Bruk av temperaturdata for vinterisering

Barents Sea Exploration Collaboration (BaSEC) er et industrisamarbeid for å forberede leteoperasjoner i Barentshavet. BaSECs siktemål er å koordinere operatører og komme med anbefalinger om tiltak som kan danne grunnlag for sikker og effektiv letevirksomhet i Barentshavet. BaSEC har 16 medlemmer, alle operatører på norsk sokkel. BaSEC bygger sine rapporter på beste tilgjengelige kunnskap og på den brede erfaring disse 16 selskapene har fra operasjoner på norsk sokkel og i andre områder med tilsvarende forhold.

Når man planlegger for operasjoner i områder med lave temperaturer er det viktig å ha en klar definisjon om hvilken temperatur man snakker om, hvilke forhold temperaturdefinisjonen er gjeldende for og hvordan bruk av denne definisjonen kan påvirke operasjonen.

Slik situasjonen er i dag, er ikke bruk av de ulike temperaturdefinisjonene i etablerte standarder og reguleringer klare. Avhengig av hvordan standardene og reguleringene tolkes vil dette kunne få forskjellige implikasjoner for vinterisering fra rigg til rigg.

BaSEC ser derfor et behov for å klargjøre retningslinjer og krav fra DNV GL og Petroleumstilsynet (Ptil) i samarbeid med industrien. På denne måten kan man komme frem til løsninger som sikrer enhetlig og konsistent applikasjon av vinteriseringsstandarder for industrien. Det er etablert en dialog rundt dette spørsmålet som fremkommer av de to påfølgende notat og vil følges vildere av BaSEC i 2016.

Memo

To

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Copy (Statoil) Åshild Tandberg Skjærseth, , Catherine Jahre-Nilsen, Øystein Bråthen

From Kenneth J. Eik

Subject **Workshop on temperature definitions and use of temperature data**

1 Introduction

In relation with Arctic projects some of the initial BaSEC[1] companies have experienced lack of clarity with respect to use of air temperature data for different applications. As both exploration and project developments take place in colder regions, the vulnerability for low air temperatures is increasing. In order to contribute towards increased understanding of temperature definitions and correct use of air temperature parameters, the initiative towards a workshop on use of air temperature data was made. The workshop was arranged jointly by BaSEC and DNV GL at Statoil, Fornebu, October 12th, 2015.

This memo summarizes the key messages from the workshop. The memo is written by Statoil after the workshop and has been circulated to selected participants for comments prior to finalization. None of the participants besides the author can however be held responsible for the content in the case it should include incorrect information or subjective views.

After the workshop, DNV GL has also prepared a memo answering many of the questions raised during the workshop. This memo is distributed together with this memo and can be made available outside BaSEC by request to DNV GL (by Steven Sawhill).

[1] Barents Sea Exploration Collaboration = BaSEC 2015 (ENI, Lundin, Engie, OMV and Statoil)

The workshop agenda is included in Appendix A, list of participants in Appendix CB and workshop objectives in Appendix C. All presentations are uploaded to the BaSEC teamsite for metocean and ice and can be made available on request also outside BaSEC.

2 Access to air temperature data

Data on air temperatures can be made available both from physical recordings and from numerical models. Physically, air temperatures can be recorded from met-stations on land, on vessels, on offshore rigs and from weather buoys. Temperature data can also be recorded from satellites but the data will then have to be calibrated by data from other sources. Numerical models are able to reproduce long time series of air temperature variations within model domains – so called hindcast. The advantage by using hindcast data, besides getting long continuous time series, is that it allows data to be extracted from different elevations and it allows for comparisons between different geographical locations.

For Norwegian waters, Statoil recommends use of the Nora 10 hindcast archive. Nora 10 is developed by the Norwegian Metoffice on behalf of the Norwegian Deepwater Programme (NDP). All companies outside NDP may buy access to Nora10 data for limited costs by sending request to Værvarslinga på Vestlandet (Met.no). Nora 10 provides wind, wave and temperature data every third hour continuously in the period 1957-2015 for the entire domain shown with red colors in Figure 2. Air temperatures can be extracted from 2 m, 30 m, 100 m and 180 m elevations. Statoil has compared Nora10 temperatures with temperatures recorded locally at different locations including the Barents Sea. Extreme low temperatures may be underestimated with up to -2ºC in Nora10 (Figure 2 b). The air temperatures in Nora10 represent 1 hourly values but are sampled every third hour.

Based on the Nora 10 time series, it is possible to provide good quality estimates on normal, severe and extreme temperatures with selected averaging intervals and at sea surface level or at rig deck level.

