RULES FOR THE CLASSIFICATION OF OFFSHORE UNITS

NR445 - JANUARY 2024

PART B
STRUCTURAL SAFETY

OFFSHORE UNITS

BUREAU VERITAS

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RULES FOR THE CLASSIFICATION OF OFFSHORE UNITS

NR445 - JANUARY 2024

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This version of the document takes precedence over previous revision. Unless otherwise specified, these rules apply to ships for which contracts are signed on or after January 1st, 2024. The Society may refer to the contents hereof before January 1st, 2024, as and when deemed necessary or appropriate.

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These rules are provided within the scope of the Bureau Veritas Marine & Offshore General Conditions, enclosed at the end of Part A of NR467, Rules for the Classification of Steel Ships. The latest version of these General Conditions is available on the Bureau Veritas Marine & Offshore website.

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RULES FOR THE CLASSIFICATION OF OFFSHORE UNITS

Part B
Structural Safety

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Part B
Structural Safety

CHAPTER 1
STABILITY AND SUBDIVISION

Section 1 General

1 Classification requirements

1.1 General

1.1.1 Unit stability and watertight integrity are to comply with the applicable requirements of the present Chapter, or, subject to a preliminary agreement, in accordance with other particular specifications based on the same principles or relevant National or International Regulations.

1.2 Damage stability

1.2.1 Except otherwise required by National Authorities, damage stability requirements are applicable only to the following units:

- units intended to receive service notations **drilling** (completed or not by an indication between brackets), **drilling assistance**, **accommodation**, **oil storage**, **liquefied gas storage**, **oil production unit**, **gas production unit** and **gas liquefaction unit**
- units intended to receive more than 100 persons on board.

In other cases, damage stability requirements of the present Chapter may be used as a guidance.

2 Statutory requirements

2.1 International Regulations

2.1.1 Attention is directed to the International Regulations the unit may have to comply with such as IMO Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU code), in particular for drilling units.

2.2 National Authorities requirements

2.2.1 Attention is drawn to special legal provisions enacted by National Authorities which units may have to comply with according to their flag, structural type, size, operational site and intended service, as well as other particulars and details.

2.3 Classification and statutory requirements

2.3.1 Compliance with statutory requirements mentioned in Article [2] is not included in classification scope but, in case of conflict between the Rules and these requirements, the latter ones are to take precedence over the requirements of the present Rules.

The Society may take into consideration particulars which may be called for or authorised by the competent National Authorities.

2.4 Operating procedures

2.4.1 Adequate instructions and information related to the stability, watertight integrity and weathertight integrity of the unit are to be provided by the Owner and included in the Operating Manual.

Note 1: The procedures and operating instructions do not fall within the scope of classification and need not to be approved by the Society.

2.5 Specific criteria

2.5.1 If the party applying for classification specifies criteria for intact and damage stability, these criteria are to be taken into account in addition to the criteria in the present Section and stated in the Design Criteria Statement.

3 Inclining test and lightweight survey

3.1 Definitions

3.1.1 Lightweight

The lightweight condition means that the unit is complete in all respects, but without consumables, stores, cargo, crew and their effects, and without any liquids on board except for machinery and piping fluids, such as lubricants and hydraulics, which are at operating levels.

The weight of mediums on board for the fixed fire-fighting systems (e.g. freshwater, CO_2, dry chemical powder, foam concentrate, etc.) are to be included in the lightweight.

3.1.2 Inclining test

The inclining test is a procedure which involves moving a series of known weights, normally in the transverse direction, and then measuring the resulting change in the equilibrium heel angle of the unit. By using this information and applying basic naval architecture principles, the ship's vertical centre of gravity (VCG or KG) is determined.

3.1.3 Lightweight survey

The lightweight survey is a procedure which involves auditing all items which are to be added, deducted or relocated on the unit at the time of the inclining test so that the observed condition of the unit can be adjusted to the lightweight condition. The weight and longitudinal, transverse and vertical location of each item are to be accurately determined and recorded. The lightweight displacement and longitudinal centre of gravity (LCG) can be obtained using this information, as well as the static waterline of the ship at the time of the inclining test as determined by measuring the freeboard or verified draught marks of the unit, the unit's hydrostatic data and the sea water density.

The transverse centre of gravity (TCG) may also be determined for units which are asymmetrical about the centreline or whose internal arrangement or outfitting is such that an inherent list may develop from off-centre mass.

3.2 Lightweight survey

3.2.1 A lightweight survey is to be carried out on each unit at the time of construction or after substantial modifications in the lightweight condition.

3.2.2 For all the units, a lightweight survey is to be conducted at each class renewal survey.

If the first class renewal survey demonstrates that an effective weight control program is maintained with an up-to-date light ship data log and it is confirmed by the records at the first class renewal survey, then light ship displacement may be verified in operation by comparison of the calculated and observed draught.

Where the difference between the expected displacement and the actual displacement based upon draught readings exceed 1% of operating displacement, a lightweight survey is to be conducted in the lightweight condition.

Alternative for permanent units are given in [3.7].

3.3 Inclining test

3.3.1 An inclining test is to be carried out on each unit at the time of construction or after substantial modifications in order to determine accurately the lightweight data (weight and position of centre of gravity).

Alternative for units of same design are given in [3.5].

3.3.2 An inclining test is also to be carried out in the following cases:

- where the lightweight survey indicates a change from the calculated lightweight displacement in excess of 1% of the displacement in working condition, or
- where the lightweight survey indicates a change from the longitudinal position of the unit centre of gravity in excess of 1% of the unit's principal horizontal dimension.

Alternative for column-stabilized units and permanents units are given respectively in [3.6] and [3.7].

3.3.3 The inclining test is to take place, when the unit is as near as possible to completion, in the presence and to the satisfaction of the attending Surveyor. The test procedure is to be submitted to the Society for examination prior to being carried out.

3.3.4 The results of the inclining test are to be submitted to the Society for review.

3.3.5 A detailed procedure for conducting an inclining test is given in Ship Rules, Pt B, Ch 3, App 1.

3.4 Operating Manual

3.4.1 The results of the lightweight survey and inclining test, or lightweight survey adjusted for weight differences when [3.5.1] is applicable, are to be indicated in the Operating Manual.

The lightweight particulars are to include the detailed list of the equipment (cranes, accommodation, features...) located on the unit when the test has been carried out.

3.4.2 A record of all changes to machinery, structure, outfitting and equipment that affect the lightweight data, is to be maintained in the Operating Manual or a in a light-weight data alteration log.

3.5 Units of same design

3.5.1 For successive units of a design or for units undergoing only minor alterations, the Society may, at its discretion, waive the requirements of [3.3] and accept the light ship data of the first unit of the series in lieu of an inclining test, provided that, notwithstanding minor differences in machinery, outfitting or equipment, both following conditions are fulfilled:

- the lightweight survey indicates a change from the lightweight displacement calculated for the first of the series less than 1% of the displacement in working condition, and
- this survey indicates a change from the horizontal position of the unit centre of gravity as determined for the first of the series less than 1% of the unit's principal horizontal dimensions.

3.5.2 For the application of [3.5.1], the party applying for classification is required to submit detailed calculations showing the differences of weights and centres of gravity. An extra care is to be given in the case of a series of column stabilized units as these, even though identical by design, are recognised as being unlikely to attain an acceptable similarity of weight or centre of gravity to warrant a waiver of the inclining test.

3.6 Alternative for column stabilized units

3.6.1 Inclining test at renewal survey

If a lightweight survey indicates a change from calculated lightweight displacement in excess of 1% of the operating displacement, an inclining test is to be conducted. As an alternative, the Society may accept that the difference in weight are placed in an indisputably conservative vertical centre of gravity.

3.7 Alternative for permanent units

3.7.1 Lightweight survey at renewal survey

When the renewal survey occurs while the permanent unit is in operation at sea, and subject to Society approval, the draughts reading may be disregarded provided a record of all changes to machinery, structure, outfitting and equipment that affect the light ship data is maintained in a light-weight data alteration log.

3.7.2 Inclining test at renewal survey

If a lightweight survey indicates a change from calculated lightweight displacement in excess of 1% of the operating displacement, an inclining test is to be conducted. As an alternative, the Society may accept that the difference in weight is placed in an indisputably conservative vertical centre of gravity.

4 Load line mark

4.1 General

4.1.1 Mobile units for which the compliance with ILLC or MODU Code is not required, are to have a load line mark which designate the maximum permissible draught when the unit is in the afloat condition. Such markings are to be placed at suitable visible locations on the structure, to the satisfaction of the Society.

4.1.2 For units mentioned in [4.1.1] the position of the load line mark is to be established based on the specific requirements given in MODU Code, Ch 3, [3.7].

5 Loading instrument

5.1

5.1.1 The use of a loading instrument is not a class requirement except when stated otherwise by the rules.

However, in case a loading instrument is present on board, it is to be approved by the Society.

