Ice Load Monitoring System (MON-ICE)

January 2015

Rule Note
NR 616 DT R00 E

Marine & Offshore Division
92571 Neuilly sur Seine Cedex – France
Tel: + 33 (0)1 55 24 70 00 – Fax: + 33 (0)1 55 24 70 25
Marine website: http://www.veristar.com
Email: veristarinfo@bureauveritas.com

BUREAU VERITAS

MARINE & OFFSHORE DIVISION

GENERAL CONDITIONS

ARTICLE 1

1.1. - BUREAU VERITAS is a Society the purpose of whose Marine & Offshore Division (the "Society") is the classification (" Classification ") of any ship or vessel or offshore unit or structure of any type or part of it or system therein collectively hereinafter referred to as a "Unit" whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

The Society:

- "prepares and publishes Rules for classification, Guidance Notes and other documents (" Rules ");
- "issues Certificates, Attestations and Reports following its interventions (" Certificates ");
- "publishes Registers.

1.2. - The Society also participates in the application of National and International Regulations or Standards, in particular by delegation from different Governments. Those activities are hereafter collectively referred to as " Certification ".

1.3. - The Society can also provide services related to Classification and Certification such as ship and company safety management certification; ship and port security certification, training activities; all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board.

1.4. - The interventions mentioned in 1.1., 1.2. and 1.3. are referred to as " Services ". The party and/or its representative requesting the services is hereinafter referred to as the " Client ". **The Services are prepared and carried out on the assumption that the Clients are aware of the International Maritime and/or Offshore Industry (the "Industry") practices.**

1.5. - The Society is neither and may not be considered as an Underwriter, Broker in ship's sale or chartering, Expert in Unit's valuation, Consulting Engineer, Controller, Naval Architect, Manufacturer, Shipbuilder, Repair yard, Charterer or Shipowner who are not relieved of any of their expressed or implied obligations by the interventions of the Society.

ARTICLE 2

2.1. - Classification is the appraisement given by the Society for its Client, at a certain date, following surveys by its Surveyors along the lines specified in Articles 3 and 4 hereafter on the level of compliance of a Unit to its Rules or part of them. This appraisement is represented by a class entered on the Certificates and periodically transcribed in the Society's Register.

2.2. - Certification is carried out by the Society along the same lines as set out in Articles 3 and 4 hereafter and with reference to the applicable National and International Regulations or Standards.

2.3. - **It is incumbent upon the Client to maintain the condition of the Unit after surveys, to present the Unit for surveys and to inform the Society without delay of circumstances which may affect the given appraisement or cause to modify its scope.**

2.4. - The Client is to give to the Society all access and information necessary for the safe and efficient performance of the requested Services. The Client is the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out.

ARTICLE 3

3.1. - **The Rules, procedures and instructions of the Society take into account at the date of their preparation the state of currently available and proven technical knowledge of the Industry. They are a collection of minimum requirements but not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.**

Committees consisting of personalities from the Industry contribute to the development of those documents.

3.2. - **The Society only is qualified to apply its Rules and to interpret them. Any reference to them has no effect unless it involves the Society's intervention.**

3.3. - The Services of the Society are carried out by professional Surveyors according to the applicable Rules and to the Code of Ethics of the Society. Surveyors have authority to decide locally on matters related to classification and certification of the Units, unless the Rules provide otherwise.

3.4. - **The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not in any circumstances involve monitoring or exhaustive verification.**

ARTICLE 4

4.1. - The Society, acting by reference to its Rules:

- "reviews the construction arrangements of the Units as shown on the documents presented by the Client;
- "conducts surveys at the place of their construction;
- "classes Units and enters their class in its Register;
- "surveys periodically the Units in service to note that the requirements for the maintenance of class are met.

The Client is to inform the Society without delay of circumstances which may cause the date or the extent of the surveys to be changed.

ARTICLE 5

5.1. - **The Society acts as a provider of services. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty.**

5.2. - **The certificates issued by the Society pursuant to 5.1. here above are a statement on the level of compliance of the Unit to its Rules or to the documents of reference for the Services provided for.**

In particular, the Society does not engage in any work relating to the design, building, production or repair checks, neither in the operation of the Units or in their trade, neither in any advisory services, and cannot be held liable on those accounts. Its certificates cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

5.3. - **The Society does not declare the acceptance or commissioning of a Unit, nor of its construction in conformity with its design, that being the exclusive responsibility of its owner or builder.**

5.4. - The Services of the Society cannot create any obligation bearing on the Society or constitute any warranty of proper operation, beyond any representation set forth in the Rules, of any Unit, equipment or machinery, computer software of any sort or other comparable concepts that has been subject to any survey by the Society.