(a) (b) (c) (d) (e)

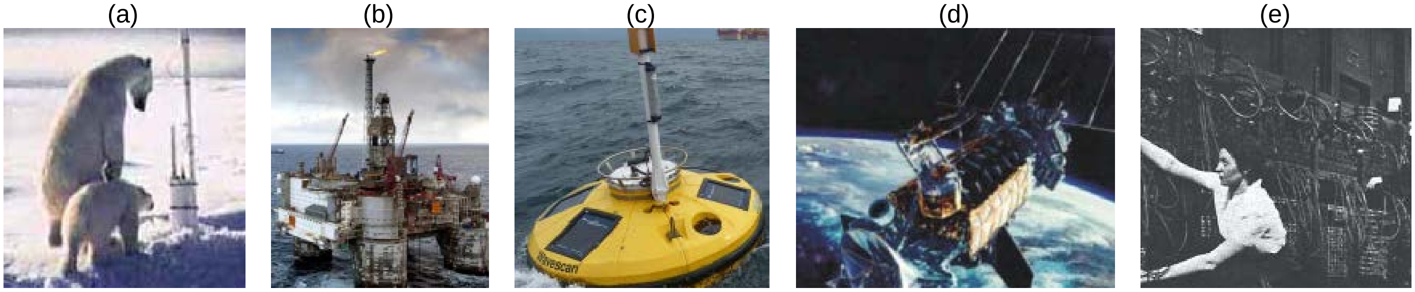

Figure 1. Temperature recordings from a) Met station on ice, b) Rig, c) Wave buoy, d) Satellite and e) Model data from weather models.

(a) (b)

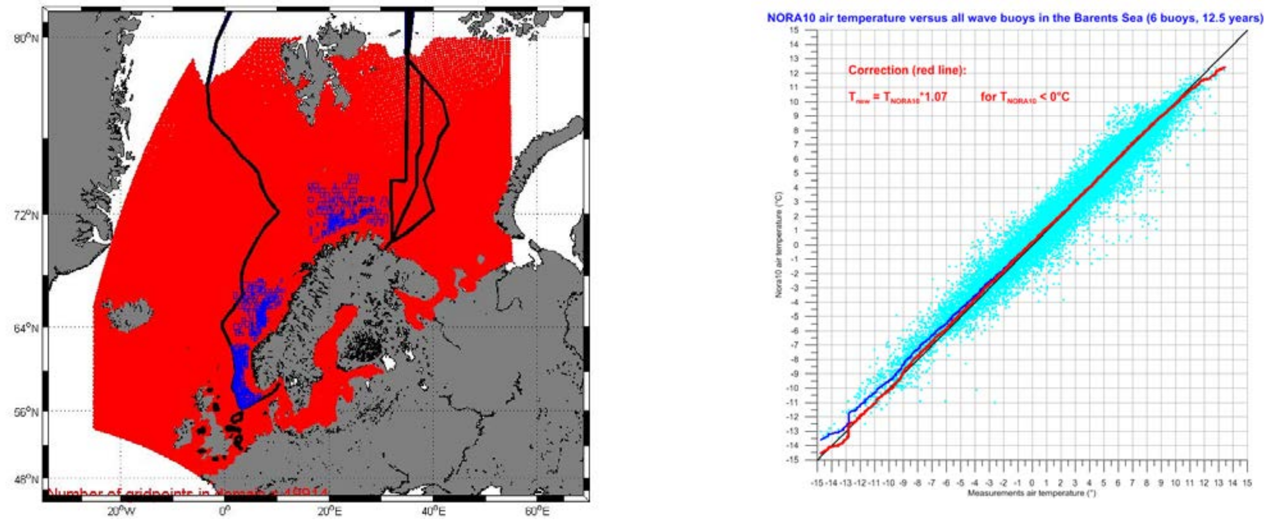

Figure 2. a) Nora 10 model domain and b) scatter plus qq plot of simultaneous measured and modeled temperature data in the Barents Sea.

3 Standards and temperature definitions

DNV GL presented a good overview of the most used air temperature definitions both for shipping, Mobile Offshore Units and Offshore Installations (Figure 3). Some of the definitions are further illustrated together with the Mean Daily Average Temperature (MDAT) curve from Bjørnøya (Figure 4).

Three of the temperature definitions are further highlighted as they are considered to be more central than others:

1. **Lowest Mean Daily Average Temperature (LMDAT)**
   At least 10-year with temperature data[2] is required to calculate LMDAT. For a time series with 10-year duration it means there will be 10 daily average temperature values for each calendar day. By averaging the 10 values for each day, the curve for Mean Daily Average Temperature (MDAT) can be established (as shown in Figure 4). LMDAT is the lowest temperature along the MDAT curve. It is not specified in any code which elevation LMDAT refers to. LMDAT is not an extreme temperature in any way and cannot be associated with a fixed probability of exceedance level. Usually, the term "design temperature" or "material design temperature" refers to LMDAT.

2. **Lowest Anticipated Service Temperature (LAST)**
   LAST is specified as 1-hour average temperature exceeded with annual probability of 10^{-2} per year. Exceeded in this respect means that temperatures becomes lower than LAST. As for LMDAT, at least 10 year with good quality data is required to provide good estimates for LAST. A practical approach is to identify the lowest 1-h temperature each winter and then fit a Gumbel distribution to all the annual minimum temperatures. By extrapolating the Gumbel distribution, LAST can be found as the value exceeded in 1 out 100 years (i.e annual probability of exceedance is 0.01). It is not specified in any code which elevation LAST refers to.