6 Lifting units

6.1 General

6.1.1 Unless otherwise specified, units assigned with the service notation **lifting** are to comply with the applicable stability requirements defined in Ship Rules, Pt E, Ch 8, Sec 3.

6.1.2 For units assigned with the structural type notation **column stabilized unit**, the stability criteria set forth in Ship Rules, Pt E, Ch 8, Sec 3, [2.2.1] item b), for lifting operations conducted under environmental and operational limitations, is replaced by:

$A_{RL} \geq 1{,}30\ A_{HL}$

with the lifted load at the most unfavourable position and the wind heeling moment curve defined by direct calculation of the windage area for a sufficient number of heel angles.

Section 2 Stability Calculations

1 General

1.1 Cases for stability calculations

1.1.1 Stability calculations are to be carried out and submitted to the Society for review for the following loading conditions:

a) lightweight condition
b) transit departure and arrival conditions, anchors to be on board and with the maximum related deck loads (for mobile units)
c) towing condition, if relevant
d) normal working conditions at maximum draught with the maximum deck loads and equipment in the most unfavourable positions
e) inspection conditions consistent with the operational procedure
f) severe storm condition assuming the same weight distribution as in item a), except for the necessary ballast adjustments to bring the unit to the survival draught and for the possible dumping of variable deck load if such is specified in the operating procedures
g) severe storm condition assuming the same weight distribution as in item b) with the necessary ballast adjustments to place the unit in the survival draught configuration. In this condition:
   - equipment liable to be disconnected, such as marine riser of drilling units, is assumed disconnected
   - equipment liable to be disconnected and stored on deck, such as stinger of a pipelaying unit, is assumed disconnected and secured on deck
   - equipment having a rest position, such as crane booms, is assumed in rest position.

The maximum amount of loads is assumed to be stored on deck, such as drill pipe stored in the pipe rack for drilling and drilling assistance units. Account may be taken of dumping of variable deck load if specified.

1.1.2 The Society may require stability calculations for additional loading conditions, based on the investigation of the Loading Manual or on the information previously submitted. These additional loading conditions are to be stated in the Design Criteria Statement.

2 Ice and snow conditions

2.1 Additional class notations ICE or ICE CLASS

2.1.1 Survival stability calculations based on particular damage conditions may be requested, in agreement with the party applying for classification, for the following cases:

- units assigned the additional class notation **ICE** or an additional class notation **ICE CLASS**, as defined in Pt A, Ch 1, Sec 2
- units intended to operate in areas where icebergs or ice-islands are expected.

2.2 Snow and frost

2.2.1 For units liable to operate in areas of snow and glazed frost, verification of the stability, intact and damage, is to be performed taking into account the possible overloads due to ice and snow accumulation.

2.2.2 In order to perform the stability calculation, the following amount of ice may be used on the fore third of the vessel's length from the exposed deck and the decks above, including the sides:

- 140 kg/m^2 for horizontal exposed areas
- 70 kg/m^2 for lateral or oblique exposed areas.

For the purpose of the calculation, the masts are excluded.

Different amount of ice corresponding to local regulations or areas where the units are operating may be used instead of the above values.

3 Stability computations

3.1 Definitions

3.1.1 The static stability curve is the righting moment curve plotted against the angle of heel. Unless otherwise specified the curve relates to the most critical axis and is to account for the effect of free surface in liquid compartments.

3.1.2 The wind heeling moment curve herein relates to the curve of the moment of overturning wind forces computed with lever arms extending from the centres of pressure of surfaces exposed to wind to the centre of lateral resistance of the underwater body of the unit assumed to float free of mooring restraint.

However, positioning systems which may adversely affect stability are to be taken into account, but no allowance is to be made for any advantage.

3.1.3 The intercepts are defined by the angles of heel at which the righting and heeling moments are equal and the forces are in equilibrium. The second intercept relates to the unstable equilibrium position.

3.1.4 The permeability of a space is the percentage of that space which can be occupied by water.

3.2 Hypotheses of computation

3.2.1 Free surface effect

Free surface effects are to be considered whenever the filling level in a tank is less than 98% of full condition. Free surface effects need not be considered where a tank is nominally full, i.e. filling level is 98% or above.

Nominally full cargo tanks should be corrected for free surface effects at 98% filling level. In doing so, the correction to initial metacentric height should be based on the inertia moment of liquid surface at 5° of the heeling angle divided by displacement, and the correction to righting lever is suggested to be on the basis of real shifting moment of cargo liquids.

Free surface effects of the flooded wells/recesses arranged in the freeboard deck are to be taken into account for stability calculations.

3.2.2 Permeability

Permeability values are normally required to be in accordance with Tab 1. Other values may be used if adequately supported by calculations and if consistent with operating practices.

Table 1 : Permeability of compartments

Spaces	Permeability
Store rooms	0,60
Accommodation	0,95
Machinery	0,85
Intended for liquids	0 or 0,95 **(1)**
(1) Whichever results in the more severe requirements	

3.2.3 Moonpool

The volume of moonpools, when fitted within the hull in open communication with the sea, is not to be included in calculation of any hydrostatic properties.

3.3 Computation model

3.3.1 The mathematical model used for stability computation is to be to the satisfaction of the Society. In particular the model is to be suitable for the determination of the most critical axis.

The damage stability calculations are to be performed with the lost buoyancy method.

3.3.2 In the case of self-elevating units, the buoyancy of any submerged parts which are not free-flooding (submerged leg structure, spud cans, mat, in particular) is to be taken into account since their vertical position relative to the upper hull may be critical.

3.3.3 Displacement and KG values are to account for the vertical component of mooring forces, and where applicable, the vertical riser tension. The necessary data are to be submitted for the range of applicable water depth.

3.3.4 The computation of the static stability curve are to account for the progressive flooding of spaces. Openings to spaces considered buoyant are to meet requirements of Ch 1, Sec 4, [1.2.2] and Ch 1, Sec 4, [1.2.3].

3.3.5 The flooded stability computation is to be to the satisfaction of the Society and, in particular, is not to introduce discontinuities in the static stability curve.

It is to be checked that the unit is in static equilibrium at every stage of flooding, the flooding water surface being taken parallel to the sea surface.

The computation may be based upon the following assumptions with respect to intermediate flooding:

a) For unsymmetrical flooding of spaces connected by pipes, ducts, etc., flooding is assumed to take place until the sea level is reached before any equalisation occurs.

b) Spaces freely connected by large unobstructed openings are assumed to equalise as they get flooded.

4 Righting moment and heeling moment curves

4.1 General

4.1.1 Curves of righting moments and of wind heeling moments are to be prepared covering the full range of operating draughts, including those in transit conditions, taking into account the maximum deck cargo and equipment in the most unfavourable position applicable. The righting moment curves and wind heeling moments are to relate to the most critical axis. Account is to be taken of the free surface of liquids in tanks. In that respect, the assumptions of [3.2.1] are to be taken into account.

4.1.2 Where equipment is of such a nature that it can be lowered and stowed, additional wind heeling moment curves may be required and such data are to clearly indicate the position of such equipment.

4.2 Wind forces

4.2.1 The curves of wind heeling moments are to be drawn for wind forces calculated by the following formula:

$F = 0,5\ C_S\ C_H\ P\ V^2\ A$

where:

F : Wind force, in N

C_S : Shape coefficient depending on the shape of the structural member exposed to the wind (refer to Tab 2)

C_H : Height coefficient depending on the height above sea level of the structural member exposed to wind (refer to Tab 3)

P : Air specific mass (1,222 kg/m^3)

V : Wind speed, in m/s

A : Projected area of the exposed surface of the structural member in either the upright or the heeled condition, in m^2.

Table 2 : Shape coefficient C_S

Shape	C_S
Spherical	0,40
Cylindrical	0,50
Large flat surface (hull, deckhouse, smooth underdeck areas)	1,00
Drilling derrick	1,25
Wires	1,20
Exposed beams and girders under deck	1,30
Small parts	1,40
Isolated shapes (crane, beam, etc.)	1,50
Clustered deckhouses or similar structures	1,10

Table 3 : Height coefficient C_H

Height above sea level (m)	C_H
0 - 15,3	1,00
15,3 - 30,5	1,10
30,5 - 46,0	1,20
46,0 - 61,0	1,30
61,0 - 76,0	1,37
76,0 - 91,5	1,43
91,5 - 106,5	1,48
106,5 - 122,0	1,52
122,0 - 137,0	1,56
137,0 - 152,5	1,60
152,5 - 167,5	1,63
167,5 - 183,0	1,67
183,0 - 198,0	1,70
198,0 - 213,5	1,72
213,5 - 228,5	1,75
228,5 - 244,0	1,77
244,0 - 259,0	1,79
above 259	1,80

4.2.2 Wind forces are to be considered from any direction relative to the unit and the value of the wind speed is to be taken as follows:

a) In general, a minimum wind speed of 36 m/s (70 knots) is to be used for normal working conditions and a minimum wind speed of 51,5 m/s (100 knots) is to be used for the extreme environmental condition.

b) Where a unit is to be limited in operation in sheltered waters, reduced wind velocities, not less than 25,8 m/s (50 knots) for normal working conditions, may be used and a Note is to be entered on the unit's Classification Certificate restricting the assigned class to the specified wind conditions.

c) For permanent installations, consideration is to be given to the actual site conditions.