ARTICLE 6

6.1. - The Society accepts no responsibility for the use of information related to its Services which was not provided for the purpose by the Society or with its assistance.

6.2. - **If the Services of the Society or their omission cause to the Client a damage which is proved to be the direct and reasonably foreseeable consequence of an error or omission of the Society, its liability towards the Client is limited to ten times the amount of fee paid for the Service having caused the damage, provided however that this limit shall be subject to a minimum of eight thousand (8,000) Euro, and to a maximum which is the greater of eight hundred thousand (800,000) Euro and one and a half times the above mentioned fee. These limits apply regardless of fault including breach of contract, breach of warranty, tort, strict liability, breach of statute, etc.**

The Society bears no liability for indirect or consequential loss whether arising naturally or not as a consequence of the Services or their omission such as loss of revenue, loss of profit, loss of production, loss relative to other contracts and indemnities for termination of other agreements.

6.3. - All claims are to be presented to the Society in writing within three months of the date when the Services were supplied or (if later) the date when the events which are relied on of were first known to the Client, and any claim which is not so presented shall be deemed waived and absolutely barred. Time is to be interrupted thereafter with the same periodicity.

ARTICLE 7

7.1. - Requests for Services are to be in writing.

7.2. - **Either the Client or the Society can terminate as of right the requested Services after giving the other party thirty days' written notice, for convenience, and without prejudice to the provisions in Article 8 hereunder.**

7.3. - The class granted to the concerned Units and the previously issued certificates remain valid until the date of effect of the notice issued according to 7.2. here above subject to compliance with 2.3. here above and Article 8 hereunder.

7.4. - The contract for classification and/or certification of a Unit cannot be transferred neither assigned.

ARTICLE 8

8.1. - The Services of the Society, whether completed or not, involve, for the part carried out, the payment of fee upon receipt of the invoice and the reimbursement of the expenses incurred.

8.2. - **Overdue amounts are increased as of right by interest in accordance with the applicable legislation.**

8.3. - **The class of a Unit may be suspended in the event of non-payment of fee after a first unfruitful notification to pay.**

ARTICLE 9

9.1. - The documents and data provided to or prepared by the Society for its Services, and the information available to the Society, are treated as confidential. However:

- "Clients have access to the data they have provided to the Society and, during the period of classification of the Unit for them, to the **classification file** consisting of survey reports and certificates which have been prepared at any time by the Society for the classification of the Unit ;
- "copy of the documents made available for the classification of the Unit and of available survey reports can be handed over to another Classification Society, where appropriate, in case of the Unit's transfer of class;
- "the data relative to the evolution of the Register, to the class suspension and to the survey status of the Units, as well as general technical information related to hull and equipment damages, may be passed on to IACS (International Association of Classification Societies) according to the association working rules;
- "the certificates, documents and information relative to the Units classed with the Society may be reviewed during certificating bodies audits and are disclosed upon order of the concerned governmental or inter-governmental authorities or of a Court having jurisdiction.

The documents and data are subject to a file management plan.

ARTICLE 10

10.1. - Any delay or shortcoming in the performance of its Services by the Society arising from an event not reasonably foreseeable by or beyond the control of the Society shall be deemed not to be a breach of contract.

ARTICLE 11

11.1. - In case of diverging opinions during surveys between the Client and the Society's surveyor, the Society may designate another of its surveyors at the request of the Client.

11.2. - Disagreements of a technical nature between the Client and the Society can be submitted by the Society to the advice of its Marine Advisory Committee.

ARTICLE 12

12.1. - Disputes over the Services carried out by delegation of Governments are assessed within the framework of the applicable agreements with the States, international Conventions and national rules.

12.2. - Disputes arising out of the payment of the Society's invoices by the Client are submitted to the Court of Nanterre, France, or to another Court as deemed fit by the Society.

