are described in ISO 35104.

Emergency Response

Clause 18 in ISO 19906 (2019) includes two new subclauses addressing emergency response plans and measures. The subject of escape, evacuation and rescue (EER), now in subclause 18.3, is limited to those issues that influence the overall design of the offshore structure. The other EER provisions have been moved to ISO 35102, for which the final standard is expected to be published by 2020.

Emergency response plans include strategies in anticipation of possible hazardous events such as those due to ice hazards or failure of the ice management system, and strategies in response to damage caused by hazardous events. Emergency response plans are required to include measures to ensure:

- safety of personnel for manned platforms;
- security of hydrocarbons and other pollutants, such that no spill onto the ice or into the water occurs.

These measures can involve shut-in of wells, down-manning, evacuation, disconnection and move-off location.

Low Temperature Provisions

A significant revision to the standard involves low temperature specifications. An important part of the changes involves separate definitions for lowest anticipated service temperature (LAST) and lowest operating service temperature (LOST).

LAST is typically associated with materials, notably steel, where ductility is influenced by temperature, and is most linked to testing temperature, see ISO 19902 and ISO/TS 35105. ISO 19906 (2019) specifies that the LAST shall not be taken as warmer than -10°C for structures in arctic and cold regions. If a test temperature based on ISO 19902 is calculated to be colder than -60°C, special considerations should be given to material thickness and service conditions in order to establish an appropriate test temperature. In such cases, the test temperature should not be warmer than -60°C.

LOST is used for winterization of non-structural and non-critical equipment and materials, and, in the absence of regulations, can be specified by the owner. Safety critical systems and equipment, however, are subject to extreme-level (EL) minimum temperatures (i.e. associated with an annual probability of 10^{-2}; a 100 year return period).

Provision is also made for recognizing that temperatures can depend on the location on the facility, whether exposed to ambient air, in water and below the seabed, and in enclosed spaces. Further details on LAST, LOST and steel testing are given in Eik and Thomas (2019).

Ice events and actions

In ISO 19906 (2019), subclause 8.2 has been retitled “Ice events and actions”. The terms “design ice event” and “design ice action” are defined more rigorously and align with the overall design philosophy outlined in ISO 19900. A limit state design approach is used for design situations where EL and AL ice actions are calculated and combined with other actions to perform limit state design verification.

An ice event is an occurrence of ice-structure interaction for which ice actions can be calculated. In this approach, an ice action hazard curve is constructed for a population of ice events from which EL and AL actions are calculated. These concepts are described in Maskevitch and Thomas (2019).

Global and local ice actions

An important change in the revision to the standard is that the global sea ice pressure equation includes a correction factor for narrow structures based on field measurements on structures in the Baltic Sea.

A clearer basis for the limit force formulation, representing actions associated with the ridge building processes, is provided to assist with parameter specification. This approach can be used for actions transmitted from thick ice features lodged against a structure.

Changes have been made with respect to the calculation of first-year ridge actions on sloping and conical structures, and a new formulation involving breaking and clearing mechanisms has been included for multi-year ridge actions on conical or sloping structures.

A number of analytical models for global ice actions in the standard rely on some key physical properties. In the revision, clarifications with respect to their specification have been made for a number of these, and especially the friction between the ice and the structure surface and ice on ice friction, see Høyland et al (2019).

The approach for estimation of ice growth from ambient air temperature (i.e. freezing degree days) has been amended to include default parameter values and completely rewritten to provide better context.

Progress has also been made towards achieving consistency in models for ice actions with the EL and AL ice actions used for design, see Ralph (2019). The ice strength multiplier in the global sea ice pressure equation can be scaled to consider exposure, the annual number of interaction events or ice drift ice past the structure. As well, the local pressure-area equation based on data for thick ice features is now related to the number of impacts per year.

Frederking (2019) also provides a test case for the specification of global and local ice actions based on the revision to the standard.

Ice-induced vibration

Ice-induced vibration due to sea ice interactions can be a significant concern for any vertical or near-vertical structure. It can also affect other structures for which the natural period of vibration is close to the period of ice failing against the structure. Ice-induced vibration can occur for a large range of ice thicknesses and ice drift speeds.

ISO 19906 (2019) has added clarification of ice-induced vibration content. It provides the user with an approach to identify whether ice-induced vibration is likely to occur and methods for estimating the amplitude range for the repetitive ice action, see also Hendrikse (2019).

Model testing

Physical model testing can be an important tool when assessing ice actions on various types of facilities. ISO 19906 (2019) incorporates modifications to ensure that the models, ice properties, technologies and approaches are appropriate to the full-scale circumstances to be modelled. The standard does not limit the applicability of the type of model testing facilities and approaches presently available and that might be used in the future.

Strategies for floating structures

Numerous changes have been made in ISO 19906 (2019) with respect to floating structures, as described in Makrygiannis et al (2019). The most obvious change is in the categorization of floaters based on four design approaches for response to ice, as follows:

- passive (without ice management support or ability to disconnect for ice hazards);
- semi-passive (with ice management support only);
- semi-active (with disconnection capability only);
- active (with ice management support and disconnection capability).

Significant new material has been added to clarify procedures for estimating EL and AL ice actions when operational measures, i.e. ice management and disconnection/move-off, are used to meet the design criteria. Ice alert procedures are based on an operating envelope of ice conditions and criteria that reflect hull capacity, stationkeeping capabilities, weathervaning capability and any assistance provided by the ice management fleet to ensure these capabilities. The revision introduces the concept of an operating envelope and its relationship with the design characteristics of the floating system.