3. **Reference Extreme Temperature ≈ Winterization Temperature (T_w)**
   T_w primarily is a parameter of relevance when end users request class notations on vessels and rigs. The DNV GL Winterisation standard [1] specifies that T_w **should** be selected by the end user to represent LAST as defined in ISO 19906 [2]. DNV GL also states that T_w shall not be colder than -15ºC relative to material design temperature (t_d). If the coastal (shelf) state doesn't require winterization temperature to be less than or equal to LAST, DNV GL will not necessarily require it either.

[2] 10-years is considered within the international metocean society to be a minimum amount of data to capture interannual variations in parameters such as, waves, winds and air temperatures. Current guidance of both DNV GL and International Association of Classification Societies (IACS) calls for use of 20-year data series for calculation of LMDAT but do currently consider reducing to minimum 10-years.

Symbol	Meaning	Reference	Use
t_D, t_d	Design temperature; Material design temperature	IACS UR S6.3 and DNVGL Rules for Ships	Ship winterization Selecting steel grade
t_w	Winterization temperature	DNVGL-OS-A201	Offshore winterization
t1, t2	Design temperature and Extreme design temperature	DNV Rules for Ships (pre-July 2013)	Ship winterization
DAT(t)	Design ambient temperature	DNVGL Rules for Ships	Class notation for struct material selection
PST	Polar service temperature	IMO Polar Code	Polar Code compliance
LMDAT	Lowest mean daily average temp.	IACS UR S6.3, DNVGL Rules for Ships, and DNVGL-OS-A201	Setting t_D, t_d, t1, DAT(t) Selecting steel grade
LMDLT	Lowest mean daily low temperature	IMO Polar Code	Setting PST PST ≤ LMDLT – 10°C
ELT	Extreme low temperature	DNVGL-OS-A201	Setting t_w
LAST	Lowest anticipated service temperature	ISO 19906	Setting t_w
RP100	Extreme low air temperature with an annual probability of exceedance not greater than 10^{-2}	ISO 19906 and NORSOK N-003	Setting LAST

Figure 3. Summary of relevant temperature definitions and reference documents.

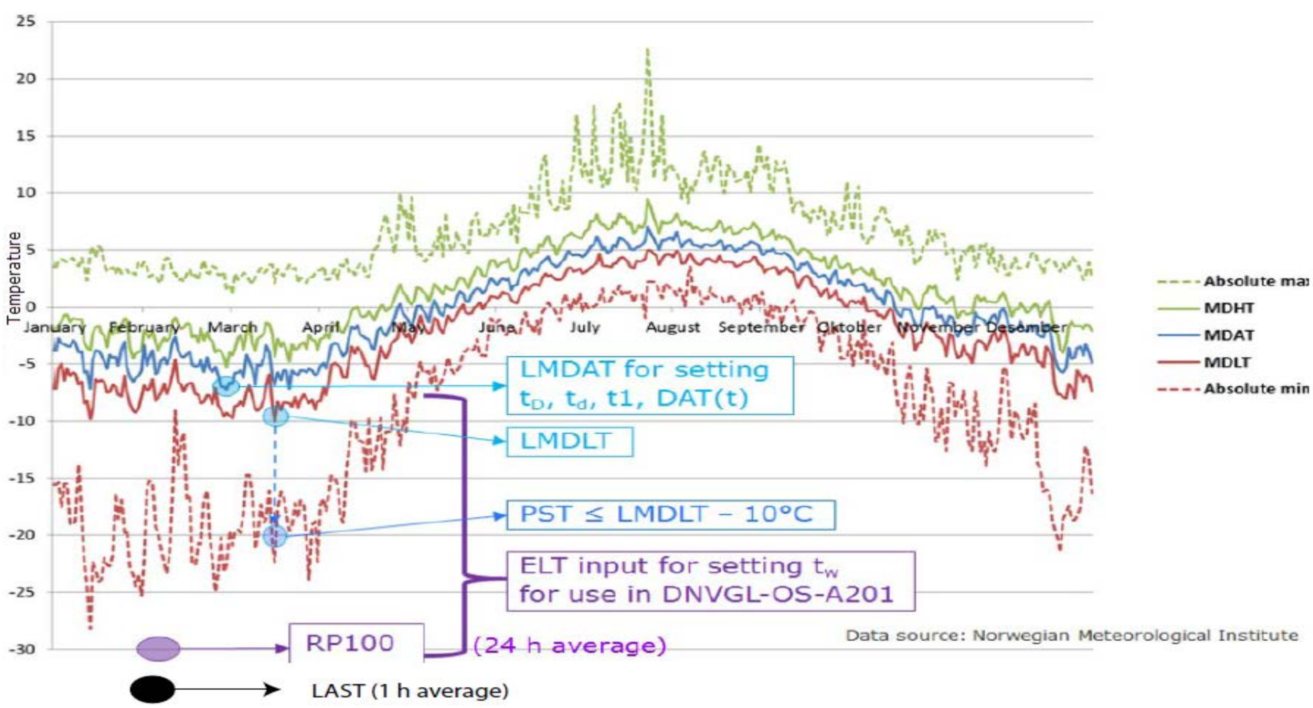

Figure 4. Mean Daily Average Temperature (MDAT), Mean Daily High Temperature (MDHT) and Mean Daily Low Temperature (MDLT) based on 15 years with recorded data from Bjørnøya. Values for key temperature parameters are indicated. Note: LAST refers to 1-hour average temperatures while other parameters refer to 24-hour average values.