12.3. - **Other disputes over the present General Conditions or over the Services of the Society are exclusively submitted to arbitration, by three arbitrators, in London according to the Arbitration Act 1996 or any statutory modification or re-enactment thereof. The contract between the Society and the Client shall be governed by English law.**

ARTICLE 13

13.1. - **These General Conditions constitute the sole contractual obligations binding together the Society and the Client, to the exclusion of all other representation, statements, terms, conditions whether express or implied. They may be varied in writing by mutual agreement. They are not varied by any purchase order or other document of the Client serving similar purpose.**

13.2. - The invalidity of one or more stipulations of the present General Conditions does not affect the validity of the remaining provisions.

13.3. - The definitions herein take precedence over any definitions serving the same purpose which may appear in other documents issued by the Society.

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RULE NOTE NR 616

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Section 1 General

Section 2 Installation

Section 3 Testing and Survey

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 The additional class notation **MON-ICE** is assigned to ships which are fitted with equipment continuously monitoring ice loads exerted on ship's hull by ice formations, complying with the requirements of this Section

1.1.2 An Ice Load Monitoring System is a system which:

- provides real-time data to the Master and officer of the ship on hull local stresses, hull girder longitudinal stresses (in case of ramming), actual ship speed in ice, vertical and horizontal accelerations the ship experiences while navigating in ice and ship global positioning
- allows the real-time data to be condensed into a set of essential statistical results. The set is to be periodically updated, displayed and stored on a removable medium.

Note 1: The information provided by the Ice Load Monitoring System is to be considered as an aid to the Master. It does not replace his own judgement or responsibility.

1.1.3 The Ice Load Monitoring System is to be able to ensure the following main functions:

- acquisition of data: hull local stresses, hull girder longitudinal strains (in case of ramming), actual ship speed, vertical and horizontal accelerations, ship global positioning
- data processing: conversion in physical units, scaling, consistency checking, statistical processing and storage of results
- display management, handling of alarms and warnings
- detection of faults and malfunctions.

1.1.4 It is responsibility of the Owner to select an appropriate additional class notation **MON-ICE**

1.1.5 The notation description given in Tab 1 is intended to guide Owners and Designers in selecting an appropriate additional class notation.

1.2 Documentation

1.2.1 The documents according to Tab 3 are to be submitted to the Society.

2 Sensor design

2.1 General

2.1.1 The Ice Load Monitoring System is to be based on sensors designed to carry out the following measurements in time domain:

- measurements of strains in hull structures: the sensors should be located at one or several areas where the maximum local ice loads are expected during navigation in ice
- measurements of vertical and horizontal accelerations at the bow and actual ship speed in ice
- measurements of longitudinal strains in the bottom: the sensors should be located at one or several transversal sections where the maximum hull girder stress can be expected during ramming.

2.2 On site calibration of sensors

2.2.1 The sensors are to be selected and installed in such a way that the periodical on-site recalibration can be carried out without extra equipment.

When this operation is impossible, the Manufacturer is to declare the period and procedure of calibration

2.3 Environment and EMC requirements

2.3.1 The sensors and the associated conditioning units are to comply with the applicable requirements concerning electromagnetic compatibility and protection against environmental conditions. The installation is to be compliant with NR467 Rules for the Classification of Steel Ships, Pt C, Ch 3, Sec 5.

2.3.2 The electrical equipment installed in hazardous areas are to be compliant to requirements of NR467, Pt C, Ch 2, Sec 2, [6], NR467, Pt C, Ch 2, Sec 3, [10] and NR467, Pt E, Ch 10, Sec 11, [4].

Table 1 : MON-ICE description

MON-ICE	Description
L(I, II, III, IV, V, VI, VII) **(1)**	The notation refers to a ship equipped with local ice load monitoring system The letter(s) denotes the location(s) of the sensors and interaction scenario
G	The notation refers to a ship equipped with hull girder ice load monitoring system required for the ships perform ramming
(1) The full notation description is presented in Tab 2.	

Table 2 : Selection of appropriate MON-ICE L notation

MON-ICE L	Design scenario	Description
I	Glancing impact	Ships navigating in ice ahead and astern
II	Ramming	Ships able to perform ramming
III	Maneuvering with POD's	Ships equipped with POD's
IV	High speed ice impact	Ships navigating with icebreaker assistance
V	Ice grounding	Ships operating in shallow waters **(1)**
VI	Ice compression	Ships operating in drifting ice
VII	Ice ridge breaking	Ships breaking through ice ridges
(1) According to NR527 Rules for the Classification of POLAR CLASS and ICEBREAKER, Sec 1, [1.4.1].		