4.2.3 In calculating the projected areas to the vertical plane, the area of surfaces exposed to wind due to heel or trim such as under decks surfaces, etc., are to be included using the appropriate shape factor. Open truss work may be approximated by taking 30% of the projected block area of both the front and back section, i.e., 60% of the projected area of one side. In the case of columns, the projected areas of all columns is to be included.

4.2.4 The lever for the wind heeling moment is to be taken vertically from the centre of the lateral resistance or, if available, the centre of hydrodynamic pressure, of the underwater body to the centre of pressure of the areas subject to wind loading. When the installation is fitted with dynamic positioning system, the thrusters effect in [4.3] is to be considered.

4.2.5 The wind heeling moment curve is to be calculated for a sufficient number of heel angles to define the curve. For surface units, the curve may be assumed to vary as the cosine function of unit heel.

4.2.6 Wind heeling moments derived from wind tunnel tests on a representative model of the unit may be considered as alternatives to the method given in [4.2.1] to [4.2.5]. Such heeling moment determination is to include lift and drag effects at various applicable heel angles.

4.3 Thrusters effect

4.3.1 When deemed necessary, for units on which dynamic positioning is installed, the thrusters negative effect on stability is to be taken into account.

Section 3 Stability Criteria

1 Intact stability

1.1 Stability criteria

1.1.1 The stability of a unit in each mode of operation (towing/transit - working - inspection - severe storm) is to meet the criteria given in [1.1.2] to [1.1.4].

1.1.2 For surface and self-elevating units the area under the righting moment curve to the second intercept, or the angle of downflooding, whichever is less, is not to be less than 40% in excess of the area under the wind heeling moment curve to the same limiting angle. See Fig 1.

1.1.3 For column stabilized units the area under the righting moment curve to the second intercept, or the angle of downflooding, whichever is less, is not to be less than 30% in excess of the area under the wind heeling moment curve to the same limiting angle. See Fig 2.

1.1.4 The righting moment curve is to be positive over the entire range of angles from upright to the second intercept.

Figure 1 : Righting moment and heeling moment curves for surface and self-elevating units

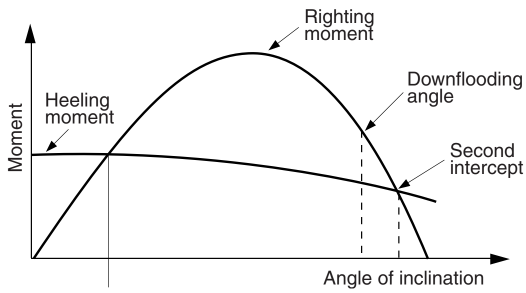
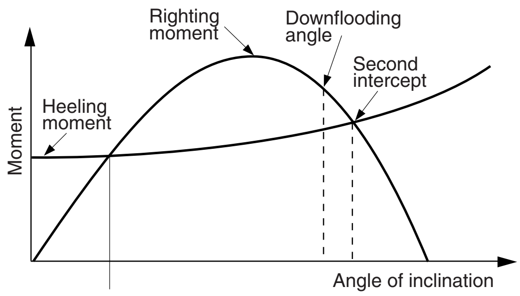


Figure 2 : Righting moment and heeling moment curves for column stabilized units



1.2 Severe storm condition

1.2.1 When ballast adjustments to bring the unit to the survival draught are required for the purpose of meeting the intact stability criteria under extreme environment wind speed, the unit is to be capable of attaining the said draught within a period of time of 3 hours.

1.2.2 The procedures recommended and the approximate length of time required to attain severe storm condition, considering both working and transit conditions, are to be contained in the Operating Manual.

1.2.3 It is to be possible to achieve the severe storm condition without the removal or relocation of solid consumables or other variable loads. However, the Society may accept that a unit is loaded past the point at which solid consumables would have to be removed or relocated to go severe storm condition under the following conditions, provided the allowable KG requirement is not exceeded:

a) In a geographic location where weather conditions annually or seasonally do not become sufficiently severe to require a unit to go to severe storm condition, or

b) where a unit is required to support extra deckload for a short period of time that falls well within a period for which the weather forecast is favourable.

The geographic locations, weather conditions and loading conditions in which this is permitted are to be identified in the Operating Manual.

1.3 Alternative criteria

1.3.1 Alternative stability criteria may be considered by the Society, provided an equivalent level of safety is maintained and if they are demonstrated to afford adequate positive initial stability. In determining the acceptability of such criteria, the following is to be considered:

- environmental conditions representing realistic winds (including gusts) and waves appropriate for world-service in various modes of operation
- dynamic response of the unit. Analysis is to include the results of wind tunnel tests, wave tank model tests, and non-linear simulation, where appropriate. Any wind and wave spectra used are to cover sufficient frequency ranges to ensure that critical motion responses are obtained
- potential for flooding taking into account dynamic responses in a seaway
- susceptibility to capsizing considering the unit's restoration energy and the static inclination due to the mean wind speed and the maximum dynamic response
- an adequate safety margin to account for uncertainties.

2 Maximum allowable KG curves

2.1

2.1.1 The maximum allowable vertical centre of gravity (KG) curves are to be established and submitted to the Society for review. Computations are to be made on the basis of the Rules intact and damage stability criteria, as defined in the present Section, for the complete range of operating draughts.

Note 1: When damaged compartments are intended for liquids storage and maximum allowable KG curves on the basis of damage stability criteria are impracticable due to run off weights, damage stability shall be computed by direct application of preprogrammed damage cases.

3 Subdivision and damage stability

3.1 All types of units

3.1.1 Units, according to their structural type, are to comply with [3.2] or [3.3]. This compliance is to be determined by calculations which take into consideration the proportions and design characteristics of the unit and the arrangements and configuration of the damaged compartments.

3.1.2 The ability to reduce angles of inclination by pumping out or ballasting compartments or application of mooring forces, etc., is not to be considered as justifying any relaxation of the requirements.

3.1.3 Anchor handling, bilge and ballast systems, lifesaving equipment, means of escape and emergency power supply and lighting are to be capable of operating in the flooded final equilibrium condition. In particular the angle at equilibrium in the worst damage condition is not to prevent the safe access to and the safe launching of lifeboats and liferafts.

3.2 Surface units and self-elevating units

3.2.1 Every unit is to have sufficient freeboard and be subdivided by means of watertight decks and bulkheads to provide sufficient buoyancy and stability to withstand in general the flooding of any one compartment or any combination of compartments for operating and transit mode of operation consistent with the damage assumptions set out in [4].

Note 1: Surface units for which MARPOL damage stability criteria defined in Pt D, Ch 1, Sec 2, [2.3] are required, may be exempted from complying with the present requirements.

3.2.2 The unit is to have sufficient reserve stability in damaged condition to withstand the wind heeling moment based on a wind speed of 25,8 m/s (50 knots) superimposed from any direction. In this condition the final waterline, after flooding and heeling due to the effect of wind, is to be below the lower edge of any opening through which progressive flooding of buoyant compartments may take place.

Such openings include air pipes (regardless of closing appliances), ventilation air intakes or outlets, ventilators, non-watertight hatches or doorways not fitted with watertight closing appliances.

3.2.3 Self-elevating unit is to provide sufficient buoyancy and stability to withstand the flooding of any single watertight compartment and with the assumption of no wind, taking into account the following criterion (see Fig 3):

$RoS \geq 7° + 1,5\ \theta_s$

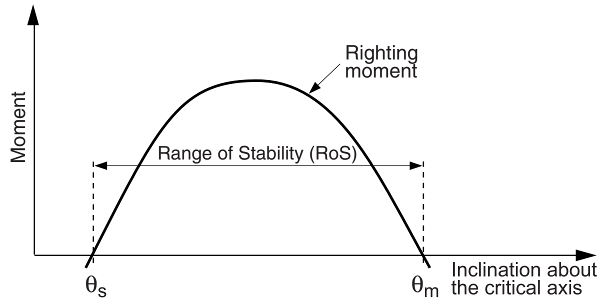
without being less than 10°

where:

RoS	:	Range of Stability, in degrees: $RoS = \theta_m - \theta_s$
θ_s	:	Static angle of inclination after damage, in degrees
θ_m	:	Maximum angle of positive stability, in degrees.

The range of stability is determined with no reference to the angle of downflooding.