4 Use of temperature data

Low air temperatures are of concerns of several reasons whereof the most obvious are as follows.

- Change in material properties (examples in Figure 5)
- Safety critical equipment malfunctioning
- Reduced functionality of equipment required for normal operations
- Negative effects on working environment

Consequences of changes in material properties are both that equipment stops working as intended and that loadbearing resistance in structures may be reduced. Effects on safety critical equipment may be e.g frozen firewater and inability to launch life boats as examples. With respect to working environment, the cooling of personnel on deck is the main concern.

As shown in Figure 3, LMDAT is used for selection of steel grades both for offshore units as well as for traditional ships. T_w, is used for winterization considerations. LAST is intended used for offshore structures both permanent and mobile and used for e.g. material selection in structural design, selection of topsides materials, material selection in design and rating of mechanical systems, equipment, instrumentations etc. For working environment considerations, the Wind Chill Temperature (WCT) (or previously wind chill index) is applied. WCT is an artificial temperature taking into account that the cooling of a human body is more severe in strong winds than in calm conditions.

Several of the presentations from the workshop provide clarifications regarding use of temperatures for different applications. Further, documents listed in the reference list do all specify or provide guidance on how to use temperature data.

	Failure mechanism		
Material category	**Plastic overloading**	**Brittle fracture**	**Failure by large changes of temperature**
Welded structural steel	**Strength increase**	**Toughness drop**	**Thermal stresses formed ***
Aluminium Titanium, stainless steel	**Strength increase**	**Toughness maintained**	**Thermal stresses formed ***
Polymer Composites	**Strength increase**	**Toughness maintained**	**Thermal stresses formed ***
Thermo-plastics	**Strength increase**	**Toughness drops**	**Cracking**
Rubber sealings	**Strength increase**	**Toughness drop ***	**Cracking**

Figure 5. Low temperature effects on materials. * Normally not a problem!

5 Workshop takeaways

Discussions and clarifications were made during the presentations. Some of the takeaways from the workshop are as follows:

- When using air temperature data, it should be clarified which elevation and averaging interval the data relates to. Extreme temperatures should be related to pre-defined levels for annual probability of exceedance.

- For the entire Norwegian shelf, including the Barents Sea, it is possible to provide good data for any averaging interval above 3 hours and for elevations between 2 m and 180 m above the sea surface.

- In the Barents Sea, extreme low temperatures are about -2^{0}C lower at 30 m compared to the sea surface (2 m elevation). In order to ensure consistent use of air temperature data new and/or updated standards should use 30 m elevation as default for all application from deck level and downwards. For applications related to e.g. derricks, temperature data from relevant elevation should be applied.

- LAST refers to 1-hour average values. With exception of Wind Chill Temperature calculations, the workshop participants have not identified any practical applications requiring 1-hour temperatures. Reason for this is that cooling of structural elements and equipment takes time. It would be more beneficial if defined temperature parameters are based on longer averaging intervals which are of importance for the applications considered.

- Use of modern formulations for Wind Chill Temperatures allows for relatively simple use of temperature data when assessing the working environment. It is not specified which elevations or averaging intervals to be used for temperatures in WCT calculations. However, since winds are specified with 1-hour averaging time and elevation 8.5 m above head of personnel, temperatures used in WCT calculations should refer to the same averaging interval and elevation.

- For load bearing structures and structural elements it should be recognized that simultaneous extreme values for both forcing parameters (e.g. wind) and air temperatures are unlikely to occur. When considering extreme loads vs structural resistance it will for many applications be conservative to use LAST for material properties. An alternative would be to use air temperatures associated with the environmental forcing or a value slightly colder than the associated value.

- ISO 19906 clause 13.8.1.2 specifies that essential systems and equipment shall be rated to perform design functions at the minimum EL or AL temperature. This appears to be a meaningless requirement as Accidental Level (10^{-4}) temperatures obviously will be more severe for all equipment compared to Extreme Level (10^{-2}) Temperatures. The rational for considering AL temperatures is unclear and workshop participants did not see any applications requiring use of 10^{-4}.

- Any standard that defines LMDAT and recommends use of this should also include a figure with the MDAT curve to avoid misinterpretation of LMDAT (similar to Figure 4).