Table 3 : Documentation to be submitted

N°	I/A	Documentation
1	A	Description and metrological characteristics of the sensors and associated conditioning units
2	A	Diagram and functional scheme of the system
3	A	Sensors calibration procedures and certificates including calibration values and tolerances
4	A	Location of sensors
5	A	Detection of faults and malfunctions of the system
6	I	Principles and algorithm used for the data processing
7	I	User's manuals (installation and maintenance manual, using manual)
8	I	List of data to be transmitted to VDR, if any
Note 1: A : to be submitted for approval I : to be submitted for information.		

3 System design

3.1 General

3.1.1 The Ice Load Monitoring system is to include at least:

- sensors and conditioning units
- the global navigation system GLONASS or/and GPS
- a computer with the sufficient resources to perform the required tasks in real time (e.g. warnings and alarms are to be given out immediately)
- a display unit readable at a distance of at least 1 m
- a data storage unit with a removable medium, allowing for the statistical data to be exploited later
- as option, a data storage unit to record time data series from sensors (see [3.5.1])
- an UPS with 30 minutes autonomy.

3.1.2 The system is to be designed to detect, as far as possible the faults and the malfunctions of the system (e.g.):

- failure of main source of power
- data out of range
- data remaining strictly constant (failure of a transducer)
- system stops or hangs (the implementation of a Watchdog is recommended).

Note 1: The detection of faults and malfunctions will trigger a visual and audible alarm.

3.2 Data processing

3.2.1 The system is to be designed in order to measure and process the stresses induced by ship impacts with ice formations and the accelerations which result from the ship motions as defined in NR467, Pt B, Ch 5, Sec 3.

3.2.2 Data processing is to be carried with the provision of the following requirements:

- analogue low-pass filters are to be used in accordance with the required bandwidth
- the sampling frequency is to be at least 20 times the low-pass filtering frequency
- the processing ranges of stress and acceleration are to be fixed in accordance with the calculated stress and acceleration limits for the ship, and will allow possible overshooting
- the signals are to be processed through a cyclic statistical procedure. The procedure (e.g. peak value, N/10 and N/3 averages, RMS value, mean value, etc.) will allow to record a set of statistical data for an offline exploitation and to display real time values for an online exploitation.

3.2.3 Provision is to be made for a connection to a Voyage Data Recorder. The Manufacturer of the Ice Load Monitoring System is to declare which information would be forwarded to the Voyage Data Recorder.

The physical connection of the Ice Load Monitoring System to the Voyage Data Recorder is to be compliant with IEC 61162.

3.3 Data displaying

3.3.1 The ice local loads, hull girder stresses and accelerations should be displayed in real time (e.g. maximum values and current values). This information is to be declared as "default condition" and displayed at the power up and reset.

3.3.2 When the visual alarm/warnings are emitted in accordance with [3.4], the corresponding information is superimposed on the above "default condition" displayed.

3.3.3 When the system detects a fault or a malfunction, the corresponding status is to be displayed.

3.4 Alarms

3.4.1 The alarm and warnings levels are to be settled in accordance with the following:

- the alarm levels are to be fixed to 80% of the maximum values of local ice loads and 60% of maximum values of hull girder ice loads for ramming obtained from the requirements on the basis of which the hull structure is approved
- the warning levels are always to be less than the alarm levels defined above.

3.4.2 The alarms and warning associated with each limit defined in [3.4.1] are to be clearly distinguishable from those relevant to faults and malfunctions.

3.4.3 When the system detects a fault or a malfunction, the alarms and warnings are to be inhibited and a visual and audible fault/malfunction alarm is to be emitted.

3.5 Data storage

3.5.1 The time data series are to be stored either by the recording device which is part of the Ice Load Monitoring System, or by an integrated bridge system, if available.

The storage media used shall have a sufficient capacity to store at least 1 year of time data.

3.5.2 The data storage recording device suitable for accumulating statistical information for feedback purposes is to be able to store at least 30 days of statistical data depending of ship's operation.

Statistical data are to be recorded in text format easily readable on a PC.

3.5.3 The data storage recording devices are to be:

- entirely automatic, apart from the replacement of the removable storage support
- such that they do not interrupt or delay the processing of the data.