Figure 3 : Residual damage stability for self-elevating units



3.3 Column stabilized units

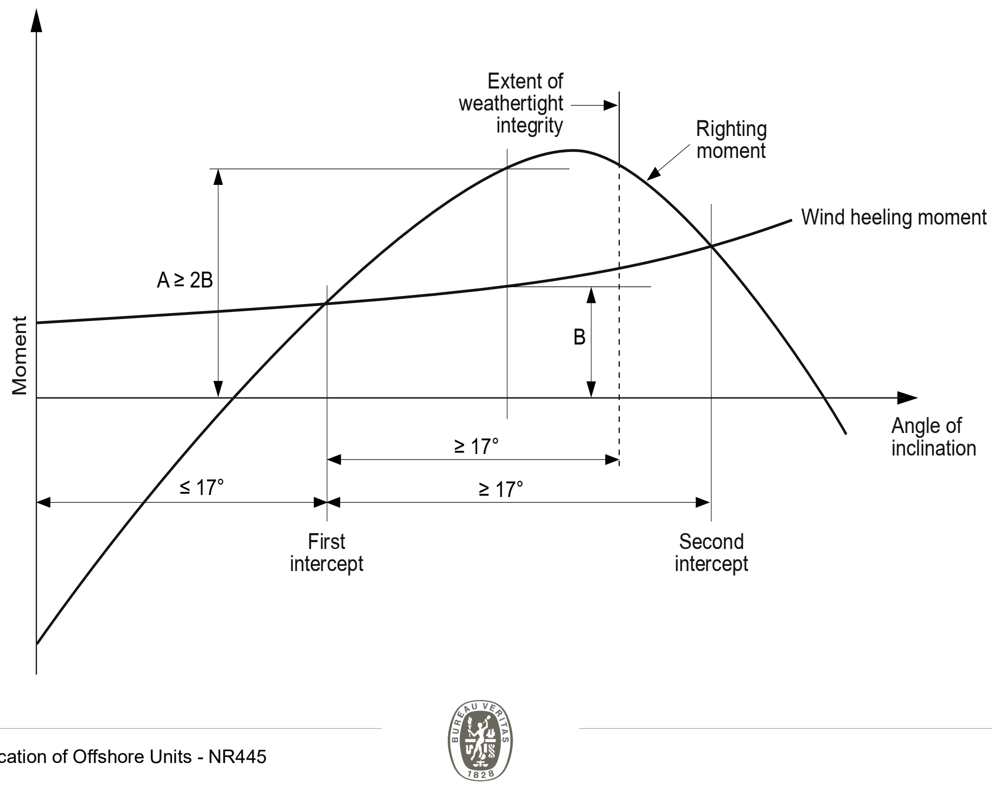
3.3.1 The unit is to have sufficient freeboard and be subdivided by means of watertight decks and bulkheads to provide sufficient buoyancy and stability to withstand a wind heeling moment induced by a wind speed of 25,8 m/s (50 knots) superimposed from any direction in any working or transit condition, taking the following considerations into account (see Fig 4):

a) The angle of inclination after the damage set out in [4.3] is not to be greater than 17°.

b) Any opening below the final waterline is to be made watertight, and openings within 4 m above the final waterline are to be made weathertight.

c) The righting moment curve, after the damage set out in item a), is to have, from the first intercept to the lesser of the extent of weathertight integrity required in item b) and the second intercept or downflooding angle whichever is less, a range of at least 7°. Within this range, the righting moment curve is to reach a value at least twice the wind heeling moment curve, both measured at the same angle (see Fig 4).

Figure 4 : Residual damage stability requirements for column stabilized units



3.3.2 The unit is to provide sufficient buoyancy and stability in any working or transit condition, with the assumption of no wind, to withstand the flooding of any watertight compartment wholly or partially below the waterline referred to in [3.3.1], which is a pump room, a room containing machinery with a salt water cooling system or a compartment adjacent to the sea, taking the following considerations into account:

a) the angle of inclination after flooding is not to be greater than 25°

b) any opening below the final waterline is to be made watertight

c) a range of positive stability of at least 7° is to be provided beyond the first intercept of the righting moment curve and the horizontal coordinate axis of the static stability curve to the second intercept of them or the downflooding angle, whichever is less.

3.4 Alternative criteria

3.4.1 Alternative subdivision and damage stability criteria may be considered by the Society, provided an equivalent level of safety is maintained. In determining the acceptability of such criteria, the following is to be considered:

- extent of damage as set out in Article [4]
- on column stabilized the flooding of any one compartment as set out in [3.3.2]
- the provision of an adequate margin against capsizing.

4 Extent of damage

4.1 Surface units

4.1.1 In assessing the damage stability of surface units, the following extent of damage is to be assumed to occur between effective watertight bulkheads:

a) vertical extent: from the baseline upwards without limit

b) horizontal penetration perpendicularly to the skin: 1,5 m.

4.1.2 The distance between effective watertight bulkheads or their nearest stepped portions which are positioned within the assumed extent of horizontal penetration are not to be less than 3 m; where there is a lesser distance, one or more of the adjacent bulkheads are to be disregarded.

4.1.3 Where damage of a lesser extent than defined in [4.1.1] results in a more severe condition, such lesser extent is to be assumed.

4.1.4 All piping, ventilation systems, trunks, etc., within the extent of damage referred to in [4.1.1] are to be assumed to be damaged; positive means of closure are to be provided, in accordance with Ch 1, Sec 4, [2], at watertight boundaries to preclude the progressive flooding of other spaces which are intended to be intact.

4.2 Self-elevating units

4.2.1 In assessing the damage stability of self-elevating units, the following extent of damage is to be assumed to occur between effective watertight bulkheads:

a) vertical extent: from the baseline upwards without limit

b) horizontal penetration perpendicularly to the skin: 1,5 m.

4.2.2 The distance between effective watertight bulkheads or their nearest stepped portions which are positioned within the assumed extent of horizontal penetration are not to be less than 3 m; where there is a lesser distance, one or more of the adjacent bulkheads are to be disregarded.

4.2.3 Where damage of a lesser extent than defined in results in a more severe condition, such lesser extent is to be assumed.

4.2.4 Where a mat is fitted, the extent of damage defined in [4.2.1] to [4.2.3] is applicable to both the platform and the mat but needs not apply simultaneously unless deemed necessary by the Society due to their close proximity to each other.

Note 1: close proximity may be generally considered to mean within 1,5 m distance.

4.2.5 All piping, ventilation systems, trunks, etc., within the extent of damage referred to in [4.2.1] are to be assumed to be damaged; positive means of closure are to be provided, in accordance with Ch 1, Sec 4, [2], at watertight boundaries to preclude the progressive flooding of other spaces which are intended to be intact.

4.3 Column stabilized units

4.3.1 In assessing the damage stability of column stabilized units, the following extent of damage is to be assumed:

a) Only those columns, underwater hulls and braces on the periphery of the unit are to be assumed to be damaged and the damage is to be assumed in the exposed outer portions of columns, underwater hulls and braces.

Note 1: The outer portions of a member are defined as portions located outboard of a line drawn through the centres of the peripheral columns of the unit.

Note 2: Special consideration is to be given to units of particular design and to units provided with efficient fendering.

b) Columns and braces are to be assumed to be flooded by damage having a vertical extent of 3 m occurring at any level between 5 m above working draught and 3 m below transit draught.

Where a watertight flat is located within this region, the damage is to be assumed to have occurred in both compartments above and below the watertight flat in question.

Lesser distances above or below the draughts may be applied to the satisfaction of the Society, taking into account the actual conditions of operation. However, in all cases, the required damage region is to extend at least 1,5 m above and below the draught specified in the Operating Manual.

c) No vertical bulkhead fitted in columns is to be assumed to be damaged, except where bulkheads are spaced closer than a distance of one eighth of the column perimeter, at the draught under consideration, measured at the periphery, in which case one or more of the bulkheads are to be disregarded.

d) Horizontal penetration of a member damage is to be assumed to be 1,5 m, measured at right angle to the shell of the member.

e) Underwater hull or footings are to be assumed to be damaged when the unit is in a transit condition in the same manner as indicated in items a), b), d) and either item c) or item f), having regard to their shape.

f) All piping, ventilation systems, trunks, etc., within the extent of damage are to be assumed to be damaged; positive means of closure are to be provided, in accordance with Ch 1, Sec 4, [2], at watertight boundaries to preclude the progressive flooding of other spaces which are intended to be intact.

Section 4 Watertight Integrity and Weathertight Integrity

1 General

1.1 Definitions

1.1.1 A closing appliance is said to be watertight if it remains tight and is capable of withstanding the hydrostatic pressure under service and damage conditions defined in Ch 1, Sec 3, [3]. The waterhead under damage conditions is to account for the sinkage and inclinations of the unit induced by the combined effect of wind and flooding.

1.1.2 A closing appliance is said to be weathertight if it is capable, under any sea conditions, of preventing the penetration of water into the unit. A weathertight closing appliance is not required to remain tight under the hydrostatic pressure occurring after damage.