- Existing temperature definitions have caused confusion for the Barents Sea operators. Despite clarifications in this memo, the new memo from DNV GL (Appendix A) and the good presentation given by the participants, there is still lack of clarity regarding which temperatures to use for what purposes. Possible consequences are that vessels and rigs either “over-winterized” or alternatively “not fit for purpose” are used.

- The best way to ensure correct, consistent and appropriate use of air temperature data would be to define unambiguous parameter definitions and clarify intended use. These definitions must clearly refer to averaging interval, elevation and probability level. The definitions should be related to LMDAT and LAST in a consistent way.

6 Way forward

Since the industry currently is preparing for license blocks announced in the 23rd concessions round and some operators are planning exploration drilling relatively far North in the Barents Sea, it is considered urgent with clarifications on how to use air temperature for a number of applications.

Personnel involved in development of the new ISO standards for Arctic Operations[3] are encouraged to use the material from the workshop and provide guidance both on temperature definitions and intended use. Correspondingly, use of air temperature data should also be considered in ongoing updates of existing standards such as ISO19906, Norsok M120, N003 and S002 as examples. Further, communication across disciplines amongst personnel involved in the standardization work is encouraged.

It would be beneficial with a good list of temperature definitions and clarifications for future users of DNV, Norsok and ISO standards. Table 1 illustrates how such a list **could** look like. It should be noted that some of the suggested parameters are new and some are defined slightly differently than in existing standards. Such a table could potentially be included in Clause 6 (or A6) in ISO 19906 on Arctic Offshore Structures which currently is being updated.

Table 1. Suggested list of parameter definitions including descriotion on how to estimate values and types of revevant applications.

Name	Definition	Applications
LMDAT	Lowest Mean Daily Average Temperature. 24 hour average temperature Based on time series of minimum 10 year with continuous data, at 30 m elevation.	Selection of material grades
LAST	Lowest Anticipated Service Temperature **6 hour** average temperature Corresponding to annual probability of exceedance of 10^{-2} Based on time series of minimum 10 year with continuous data at 30 m elevation	Safety critical equipment to be documented as functional when exposed to LAST
WCT	Wind Chill Temperature Based on formulation as suggested by 1 hour average temperatures to be used as input to formulations Combined wind and temperature time series of minimum 10 year recommended to provide statistics for WCT Use 30 m elevation for offshore installations and mobile offshore units Use 10 m elevation or alternatively 30 m elevation (conservative) for vessels.	Working environment
T_w	Winterization temperature 24 hour average temperature Not allowed to be less than -15ºC below material design temperature Need to be consistent with shelf state requirement. If shelf state require use of LAST, material design temperature may sometimes have to be	Used to assess functionality of equipment

[3] Specifically ISO35101 Arctic Working Environment, ISO35105 Arctic Materials and ISO35106 Metocean, Ice and Seabed in the Arctic.

	less than LMDAT.	
$T_{ass\text{-}wind}$	Air temperature associated with extreme (10^{-2}) winds 1 hour average temperature at 10 m elevation (same as wind)	Used to assess structural capacity in extreme loading conditions caused by winds
$T_{ass\text{-}wave}$	Air temperature associated with extreme (10^{-2}) waves 1 hour average temperature at 10 m elevation	Used to assess structural capacity in extreme loading conditions caused by waves

7 References

1. DNV GL OS A-201 *Winterization for Cold Climate Operations* (2015)
2. ISO 19906:2010 Petroleum and natural gas industries – *Arctic offshore structures* (2010)
3. IACS, Unified requirements UR S6, *Use of steel grades for various hull members – Ships of 90 m in length and above*, Rev. 7 (2013)
4. DNV GL Rules for Classification - Ship, DNVGL-RU-SHIP Pt.6 Ch.6 Sec.4 *Design Ambient Temperature (DAT)* and DNVGL-RU-SHIP Pt.6 Ch6 Sec.3 *Operation in Cold Climate – Winterized* (2015).
5. *International code for ships operating in polar waters* (Polar Code). Adopted by IMO resolution MSC.385(94) of 2014-11-21 and resolution MEPC.264(68) of 2015-05-15.
6. NORSOK Standard N-003 Action and action effects, Edition 2, September 2007.
   URL: http://www.standard.no/

Appendix A – Workshop agenda

Time	Subject	Responsible
09:00-09:20	Welcome, introduction and objectives	Kenneth Eik
09:20-09:40	Air temperature data – what is available for Norwegian shelf and what is the consequence of varying averaging intervals, return periods and elevations?	Einar Nygaard
09:45-10:05	Temperature data for design - Materials	Agnes M. Horn
10:10-10:30	Temperature data for design – Offshore class rules	Ove Garen
10:30-10:45	Coffee break	
10:45-11:05	Temperature data for Winterization of rigs	Steven Sawhill
11:10-11:30	Application of ISO 19906 temperature	Rolf Lande
11:35-11:55	Temperature data in design of offshore structures	Per Olav Moslet
12:00-12:45	Lunch	
12:45-13:15	Needs for clarifications on temperatures in ISO 35101, 35105 and 35106 (Working Environment, Materials and Metocean in the Arctic respectively)	Mons Hauge, Arne Haugan, Pavel Liferov
13:15-14:15	Discussions and questions	All
14.15–14:30	Coffee break	
14:30-15:45	Discussions and questions	All
15:45-16:00	Summary and way forward	Kenneth Eik