3.5.4 The recorded data (time and statistical) must be time dated.

3.6 Exploitation of storage data

3.6.1 The exploitation of the recorded statistical data according to [3.5.2] is let to the responsibility of the owner.

3.7 Checking facility

3.7.1 The Ice Load Monitoring System is to include an auto checking facility so that the verification of the System can be carried out without the need of external devices.

3.8 Power supply

3.8.1 The Ice Load Monitoring System is to be supplied by the main source of power of the ship through uninterruptible 30 minutes autonomy Power Source.

SECTION 2 INSTALLATION

Symbols

AE : Aft end, perpendicular to the waterline at the distance L_{ui} aft of the fore end

c_i : Shape coefficient, defined in [2.2.3]

FE : Fore end, perpendicular to the upper ice waterline (UIWL) at the forward side of the stem

H_{ice} : Ice thickness, in m

ILMS : Ice Load Monitoring System

L : Rule length, in m, defined in NR467, Pt B, Ch 1, Sec 2, [3.1]

LIWL : Lower ice waterline, as defined in NR527, Sec 1, [1.3]

L_{ui} : Ship length measured at the upper ice waterline (UIWL), in m

R_{eH} : Minimum yield stress of the material, in N/mm^2

UIWL : Upper ice waterline, as defined in NR527, Sec 1, [1.3]

x : Distance from the aft end (AE) to the section under consideration, in m

α : Upper ice waterline angle, in degree, as defined in NR527, Sec 2, [1.2]

θ : Normal frame angle at the upper ice waterline, in degree, as defined in NR527, Sec 2, [1.2]

τ_y : Shear stress, in N/mm^2.

1 General

1.1 Additional requirements

1.1.1 The components of the Ice Load Monitoring System including data processing, storage, display units and UPS are to be type-approved in accordance with NR467, Pt C, Ch 3, Sec 6 (see also Sec 1, [2.3.1]).

The design of the display unit installed on the bridge is to be compliant to requirements of IEC 60945.

1.2 Hull areas

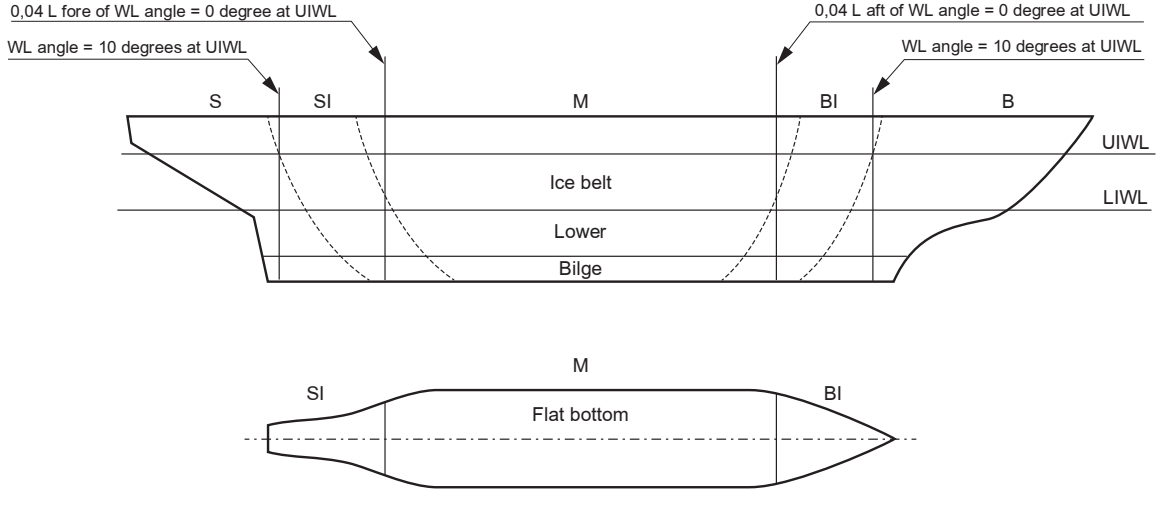
1.2.1 The hull of all ships having the additional class notation(s) **MON-ICE L(i)** or/and **MON-ICE G** is divided into regions reflecting the magnitude and frequency of ice loads:

- five regions in longitudinal direction:
  - bow (B)
  - bow intermediate (BI)
  - midbody (M)
  - stern intermediate (SI)
  - stern (S)
- themselves divided into:
  - ice belt
  - lower
  - bilge
  - flat bottom.