1.1.3 A manually operated closing appliance meeting the requirements of [1.1.1] or [1.1.2] is not to be considered water or weathertight unless, simultaneously:

a) the closing appliance is unambiguously required in the Operating Manual to be closed in a particular mode of operation of the unit

b) the closure of the appliance has been ascertained by the party applying for classification to be fully practicable and compatible with the particular mode of operation of the unit.

1.1.4 A space is considered buoyant and taken into account in the stability calculations if it complies with [1.2].

1.1.5 A weathertight enclosure is a decked structure above a buoyant space with enclosing bulkheads of adequate strength with any opening fitted with weathertight closing appliances. Enclosed superstructures meeting the requirements of the International Convention on Load Lines, 1966 are considered as weathertight enclosures.

1.1.6 Exposed herein means directly exposed to or not protected from the effect of the sea, spray and rain by a weathertight enclosure.

1.1.7 Downflooding means any flooding of the interior or any part of the buoyant structure of a unit through openings which cannot be closed weathertight, watertight or which are required for operations reasons to be left open in all weather conditions.

1.2 Buoyant spaces

1.2.1 Except where otherwise stated, spaces considered buoyant for the purpose of the stability computations are to comply with the following requirements.

1.2.2 If the space is considered buoyant in the damage stability calculation all its openings not fitted with watertight closing appliances are to be located above any final damage water plane.

1.2.3 If the space is considered buoyant in the intact stability calculation any opening in the space, which may become submerged before the heeling angle at which the required area under the intact righting moment curve is achieved, is to be fitted with a weathertight closing appliance or protected by a weathertight enclosure. In addition watertight closing appliances are to be provided for openings which may become submerged before the first intercept equilibrium angle.

1.2.4 All watertight and weathertight boundaries of the considered compartments, spaces and their closing appliances are to have adequate strength to be determined in accordance with the applicable requirements of the Rules.

1.2.5 A drainage system is to be provided for watertight compartments as required in Pt C, Ch 1, Sec 7, [6].

1.3 Operating manual

1.3.1 An operating manual as defined in Pt A, Ch 1, Sec 4 is to be submitted.

1.3.2 A plan identifying the location of all watertight and weathertight closures and all non-protected openings and identifying the position open/closed of all non-automatic closing devices is to be submitted to the Society for review. This plan is to be included in the Operating Manual.

2 Watertight integrity

2.1 General requirements

2.1.1 All units are to be adequately subdivided with an adequate number of watertight decks and bulkheads to meet the damage stability requirements.

2.1.2 All surface type units are to be fitted with a collision bulkhead. Sluice valves, cocks, manholes, watertight doors, are not to be fitted in the collision bulkhead. Elsewhere, watertight bulkheads are to be fitted as necessary to provide transverse strength and subdivision.

2.1.3 The number of openings in watertight subdivisions is to be kept to a minimum compatible with the design and safe operation of the unit. Where penetrations of watertight decks and bulkheads are necessary for access, piping, ventilation, electrical cables, etc., arrangements are to be made to restore the integrity of the enclosed compartments.

2.1.4 In order to minimise the risk of progressive flooding, pipes and ducts are to be, insofar as practicable, routed clear of areas liable to be damaged as defined in Ch 1, Sec 3, [4]. When pipes and ventilation ducts are located within those areas liable to be damaged and serve more than one compartment, they are to be provided with a valve in each compartment served, and non-watertight ventilation ducts are to be provided with a watertight valve at each penetration of a watertight boundary.

2.1.5 Where valves are provided at watertight boundaries to maintain watertight integrity, these valves are to be capable of being locally operated. Remote operations may be from a pump room or other normally manned space, a weather deck, or a deck which is above the final waterline after flooding. In the case of a column stabilized unit this is to be the central ballast control station. Valve position indicators are to be provided at the remote control station.

2.1.6 Watertight doors are to be designed to withstand water pressure to a head up to the bulkhead deck or freeboard deck respectively. A prototype pressure test is to be conducted for each type and size of door to be installed on the unit at a test pressure corresponding to at least the head required for the intended location. The prototype test is to be carried out before the door is fitted. The installation method and procedure for fitting the door on board shall correspond to that of the prototype test. When fitted on board, each door is to be checked for proper seating between the bulkhead, the frame and the door. Large doors or hatches of a design and size that would make pressure testing impracticable may be exempted from the prototype pressure test, provided that it is demonstrated by calculations that the doors or hatches maintain watertight integrity at the design pressure, with a proper margin of resistance. After installation, every such door, hatch or ramp shall be tested by means of a hose test or equivalent.

2.1.7 For self elevating units the ventilation system valves required to maintain watertight integrity are to be kept closed when the unit is afloat. Necessary ventilation in this case is to be arranged by alternative approved methods.

2.2 Scuppers, inlets and sanitary discharges

2.2.1 Scuppers, inlets and discharges are to satisfy the following requirements:

a) Scuppers and discharges leading through the shell from buoyant spaces are to have an automatic non return valve with a positive means for closing from an accessible position above the final damage waterline, or two automatic non return valves, the upper of which is always to be accessible in service.

b) In manned machinery spaces sea inlets and discharges in connection with the operation of machinery may be controlled by locally operated valves situated in a readily accessible position.

c) Indicators showing whether the valves mentioned in item a) or b) above are closed or open are to be provided.

d) Scuppers leading from non buoyant space are to be led overboard.

2.3 Overflows

2.3.1 Overflow pipes are to be located giving due regard to damage stability and to the location of the worst damage waterline. Overflow pipes which could cause progressive flooding are to be avoided unless special consideration has been taken in the damage stability review.

2.3.2 In cases where overflow pipes terminate externally or in spaces assumed flooded, the corresponding tanks are also to be considered flooded. In cases where tanks are considered damaged, the spaces in which their overflows terminate are also to be considered flooded.

2.3.3 Overflows from tanks not considered flooded as a result of damage and located above the final immersion line may require to be fitted with automatic means of closing.

2.3.4 Where overflows from tanks intended to contain the same liquid or different ones are connected to a common main, provision is to be made to prevent any risk of intercommunication between the various tanks in the course of movements of liquid when emptying or filling.

2.3.5 The openings of overflow pipes discharging overboard are generally to be placed above the load waterline; they are to be fitted where necessary with non-return valves on the plating, or any other device of similar efficiency.

2.4 Internal openings

2.4.1 The means to ensure the watertight integrity of internal openings are to comply with the following:

a) Doors and hatch covers which are used during the operation of the unit while afloat are to be remotely controlled from the central ballast control station and are also to be operable from each side. Open/shut indicators are to be provided at the control station. In addition, remotely operated doors provided to ensure the watertight integrity of internal openings which are used while at sea are to be sliding watertight doors with audible alarm. The power, control and indicators are to be operable in the event of main power failure. Particular attention is to be paid to minimizing the effect of control system failure. Each power-operated sliding watertight door is to be provided with an individual hand-operated mechanism. It is to be possible to open and close the door by hand at the door itself from both sides.

b) Doors and hatch covers in self-elevating units, or doors placed above the deepest load line draft in column-stabilized and surface units, which are normally closed while the unit is afloat, may be of the quick acting type and are to be provided with an alarm system (e.g. light signals) showing personnel both locally and at the central ballast control station whether the doors or hatch covers in question are open or closed. A notice is to be affixed to each such door or hatch cover stating that it is not to be left open while the unit is afloat.

2.4.2 The means to ensure the watertight integrity of internal openings which are kept permanently closed during the operation of the unit, while afloat, are to comply with the following:

a) A notice is to be affixed to each closing appliance stating that it is to be kept closed while the unit is afloat.

Note 1: The present requirement is not applicable to manholes fitted with watertight bolted covers.

b) An entry is to be made in the official logbook or tour report, as applicable, stating that all such openings have been witnessed closed before the unit becomes waterborne.

c) The closing appliances are to have strength, packing and means for securing which are sufficient to maintain watertight integrity under the design load.

2.5 External openings

2.5.1 External openings such as air pipes (regardless of closing appliances), ventilators, ventilation intakes and outlets, non-watertight hatches and weathertight doors, which are used during operation of the unit while afloat, are not to submerge when the unit is inclined to the first intercept between the righting moment and wind heeling moment curves in any intact or damaged condition.

Openings such as side scuttles of the non-opening type, manholes and small hatches, which are fitted with appliances to ensure watertight integrity, may be submerged, provided that the requirements of [2.5.3] and [2.5.4] are complied with. Such openings are not to be regarded as emergency exits.

2.5.2 As a rule, openings such as side scuttles of the non-opening type, manholes and small hatches, that may be submerged, are not allowed in the column of column stabilized units.

2.5.3 All downflooding openings the lower edge of which is submerged when the unit is inclined to the first intercept between the righting moment and wind heeling moment curves in any intact or damaged condition are to be fitted with a suitable watertight closing appliance, such as closely spaced bolted covers.