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Appendix C – Workshop objectives

- Increase awareness regarding use of air temperature data and contribute towards «correct» use in the future.
- Get expert views on the “usefulness” on existing air temperature definitions
- Suggest and agree on appropriate definitions for temperature parameter applicable for defined tasks.
- If definitions in existing standards are revealed not to be appropriate for intended use or if definitions are ambiguous and unclear – the participants should suggest improvements and seek consensus regarding possible applications.
- Provide a foundation for a common approach amongst Barents Sea operators on all issues related to low air temperatures

DNV·GL

Memo to:
Kenneth J. Eik, Statoil

Copied to:
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Memo No: 1XH3HD3-3/ STESAW
From: Steven Sawhill, Maritime Advisory (MANNO279)
Date: 2015-11-20
Verified by: Espen Wetterhus, Offshore Safety & Systems (MOANO384)

USE OF TEMPERATURE IN STANDARDS AND CLASSIFICATION RULES FOR OFFSHORE INSTALLATIONS

1 INTRODUCTION

DNV GL appreciates the initiative of the BaSEC companies in arranging the Workshop on Temperature Definitions and Use of Temperature Data, held at Statoil Fornebu on 12 October 2015. The workshop provided a valuable opportunity to discuss how cold temperatures affect the participants' operations. It contributed to increasing general awareness and understanding of existing temperature definitions in various codes, standards and classification rules.

Given feedback we received during and after the workshop, DNV GL desires to take this opportunity to:

- Correct some inaccuracies in its presentations given at the workshop;
- Clarify some issues on the use of temperature in DNV GL standards and classification rules; and
- Outline actions that DNV GL is taking.

2 COMMON TEMPERATURE DEFINITIONS

DNV GL presented an overview of common temperature definitions currently in use for the design and operation of ships, mobile offshore units and offshore installations. These are outlined in Figure 1, some of which are illustrated in Figure 2, which presents a set of temperature curves based on recorded temperature observations at Bjørnøya from 1998 to 2012.

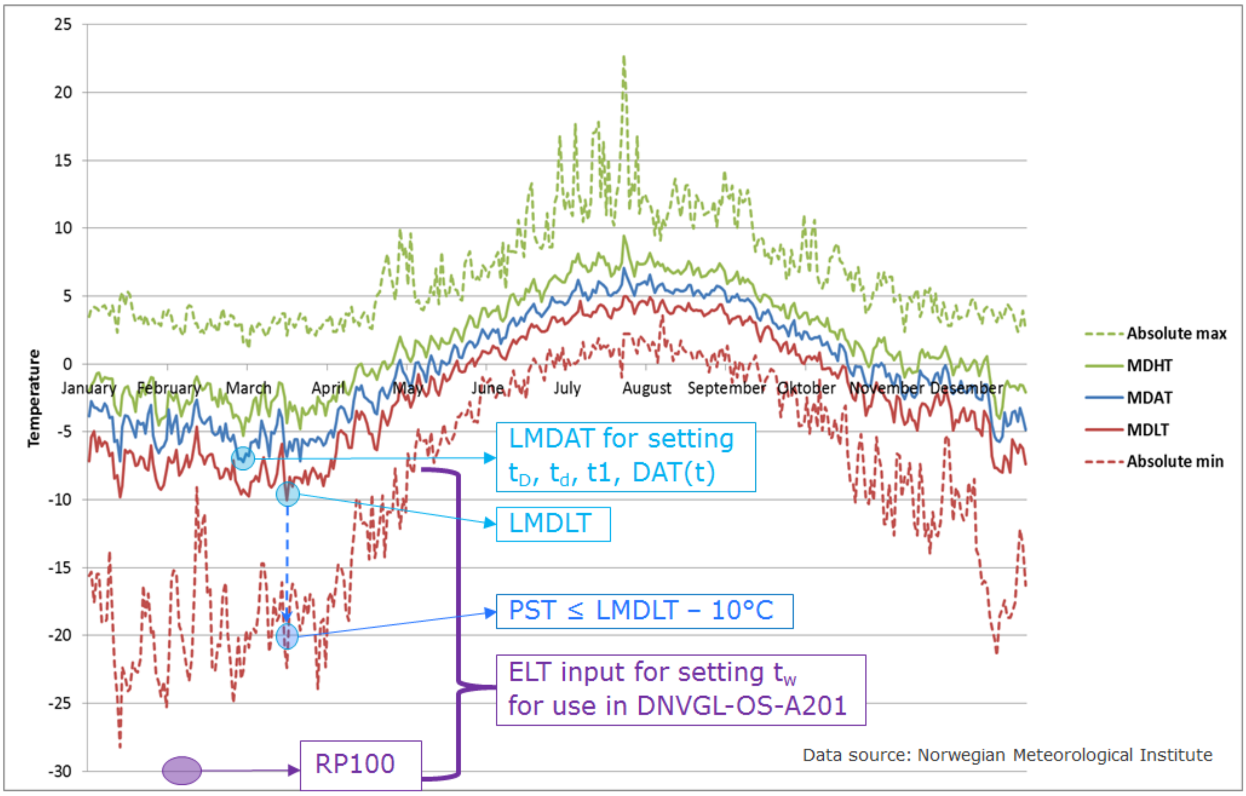
Both Figure 1 and Figure 2 were revised after the workshop in response to questions and feedback, with the aim of resolving any confusion on their use.