The extent of each hull area is indicated in Fig 1.

Note 1: For the units having particular shapes, the extent of regions will be defined on a case-by-case basis, upon the agreement of the Society.

Figure 1 : Hull areas locations



2 Monitoring areas

2.1 General

2.1.1 Location of monitoring areas should be selected complying with the expected design scenario and **MON-ICE L** notations specified in Sec 1, Tab 2.

2.2 L(I) notation

2.2.1 All ships operating in ice should be equipped with the sensors in the regions **B** or **BI**.

2.2.2 The waterline length of the **B** or **BI** regions is to be divided into eight sub-regions "i" of equal length. The shape coefficient c_i are to be calculated with respect to the mid-length position x_i for each sub-region.

2.2.3 The shape coefficient c_i, in each sub-region is to be obtained from the following formulae:

- for the bow region:

$$c_i = \left(0,097 - 0,68\left[0,85 - \frac{x_i}{L_{ui}}\right]^2\right)\frac{\alpha_i}{\sqrt{\theta_i}}$$

- for the stern region:

$$c_i = \left(0,097 - 0,68\left[\frac{x_i}{L_{ui}} - 0,15\right]^2\right)\frac{\alpha_i}{\sqrt{\theta_i}}$$

2.2.4 The longitudinal coordinate of midpoint of monitoring area corresponds to the location of the sub-region where the shape coefficient c_i is maximal.

2.2.5 The upper boundary of ILMS should not be less than 1 m above UIWL.

2.2.6 The lower boundary of ILMS should not be less than 1,5 H_{ice} below UIWL, where H_{ice} is the maximum ice thickness specified for considered service notation (see NR527, Sec 1, Tab 2).

2.2.7 If ship can perform astern navigation in ice, the sensors should be installed in the regions **S** or **SI** complying with requirements for the regions **B** and **BI** specified in [2.2.2] to [2.2.6].

2.3 L(II) notation

2.3.1 The ships intended to perform ramming should be equipped with the sensors in region **B** and **S** regions for ahead and astern navigation respectively.

2.3.2 The longitudinal coordinate of midpoint of monitoring area should be located at 0,05 L from the FE or AE for ahead and astern navigation respectively.

2.3.3 The upper boundary of ILMS should not be less than 1 m above UIWL.

2.3.4 The lower boundary of ILMS should not be less than 1,5 H_{ice} below UIWL, where H_{ice} is the maximum ice thickness specified for considered service notation (see NR527, Sec 1, Tab 3).

2.4 L(III) notation

2.4.1 The ships operating in ice with AZIPODs should be equipped with the sensors within **M** region.

2.4.2 The sensors should be installed in fore and aft ends of the **M** region.

2.4.3 The fore boundary of the fore area should be located at the boundary between **BI** and **M** regions.

2.4.4 The aft boundary of the aft area should be located at the boundary between **M** and **SI** regions.

2.4.5 The upper boundary of ILMS should not be less than 1 m above UIWL.

2.4.6 The lower boundary of ILMS should not be less than 1,5 H_{ice} below UIWL, where H_{ice} is the maximum ice thickness specified for considered service notation (see NR527, Sec 1, Tab 2 and NR527, Sec 1, Tab 3).

2.4.7 It is recommended to install the fore and aft monitoring areas on both ship's sides. However, to reduce the number of sensors, only one fore and one aft monitoring areas can be equipped with the sensors. In this case the fore and aft monitoring area should be installed on the opposite sides.

2.5 L(IV) notation

2.5.1 The ships operating with icebreaker assistance should be equipped with the sensors in **B Icebelt** and **BI Icebelt** regions.

2.5.2 The sensors should be installed in the **B Icebelt** and **BI Icebelt** regions complying with requirements specified in [2.2].

2.5.3 The additional sensors can be installed in the **B Bilge** and **BI Bilge** regions.

2.6 L(V) notation

2.6.1 Ships operating in shallow waters should be equipped with the sensors in the **Bilge** and adjusted **Flat Bottom** areas in the **BI** and **SI** regions for ahead and astern navigation respectively (according to NR527, Sec 1, [1.4.1].

2.6.2 The monitoring area in **Flat Bottom** should be limited by adjacent side girders and bottom floors, but not less than four spacings.