2.5.4 External openings fitted with appliances to ensure watertight integrity, which are kept permanently closed while afloat, are to comply with the requirements of [2.4.2], a), b) and c).

2.5.5 Where flooding of chain lockers or other buoyant volumes may occur, the openings to these spaces are to be considered as downflooding points.

3 Weathertight integrity

3.1 Scope

3.1.1 The conditions given in [3.2] are applicable to all units liable to operate in waters other than sheltered waters. Alternative requirements are to be given for units intended to be used in sheltered waters only after examination of each particular case.

3.1.2 The attention of the Owners and/or the party applying for classification is directed to the applicable requirements of the MODU Code and of the ILLC 1966.

3.2 Assignment conditions

3.2.1 The assignment conditions are applicable to openings leading to spaces considered buoyant in the intact stability computation, to weathertight closing appliances and to weathertight enclosures. Where buoyancy in the damage conditions is required, the applicable requirements of [2] are to be satisfied.

3.2.2 In accordance with [1.2.4], weathertight boundaries and closing appliances fitted to exposed decks and bulkheads of a space or enclosure mentioned in [3.2.1] are to comply with the applicable requirements of the Ship Rules, applying the pertinent loads as described in Pt D, Ch 1, Sec 5.

Note 1: The present requirement concerns particularly the doors, hatchways covers, machinery casings and ventilators coamings.

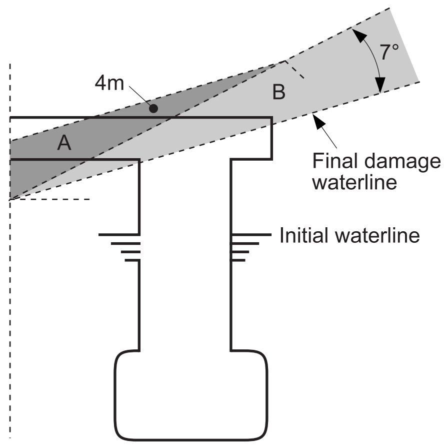
3.2.3 Any opening, such as an air pipe, ventilator, ventilation intake or outlet, non-watertight sidescuttle, small hatch, door, etc., having its lower edge submerged below a waterline associated with the zones indicated in items a) and b), is to be fitted with a weathertight closing appliance to ensure the weathertight integrity, when:

a) a unit is inclined to the range between the first intercept of the right moment curve and the wind heeling moment curve and the angle necessary to comply with the requirements of Ch 1, Sec 3, [1.1] during the intact condition of the unit while afloat; and

b) a column stabilized unit is inclined to the range:

- necessary to comply with the requirements of Ch 1, Sec 3, [3.3.1] and with a zone measured 4,0 m perpendicularly above the final damaged waterline referred to Fig 1, and
- necessary to comply with the requirements of Ch 1, Sec 3, [3.3.2].

Figure 1 : Minimum weathertight integrity requirements for column stabilized units



A = 4m zone of weathertightness
B = 7° zone of weathertightness

3.2.4 External openings fitted with appliances to ensure weathertight integrity, which are kept permanently closed while afloat, are to comply with the requirements of [2.4.2], items a) and b).

3.2.5 External openings fitted with appliances to ensure weathertight integrity, which are secured while afloat are to comply with the requirements of [2.4.1].

3.2.6 All access openings in exposed bulkheads of weathertight enclosures are to be fitted with doors of steel or other equivalent material so arranged that they can be operated from both sides of the bulkhead. The means of securing these doors weathertight are to consist of gaskets and clamping devices or other equivalent means permanently attached to the bulkhead or to the doors themselves. Unless otherwise specified the height of the sills of access openings in exposed bulkheads is not to be less than 380 mm above the deck.

3.2.7 Hatchways and other openings in exposed decks of a space or enclosure mentioned in [3.2.1] are to be provided with coamings and weathertight steel covers or other equivalent material fitted with gaskets and clamping devices. The height of coamings is generally required to be not less than 600 mm but may be reduced, or the coamings omitted entirely, subject to the approval of the Society, in each particular case, taking into consideration the structural type and stability characteristics of the unit, the space to which the opening leads, its size and location.

Manholes and flush scuttles located on exposed decks or within enclosures not considered weathertight are to be closed by substantial covers capable of being made watertight. Unless secured by closely spaced bolts, the covers are to be permanently attached.

3.2.8 Ventilators leading to spaces or enclosures mentioned in [3.2.1] are to comply with the following:

a) Coamings of steel or other equivalent material having adequate strength are to be provided and efficiently connected to the deck. The coaming of a ventilator passing through non weathertight enclosures is to be fitted at the exposed deck of the buoyant space.

b) Coamings are to have a height of at least 900 mm above the deck of a buoyant space and 760 mm above the deck of a weathertight enclosure. For self propelled surface units ventilators coamings are to be at least 900 mm in height if located upon exposed freeboard and raised quarter decks, and upon enclosed superstructures decks situated forward of a point located a quarter of the unit's length from the forward perpendicular.

c) Ventilator openings are to be provided with weathertight closing appliances permanently attached or, subject to the approval of the Society, conveniently stowed near the ventilators to which they are to be fitted. The weathertight closing appliance may however not be required where the ventilator coaming exceeds 2,3 m above the deck and where the intact stability calculations show that the ventilator opening is not submerged before the heeling angle at which the required area ratio is achieved.

3.2.9 Any exposed portion of air pipes to ballast or other tanks considered buoyant in the intact stability calculation is to be of substantial construction and is to be provided with permanently attached weathertight closing appliances. Their height from the exposed deck to the point where water may have access below is to be at least 760 mm on the deck of a buoyant space and 450 mm on the deck of a weathertight enclosure. Lower heights may be accepted by the Society after examination in each case taking into consideration the stability calculations.

3.2.10 Openings to machinery spaces are to be protected by weathertight enclosures or steel casings of equivalent strength and weathertight integrity. Ch 1, Sec 3, [3.1.3] is applicable to machinery spaces with emergency equipment.

Part B
Structural Safety

CHAPTER 2
ENVIRONMENTAL CONDITIONS - LOADINGS

Section 1 General

1 General

1.1 Application

1.1.1 The present Chapter contains requirements applicable to all offshore units for which the structural type notations and the service notations are defined in Pt A, Ch 1, Sec 2, [4] and Pt A, Ch 1, Sec 2, [5] respectively.

2 Design data

2.1 General

2.1.1 It is the responsibility of the party applying for classification to specify, for each condition of operation of the unit, the following data on which the structural design of the unit is based as defined in Pt A, Ch 1, Sec 1:

- working condition
- severe storm condition
- transit condition
- other condition, as applicable to subject unit.

2.1.2 Data mentioned in [2.1.1] are to include, for each condition, a description of:

- the general configuration of the unit
- environmental conditions
- any other relevant data.

2.2 Design Criteria Statement

2.2.1 Design data mentioned in [2.1], on the basis of which class is assigned to the unit, is to be entered in the Design Criteria Statement (see Pt A, Ch 1, Sec 1, [1.6]).

3 Operational data

3.1 Situation of the unit

3.1.1 The draught or elevation, the situation of main equipment and other relevant parameters defining the general situation of the unit in each condition are to be specified by the party applying for classification, taking into account their possible range of variation (e.g. the range of draught of a floating unit, the drill-floor position of a cantilever rig, etc.).

3.1.2 When the structural design relies upon the adjustment of some operational parameters (e.g. altering the loading, draught, trim, orientation or mooring systems parameters) in specific conditions, then the corresponding data are to be clearly specified and are to be entered in the Design Criteria Statement. Where necessary, adequate procedures are to be provided in the Operating Manual.

3.2 Operational loads

3.2.1 Operational loads are to be specified by the party applying for classification in accordance with provisions of Ch 2, Sec 3, [1.3].

3.2.2 Operational instructions concerning the operational loads, including but not limited to the permissible deck loads, variable loads limits and preloading are also to be clearly stated in the Operating Manual.

4 Environmental conditions

4.1 Environmental data

4.1.1 Environmental data on which the structural design of the unit is based are to be specified by the party applying for classification.

They are to include:

- data for the extreme (severe storm) condition
- data for the limiting environmental (threshold) conditions considered for each working condition, for towing/transit condition (where applicable) or any other specific design condition of the subject unit (e.g. jack-up preloading)
- the long term distribution of environmental data on which the design of the structure for fatigue is based
- data for any other particular design condition of the subject unit.

Note 1: Different limiting conditions may be associated with different operational loads arising from the various equipment related to each unit service but also from a given equipment (e.g. crane, etc.).

Note 2: For surface units, reference is also to be made to the provisions associated with navigation notation when such notation is granted.

4.1.2 As stipulated in Pt A, Ch 1, Sec 1, it is the responsibility of the party applying for classification to ascertain that the environmental parameters are correct, complete and compatible with the use of the unit, in accordance with provisions of [4.2].