Figure 1 – Common temperature definitions

Symbol	Definition	Reference	Applicable for:
t_D, t_d	Design temperature; Material design temperature	IACS UR S6.3 and DNVGL Rules for Ships	Ship winterization Selecting steel grade
t_w	Winterization temperature	DNVGL-OS-A201	Offshore winterization
t1, t2	Design temperature (t1) and Extreme design temperature (t2)	DNV Rules for Ships (pre-July 2013)	Ship winterization

Symbol	Definition	Reference	Applicable for:
DAT(t)	Design ambient temperature	DNVGL Rules for Ships	Class notation for structural material selection
PST	Polar service temperature	IMO Polar Code	Polar Code compliance
LMDAT	Lowest mean daily average temp.	IACS UR S6.3, DNVGL Rules for Ships, and DNVGL-OS-A201	Setting t_D, t_d, t1, DAT(t) Selecting steel grade
LMDLT	Lowest mean daily low temperature	IMO Polar Code	Setting PST PST ≤ LMDLT – 10°C
ELT	Extreme low temperature	DNVGL-OS-A201	Setting t_w No prescribed definition
LAST	Lowest anticipated service temperature	ISO 19902, ISO 19906	Offshore installation design
RP100	Extreme low temperature with an annual probability of exceedance not greater than 10^{-2}	ISO 19906 and NORSOK N-003	Setting LAST

Figure 2 – Temperature definitions illustrated using observations at Bjørnøya (1998–2012)



3 TEMPERATURE USAGE IN DNV GL STANDARDS AND RULES

3.1 General

In DNV GL, two principal temperature terms are used:

- Design temperature (t_d) – used in both ship and offshore classification; and
- Winterization temperature (t_w) – used in offshore classification.

3.2 Design temperature (t_d)

For ships – T_d is the principal term used in DNV GL Rules for Classification of Ships with respect to cold climate operations. It is used in two contexts:

- As one of several parameters in selecting appropriate steel grades for the construction of ship structures for use in cold climate (Ref. 1); and
- As a parameter for setting ship winterization performance requirements (Ref. 2).

For offshore – T_d is used by DNVGL-OS-C101, *Design of offshore steel structures*, as one of several parameters in selecting appropriate steel grades for construction of offshore structures (Ref. 3).

DNV GL usage of t_d in its own classification rules and standards is based upon the LMDAT framework. Our definition of t_d and LMDAT—and their use in selecting materials—are harmonized with those of the International Association of Classification Societies (IACS) in its Unified Requirements (Ref 4).

- Current guidance of both DNV GL and IACS call for using at least a 20-year data series for calculating LMDAT. A proposal to reduce this to at least a 10-year data series is currently under consideration within IACS, but this proposal has not yet been adopted by IACS or implemented by its members.
- Neither DNV GL nor IACS specify how often or at what elevation temperature readings shall or should be recorded for calculating LMDAT.

3.3 Winterization temperature (t_w)

3.3.1 Definition of t_w

The winterization temperature (t_w) is defined by DNV GL as a *reference extreme low air temperature* that governs the technical provisions contained in offshore standard DNVGL-OS-A201 (Ref. 5; see Ch.1 Sec. 1 [1.4.5]).

DNV GL does not prescribe a single definition, framework or methodology for specifying t_w.

3.3.2 What t_w is used for

T_w is used as a parameter in DNVGL-OS-A201 for setting technical winterization performance requirements. In general, t_w is the lowest specified ambient temperature to which various systems must maintain satisfactory performance. Examples include power generation; mooring and positioning systems; fire detection, protection and extinguishing systems; life-saving appliances; telecommunications and navigation systems; heating and ventilation; etc.

> **Example –** *Fire-fighting systems shall have anti-icing and anti-freezing protection based on an external ambient temperature of t_w* (DNVGL-OS-A201, Ch.2 Sec.2 [2.5.2]). If t_w for a unit is specified as −25°C, then the fire-fighting system must be effectively protected such that the system will not freeze when the ambient temperature ≥ −25°C.

3.3.3 How t_w is specified

The t_w value is specified by the end-user and is subject to agreement with DNV GL (DNVGL-OS-A201 Ch.3 Sec.1 [1.2.7]).