2.7 L(VI) notation

2.7.1 The ships operating in drifting ice and having a risk of nipping should be equipped with the sensors within **M** region at the level of UIWL.

2.7.2 The upper boundary of ILMS should not be less than 1 m above UIWL.

2.7.3 The lower boundary of ILMS should not be less than 1,5 H_{ice} below UIWL, where H_{ice} is the maximum ice thickness specified for considered service notation (see NR527, Sec 1, Tab 2 and NR527, Sec 1, Tab 3).

2.7.4 For ships with notation **MON-ICE L(III)**, the installation of additional sensors within **M** region is not required.

2.8 L(VII) notation

2.8.1 The ships intended to break through ice ridges should be equipped with the sensors in the **B**, **BI Bilge**, **BI Flat Bottom** regions.

2.8.2 The monitoring area within **B** region should comply with [2.3].

2.8.3 The monitoring area in **Flat Bottom** area should comply with [2.6.2].

2.8.4 The ships operating astern to break thought ice ridge should comply with [2.8.1] to [2.8.3] for **S** and **SI** regions respectively.

2.9 G notation

2.9.1 The ships intended to perform ramming should be equipped with the sensors in the **Flat Bottom** area in the region **M**.

2.9.2 The sensors should be installed at the distance

- $0,5 < x/L < 0,6$ for ahead ramming
- $0,4 < x/L < 0,5$ for astern ramming.

3 Sensors

3.1 General

3.1.1 The number of sensors should be enough to be able to ensure the main functions, as defined in Sec 1, [1.1.3].

3.1.2 The number of sensors should be selected accounting for sensor's measurements range, ship's structure arrangement, element's scantlings, material properties.

3.2 Design and installations

3.2.1 The distance between sensors, shell plating and neighboring gages along the frame should be sufficient to register the strain due to expected ice impact load.

3.2.2 The critical level of hull girder bending and shear monitoring should be in accordance with criteria defined in NR527, Sec 2, [5].

3.2.3 Then the ice load is acting directly on sensor the stain registered by neighboring sensors should be zero.

3.2.4 Then ice load is acting between two sensors the response at each sensor should be about 50 percent of the directly loaded response.

3.2.5 The monitoring zone should include five adjacent frames or longitudinals within monitoring area.

3.2.6 Direct analyses can be carried out for assessment of critical level of ice impact load. The load patch is to be applied at locations where the capacity of the structure under the combined effects of bending and shear are minimized. In particular, the structure is to be checked with load centered at the UIWL, 0,5 H_{ice} below the LIWL, and positioned several vertical locations in between. Several horizontal locations are also to be checked, especially the locations centered at the mid-span or mid-spacing.

Acceptance criterion for designs is that the combined stresses from bending and shear, using the von Mises yield criterion, are lower than the yield point R_{eH} . When the direct calculation is using beam theory, the allowable shear stress is not to be larger than 0,9 τ_y , where:

$$\tau_y = \frac{R_{eH}}{\sqrt{3}}$$

3.2.7 Attention is drawn to the possible existence of local strains induced by temperature gradients in the hull structure.

The strain sensors are to be located in areas free from these temperature gradients.

If a temperature compensation device is implemented, the Manufacturer is to demonstrate its effectiveness on site. When measurement systems are based on strain gauges, temperature compensated strain gauges are to be used and thermal effects management detailed.

3.2.8 Strain transducers are to be installed on the hull taking into account the influence of local stresses which may corrupt the global hull strain values.

SECTION 3 TESTING AND SURVEY

1 General

1.1 Application

1.1.1 The requirements of this Section apply to ships which have been assigned the additional class notation **MON-ICE**, as described in Sec 1, [1].

2 Testing

2.1 Testing conditions

2.1.1 The first on-site calibration of the Ice Load Monitoring System should be based on an approved loading case.

2.1.2 This first on-site calibration of the Ice Load Monitoring System is to be surveyed by Society.

2.1.3 The difference between the reading obtained from the Ice Load Monitoring System and the approved values are to be less than 10 N/mm^2 or 10% of the reading, whichever is the greater.

3 Survey

3.1 Annual survey

3.1.1 The Owner or his representative is to declare to the attending Surveyor that:

- all the components of the Ice Load Monitoring System are able to ensure the main functions, as defined in Sec 1, [1]
- the ice load monitoring equipment has been calibrated complying with the declaration of the Manufacturer for the period and procedure of calibration.