4.1.3 Environmental data are to be specified in accordance with provisions of Ch 2, Sec 2.

The Society may consider alternative specifications provided that the characteristic parameters most pertinent to the design of the unit are available for the purpose of Rules application.

4.2 Environmental loads

4.2.1 Environmental loads are to be evaluated in accordance with provisions of Ch 2, Sec 3, [1.4] and Ch 2, Sec 3, [3].

4.2.2 In order to meet the intent of the Rules, the environmental data for the extreme (severe storm) condition and the methods by which the maximum loads are evaluated are to be such that the resulting loads and stresses in structural members have a return period not lower than:

- 20 years except otherwise specified in Data Criteria Statement
- 50 years for units intended to be granted the service notation **drilling** or **drilling assistance**, and for drag-dominated structures (e.g. jack-ups)
- 100 years for permanent installations.

Note 1: This corresponds to probability of exceedence per passing wave of approximately 10^{-8}, $10^{-8,4}$ and $10^{-8,7}$ at the reference site.

4.2.3 In all other conditions, environmental loads are normally to be taken as the maximum loads over a 3 hour period, conditional upon the occurrence of specified conditions.

4.3 Accidental situations

4.3.1 Depending on the type and service of the unit, a risk analysis may be required to assess the risk of explosion, collision and dropped objects.

4.3.2 As a rule, the design of the primary structure is to consider the possibility of accidental loads as may result from collisions, dropped objects, fire or explosions.

The risk of accidental damage is normally minimised by suitable preventive and protective measures such as:

a) adequate operation and maintenance of structures and equipment as stipulated in Pt A, Ch 1, Sec 1, [3.3]; procedures are to specify all operational limits and related limiting environmental conditions

b) appropriate safety requirements for visiting structures with respect to the limiting environmental conditions, the communication and survey procedures for berthing, landing, stowage and disconnection

c) adequate arrangement of structure and facilities

d) adequate protective arrangements such as guarding, fendering, weak links, quick release mechanisms, shut-off means for high pressure piping systems, etc.

4.3.3 The Society is to be advised when the provisions of [4.3.2] cannot be satisfactorily achieved under particular operational conditions. The party applying for classification may then be required to consider some specific accidental loadings.

4.3.4 In accidental conditions, environmental loads are to be evaluated taking into account the circumstances in which the considered situation may realistically occur, and the time needed for evacuation or other remedial action. In principle, the return period of such environmental loads need not be taken greater than 1 month, unless otherwise specified for the considered unit.

Section 2 Environmental Data

1 General

1.1 Documentation to be submitted (all units)

1.1.1 The party applying for classification is to specify the data defining the environmental conditions to which the unit may be subject in each condition of operation, viz.:

- wave data
- wind data
- current data
- waterdepth and tide data
- atmospheric and sea temperatures data

and, where applicable:

- ice and snow data
- earthquake conditions
- any other relevant information.

1.2 Permanent installations

1.2.1 For permanent installations, the party applying for classification is to submit, in addition to documentation required in [1.1] and in accordance with provisions of Pt A, Ch 1, Sec 1, adequate documentation describing the environmental conditions at site.

1.2.2 The party applying for classification is to derive as necessary from these data the characteristic parameters required for the purpose of Rules application.

The statistical techniques used to derive the required characteristic parameters are to be documented to the satisfaction of the Society.

1.2.3 For waves, wind, current, and for water level when relevant, the extreme omnidirectional data, with a return period as specified in Ch 2, Sec 1, [4.2.2] are to be presented (independent extremes).

1.2.4 Directional data may be considered, where applicable, if sufficient information is available to support their use, subject to the agreement of the Society.

1.2.5 When adequate information is available on the joint occurrence of elements, design data may be further specified as sets of associated values.

2 Waves

2.1 General

2.1.1 Waves data are to be specified, for the purpose of air gap determination, if applicable, and for strength and fatigue analysis. The data are to be specified in a manner compatible with the design techniques and to include design data for each condition of the unit, and long term data for fatigue analysis.

2.2 Design data

2.2.1 Where the spectral approach is used, the design sea states are to be specified by their significant wave heights, and mean zero up-crossing (or spectral peak) period, together with adequate formulations of spectral energy distribution and, as applicable, spectral dispersion in direction.

2.2.2 For a given condition of operation of the unit, the maximum significant wave height is to be specified for a sufficient range of periods, such that the maximum response of the unit is properly covered for all sea states liable to be met in such condition (refer also to Ch 2, Sec 3, [6.2.2]).

Directional data may be considered, where applicable.

2.2.3 Where no particular wave data are specified, significant wave height and mean zero-up crossing period in the (extreme) severe storm condition is to be assumed as follows:

$H_S = 1,65\ T_0 - 4,33$ for $T_0 < 13$ seconds

$H_S = 17$ m for $T_0 \geq 13$ seconds

where:

H_S : Significant wave height, in m

T_0 : Mean zero up-crossing period, in seconds.

2.2.4 Where the design wave approach is used, waves data are to be specified for each design condition in terms of wave height, associated period or range of periods and, where applicable, associated range of still water level.

2.3 Long term data

2.3.1 Where spectral approach is used, the sea states joint probability of occurrence $p(H_S, T_0)\ dH_S\ dT_0$ is to be specified by means of a wave scatter diagram or of any other appropriate format.

2.3.2 Where the design wave approach is used for fatigue evaluation, the long term distribution of wave heights and the corresponding wave periods are to be specified.

3 Wind

3.1 Wind specification

3.1.1 Wind data are to be specified for the purpose of global and local strength analysis and for mooring and stability analysis of floating units.

3.1.2 The wind design data are to be specified as the wind speed at a reference height above the water level (usually taken as 10 m above the mean water level) and averaged over 1 min., or another suitable reference time interval.

The wind speeds averaged over other time intervals and the vertical profiles of wind speed, which are required for the calculation of wind loads, are to be derived from the above reference wind speed using recognised relations.

Directional data may be considered, where applicable.

3.2 Values for classification

3.2.1 Where no particular wind data are specified, the one min. wind velocity at 10 m above the mean water level is to be taken for classification as provided by Tab 1.

3.2.2 Wind speeds for stability analysis are to be taken as provided by Tab 1, unless otherwise provided for in Ch 1, Sec 2.

Table 1 : Winds speeds for classification

Condition of operation	Wind speed (m/s)	
	Column stabilized units	Other units
Transit	36,0 **(1)**	51,5
Working	36,0	36,0
Severe storm	51,5	51,5
(1) If ballasting systems remain fully operational during transit, otherwise 51,5 m/s is to be considered.		

4 Current

4.1 Current specification

4.1.1 Current data are to be primarily specified for the purposes of load analysis of drag dominated structures and mooring analysis of floating units.

4.1.2 The current velocity profiles are to be specified taking into account the contribution of all (circulational, tidal and wind generated) relevant components. Unusual bottom or stratified effects are to be clearly stated.

Directional profiles may be considered where applicable.

4.2 Values for classification

4.2.1 Where no particular data are specified, the following current velocities U, in m/s, is to be used for classification:

- at sea bottom:

  $U = 0{,}5$

- at the still water level:

  $U = 0{,}5 + 0{,}02\ V_{10}$

where:

V_{10} : 10 minutes wind speed, in m/s, at 10 m above still water level.

5 Waterdepth and tides

5.1 General

5.1.1 For general reference, the maximum nominal waterdepth for operation of the unit is to be specified.

5.2 Bottom supported units

5.2.1 For bottom supported units, the design maximum waterdepth (as defined in Part A, Chapter 1, i.e. including all tide and surge components), is to be specified for the purposes of air gap determination and for strength and fatigue analysis.

5.2.2 For the purpose of strength analysis of the unit at a given site, consideration is also to be given to the minimum waterdepth associated with extreme waves.

5.2.3 Directional data (i.e. data depending on the direction of incoming elements) may be considered where applicable.

6 Design temperatures

6.1 Principle

6.1.1 Design temperature of structural elements is to be taken as follows:

- for the emerged part of the structure (splash zone and above), the design temperature is the air temperature defined in [6.2]
- for the immersed part of the structure, the design temperature is the water temperature defined in [6.3].

6.1.2 The Society may accept values of design temperature obtained through direct calculation, provided that:

- the calculations are based on air temperature and water temperature as defined in [6.2] and [6.3]
- the calculations provide a design temperature corresponding to the worst condition of the unit in operation, towing/transit and inspection
- a complete calculation report, including a documentation of methods and software, is submitted to the Society.

6.1.3 For units intended to receive the service notation **liquefied gas storage**, **gas production unit** or **gas liquefaction unit**, the design temperature of structural elements is to be taken as required in NR542 Classification of Floating Gas Units.

6.2 Air temperature

6.2.1 Air temperature requested by [6.1] is to be taken as the mean air temperature of the coldest day (24 h) of the year for any anticipated area of operation.