DNV GL provides the following guidance to assist the end-user in specifying an appropriate t_w for a particular offshore unit or installation.

Stationary offshore installation – For stationary offshore installations (e.g., FPSO) where site-specific information is available, t_w shall be selected using the reference extreme low air temperature adopted for compliance with coastal (shelf) state requirements and based on the coastal (shelf) state methodology (DNVGL-OS-A201 Ch.2 Sec.5).

Mobile offshore unit – Specifying an appropriate t_w for a mobile offshore unit can be challenging as they are often built without specific operating locations in mind and thus site-specific temperature information may not be available to inform design decisions. For mobile offshore units, the t_w specified becomes a reference extreme low air temperature for assessing locations where the unit can later be transported, installed and operated.

To be considered suitable, a mobile unit's t_w should be lower (i.e., colder) or equal to the relevant extreme low temperature set by the coastal (shelf) state authority for the location under consideration. For seasonally restricted operations, the relevant extreme low temperature for the season may be applied. (DNVGL-OS-A201 Ch.1 Sec.1 [4.2])

Must ISO 19906 be used to set t_w?

In a guidance note, DNVGL-OS-A201 refers to and recommends the ISO 19906 definition of Lowest Anticipated Service Temperature (LAST) for specifying t_w:

> **Guidance note** – T_w should be selected by the end user to represent the Lowest Anticipated Service Temperature for the air at the intended area of operation as per ISO 19906, section 3.48, which is considered as generally compatible with the approach adopted by coastal state authorities for establishing the extreme low temperature with an annual probability of exceedance not greater than 10^{-2}. (DNVGL-OS-A201 Ch.3 Sec.1 [1.2.7])

Guidance notes in DNV GL classification rules and standards are advisory – not prescriptive – in nature. Furthermore, in DNV GL parlance, the word "should" is defined as a verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required (DNVGL-OS-A201 Ch.1 Sec.1 [4.1]).

Therefore, using a LAST as defined by ISO 19906 to specify t_w is *acceptable* to DNV GL, but this method is *not obligatory* unless the relevant coastal (shelf) state regime requires it.

3.4 Relationship between t_d and t_w

In offshore classification with DNV GL, an offshore installation's material design temperature (t_d) and winterization temperature (t_w) must be consistent with each other. What is consistent for a particular unit depends upon the structural design code used and how t_d is defined within that code.

Some international design codes are based on a LAST framework, defining t_d at an extreme-level (EL) temperature with an annual probability of exceedance not greater than, for example, 10^{-2}. Other design codes, such as DNVGL-OS-C101, are based on a LMDAT framework.

If DNVGL-OS-C101 is used as the design code for an offshore installation, then to be considered consistent, the value of t_w selected for winterization shall not be more than 15°C colder than the structural design temperature t_d applied in DNVGL-OS-C101 for material selection of structural steels. In other words, $t_w \geq (t_d - 15°C)$. (DNVGL-OS-A201 Ch.1 Sec.1 [1.4.5] and Ch.3 Sec.1 [1.2.7])

If a different design code is used for an offshore installation, then consistency between t_d and t_w is determined by DNV GL on a case-by-case basis.

4 FUTURE ACTIONS

DNV GL reviews its standards and classification rules on a regular basis. We highly value industry feedback such as that we received during the temperature workshop arranged by Statoil, and will use this when considering amendments, refinements and clarifications to DNVGL-OS-A201 and other relevant rules and standards.

Our winterization classification rules for ships (Ref. 2) are currently under review. Our intent is to harmonize them with new mandatory requirements established by the IMO Polar Code (Ref. 7), which comes into force on 1 January 2017. As the Polar Code does not apply to mobile offshore units or offshore installations, there are no implications for DNVGL-OS-A201 or other offshore standards.

5 REFERENCES

/1/ DNV GL, Rules for Classification – Ship, DNVGL-RU-SHIP Pt.6 Ch.6 Sec.4, *Design ambient temperature – DAT* (2015). [Previously DNV Rules for Ships, Pt.5 Ch.1 Sec.7]

/2/ DNV GL, Rules for Classification – Ship, DNVGL-RU-SHIP Pt.6 Ch.6 Sec.3, *Operation in cold climate – Winterized* (2015). [Previously DNV Rules for Ships, Pt.5 Ch.1 Sec.6]

/3/ DNVGL, Offshore Standard DNVGL-OS-C101, *Design of offshore steel structures, general – LRFD method* (2015).

/4/ IACS, Unified Requirements UR S6, *Use of steel grades for various hull members – Ships of 90 m in length and above*, Rev. 7 (2013).

/5/ DNV GL, Offshore Standard DNVGL-OS-A201, *Winterization for cold climate operations* (2015).

/6/ ISO 19906, *Petroleum and natural gas industries — Arctic offshore structures* (2010).

/7/ *International code for ships operating in polar waters (Polar Code).* Adopted by IMO resolution MSC.385(94) of 2014-11-21 and resolution MEPC.264(68) of 2015-05-15.