Man-made islands and land extensions

In addition to addressing man-made islands, clause 10 in ISO 19906 (2019) is enhanced to address land extension. Work on land extensions originally planned for a separate standard under ISO/TC 67/SC 8 (Arctic operations) has been incorporated in the revision of ISO 19906, because considerations for design, construction, monitoring and maintenance, and decommissioning and removal are similar.

New provisions for construction are included, with emphasis on the quality control of fill and armour rock by measurement, sampling, and testing. There are expanded provisions for slope and slope-protection monitoring in service. The commentary (Annex A.10) was expanded to discuss island and land-extension types, coastal engineering, and slope protection, as well as further information on construction, and monitoring and maintenance.

RECENT, CURRENT AND FUTURE PROJECTS

Since its initial publication, ISO 19906 (2010) has been the primary reference standard for the design of offshore structures for the oil and gas industry in arctic and cold regions. Recent, ongoing and proposed offshore developments span many arctic and cold regions, and illustrate the range of different structure types that can be used effectively.

Offshore oil and gas developments coming on stream since 2010 include Prirazlomnaya in the Pechora Sea in northern Russia, the Sakhalin-I Arkutun-Dagi field in eastern Russia, and the Hebron development in eastern Canada. Prirazlomnaya (First Oil December 2013) is a gravity-based structure in 20m of water, designed to withstand heavy sea ice conditions (see Figure 2). The Sakhalin-I Berkut platform (First Oil January 2015, see Figure 3) is a four-column concrete gravity-based structure in 35 m water, designed to withstand high seismic loads, sea states, cold temperatures and first year sea ice, ridges, and stamukhi. Hebron (First Oil November 2017) is a gravity-based platform in 93 m of water, consisting of a reinforced concrete structure with a cylindrical base of approximately 130 m diameter and designed to withstand sea-ice, icebergs and metocean conditions (see Figure 4).

Figure 2. Prirazlomnaya in the Pechora Sea, offshore Russia (photo courtesy of United Shipbuilding Corporation)

Figure 3. Berkut platform, Arkutun-Dagi field, Sakhalin (image from http://sdelanounas.ru)

Figure 4. Hebron, Grand Banks, Canada (photo courtesy of ExxonMobil)

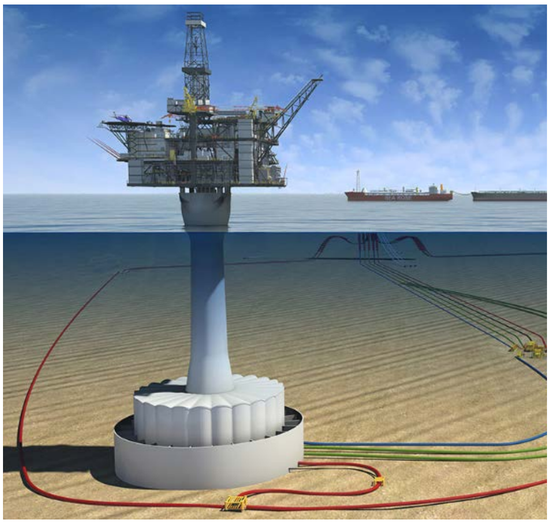

Figure 5. Wellhead platform for West White Rose field, Grand Banks, Canada (http://westwhiteroseproject.ca/about/)

For the Amauligak project in the Canadian Beaufort Sea, shelved indefinitely in 2014, the proposed facility involved a gravity base structure in 30 m of water designed to withstand loads from multi-year sea ice.

The West White Rose Wellhead Project (First Oil expected 2022) is currently being built for operation off Canada's East coast. This is a concrete gravity structure (CGS) wellhead platform (see Figure 5) that will produce back to the White Rose FPSO. The CGS design is 122m diameter at its base and 145m high, and will be in approximately 120m of water depth. It is designed to withstand sea states (storms), icebergs, and milder sea ice.

At Kalamkas in the north Caspian Sea (First Oil expected 2026 or 2027), the proposed structural concept is a large gravel island, similar to those in the nearby Kashagan field, in Kazakhstan. The shallow water depth (less than 10 m) and large production facilities make the choice of caisson-retained islands attractive. Due to ice rubble build-up, the design also involves satellite ice protection structures to ensure reliable vessel access and EER during the ice season. At the nearby Khazar field, a smaller diameter sloping structure is anticipated.

In the Norwegian part of the Barents Sea, the Johan Castberg and Wisting fields are in the development process. In each case, there is potential for iceberg hazards. At Johan Castberg, a non-disconnectable FPSO is planned (see Figure 6), while different floating structure options are being investigated for Wisting. At Bay du Nord, in Canada's Flemish pass off Newfoundland, a disconnectable FPSO is anticipated in an approximate water depth of 400 m.

Figure 6. Proposed FPSO for the Johan Castberg field (concept graphic courtesy of Equinor)

CONCLUSIONS

The revised ISO 19906 (2019) standard has changed significantly from the first edition (ISO 19906, 2010). Key clauses have been updated incorporating advances in arctic technology and engineering for which consensus has been achieved. ISO country member comments on the Draft International Standard (DIS) were the source for other changes to the document. Best efforts have also been made to update ISO 19906 in the context of ongoing updates to the ISO 19900 series of standards prepared by ISO/TC 67/SC 7 and to the arctic operations series of standards (ISO 35101 to ISO 35106) prepared by ISO/TC 67/SC 8.

The second edition of ISO 19906 (2019) will be ready for adoption and use as one of the ISO 19900 series of standards for offshore structures. As with the 2010 edition, it is expected that ISO 19906 (2019) will be adopted worldwide by national standards bodies, and applied by regulators and companies operating in the oil and natural gas industries in arctic and cold regions.

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