6.2.2 Where no particular value is specified, classification is to be based upon the following air temperature:

- 0°C for units not intended to operate in cold areas
- – 10°C for units intended to operate in cold areas.

6.3 Water temperature

6.3.1 Water temperature requested by [6.1] is to be taken as the water temperature of the coldest day (24 h) of the year for any anticipated area of operation.

6.3.2 Where no particular value is specified, classification is to be based upon 0°C water temperature.

7 Ice and snow

7.1 Operating in ice conditions

7.1.1 For units other than surface units, the following ice data are to be provided if the additional class notation **ICE** or an additional class notation **ICE CLASS** is intended to be granted:

- ice conditions liable to be met (ice-floe, pack, ice bank, etc.)
- extreme level ice thickness, type (first or multi-year) and drifting speed
- extreme ridge size and type (first or multi-year)
- existence of ice-islands and/or icebergs
- a table of the various ice thicknesses and types with associated probability of observation at reference site
- a ridge size classification with associated probability of observation at reference site.

For level ice, the following properties are to be specified:

- crushing strength
- bending strength
- buckling strength
- or brine volume.

Note 1: strength values may be defined by an absolute figure or by the brine volume using an appropriate formulation.

7.1.2 Snow and frost

For units liable to operate in areas of snow and glazed frost the following possibilities are to be considered:

- snow accumulation on exposed decks
- ice and snow accumulation on secondary structures or unit's undersides
- ice accretion on lattice structures, such as derricks, crane booms, etc.

Relevant parameters (thickness, density) corresponding to these conditions and the associated metocean parameters (e.g. the wind speed) are to be specified.

8 Soil and earthquake data

8.1 General

8.1.1 For bottom-supported structures and for permanent installations, necessary soil data and, where relevant, earthquake data are to be specified and are to be included in the Design Criteria Statement.

8.1.2 For permanent installations, the soil characteristics are to be taken from the soil survey performed on the location where the platform is intended to be installed.

The derivation of the soil engineering characteristics is to be made using recognised techniques and are to be documented to the satisfaction of the Society.

8.2 Soil

8.2.1 As needed, the nature, strength and behavioural parameters (such as liquefaction potential, long term consolidation, etc.) of soil for which the unit is designed in relation with the expected type of foundation are to be specified.

8.2.2 As a minimum, the maximum design penetration of leg tip, footings, mat, etc., below mud line is to be specified.

8.3 Earthquake

8.3.1 Parameters defining intensity of ground motions are to be specified using a suitable format in relation with techniques of analysis and seismic knowledge of the area. Usually, magnitudes are defined for both a “design” and a “rare intense” earthquakes.

Section 3 Design Loads

1 Categories of loads

1.1 General

1.1.1 The following categories of loads are considered: fixed, operational, environmental, accidental, testing and temporary construction loads.

1.2 Fixed loads

1.2.1 Fixed load or light weight is the weight of the complete unit with all permanently attached machineries, equipment and other items of outfit such as:

- piping
- deckings, walkways and stairways
- fittings
- spare parts
- furniture.

The light weight of the unit includes the weight, to their normal working level, of all permanent ballast and other liquids such as lubricating oil and water in the boilers, but excludes the weight of liquids or other fluids contained in supply, reserve or storage tanks.

1.3 Operational loads

1.3.1 Operational loads are loads associated with the operation of the unit and include:

- the weights of all moving equipment and machineries
- variable loads of consumable supplies weights such as:
  - casing, drill and potable waters
  - mud
  - cement
  - oil
  - gas
  - chemical products
- other storage loads
- hydrostatic loads (buoyancy)
- liquids in tanks
- ballast loads
- riser tensioner forces
- hook or rotary table loads
- loads resulting from lifting appliances in operation
- loads due to pipelaying, etc.

Dynamic loads induced by equipment in operation are to be considered as operational loads.

1.4 Environmental loads

1.4.1 Environmental loads are loads resulting from the action of the environment and include loads resulting from:

- wind
- waves
- current
- ice and snow where relevant
- earthquake where relevant.

Dynamic loads induced by unit's motions (inertia forces) or by dynamic response to environment action are to be considered as environmental loads.

Reactions to environmental loads (such as those of foundations or mooring loads) are to be considered as environmental loads.

1.5 Accidental loads

1.5.1 Accidental loads are loads that may be sustained during accidental events, such as:

- collisions by supply boats or other craft
- impact by dropped objects
- breaking of mooring lines.

Accidental loads also include loads resulting of such event (damaged situations) or of other exceptional conditions to be determined with regard to the activities of the unit in accordance with Ch 2, Sec 1, [4.3].

1.6 Testing loads

1.6.1 Testing loads are loads sustained by the structure during testing phases of tanks or equipment.

1.7 Temporary construction loads

1.7.1 In accordance with the provisions of Part A, Chapter 1, temporary construction loads not resulting from the tests required to be performed by the applicable Rules requirements are not subject to review by the Society unless a specific request is made. The attention of the Builder is however called upon the provisions of Part B, Chapter 3 concerning construction procedures liable to affect, for instance by prestressing, the strength of the unit.

2 Fixed and operational loads

2.1 General

2.1.1 The fixed and operational loads defined in [1.2] and [1.3] are to be clearly specified using a format acceptable by the Society. Where stated, minimum Rules prescribed loads are to be taken into consideration.

2.2 Load distribution

2.2.1 For the purpose of overall structural calculations, a complete description of load distribution is to be provided.

A sufficient number of load cases, adequately representing all possible distributions in each condition of operation, are to be defined unless corresponding restrictions are entered in the Operating Manual.

2.3 Loads on decks

2.3.1 Operational loads acting on decks are to be clearly specified on the permissible loadings decks drawings required in Pt A, Ch 1, Sec 4, [2.3]. All the distributed and concentrated loads in all deck areas are to be shown on the drawings.

For the purpose of local scantling, design distributed deck loads including deck self-weight are not to be taken less than given on Tab 1.

Note 1: for decks used as helideck, refer also to [2.4].

Note 2: for exposed decks, refer also to [3.9].

2.3.2 As appropriate according to deck use, operational concentrated loads applied on decks are to be combined with the distributed loads given in Tab 1.

Table 1 : Minimum deck loads

Deck area	Minimum design loads (kPa)
Non loaded decks	2,0
Crew and similar spaces	4,5
Work areas	9,0
Storage areas	minimum 13,0 or ρ H **(1)**

(1) ρ : Cargo specific weight, in kN/m^3
If the value of this specific weight is not specified, ρ = 7 is to be taken for calculation
H : Storage height, in m.

2.4 Loads on helidecks

2.4.1 The design of the helideck is to be based on the loads associated with the largest helicopter intended to be used.

2.4.2 The following information concerning the largest helicopter intended to be used are to be supplied and included in the Design Criteria Statement:

- type and maximum takeoff weight Q
- distance between main wheels or skids
- length of skid contact area or distance between main wheels and tail wheel
- print area of wheels
- rotor diameter and overall length measured across main and tail rotors or across main rotors for helicopters with tandem main rotors.

In addition, general arrangement of the helicopter deck is to be provided.

2.4.3 Two design loading cases, at least, are to be considered:

- helicopter stowed
- helicopter hard landing.

Other conditions may be considered as design cases provided they lead to an equivalent degree of safety.

2.4.4 Corresponding loads are to be calculated according to applicable national standards.

2.5 Loads due to operations

2.5.1 For operational equipment liable to induce, when in use, important loads within the structure of the unit, the party applying for classification is to provide, in accordance with Part A, Chapter 1, all necessary information on these loads such as:

- for a drilling rig, loads induced by rig components (derrick, turntable, tensioners, etc.) in the various situations of drilling activities
- for a revolving crane, calculations of loads on crane pedestal during crane operation, and those on pedestal, boom and hook rests, for the stowed situation
- stinger and tensioner loads (pipelaying)
- for the different lifting and handling equipment, the precise indication of the loads they may induce in the structure of the unit (magnitude, direction, footprint, etc.), with their nature (permanent, non permanent, normal, extreme, etc.).

2.5.2 Loads are to adequately include all significant static and dynamic components. The wave-induced motions considered in load evaluation are to be specified.

2.5.3 Unless otherwise documented, the dynamic actions and test loads induced by lifting and handling equipment are to be taken as provided for in:

- NR526 Rules for the Certification of Lifting Applicances onboard Ships and Offshore Units
- NR595 Rules for the Classification of Offshore Handling Systems.

2.6 Hydrostatic loads

2.6.1 The maximum and minimum draughts in each condition of operation are to be considered for calculation of hydrostatic loads on outer shell. If the shell forms tank boundary, the maximum inner pressure or minimum differential inner pressure between internal or external pressure is to be considered as well. Refer also to [3.9].

2.6.2 The panels forming boundaries of ballast, fuel oil and other liquid compartments are to be designed for a liquid specific gravity at least equal to sea water.

Unless adequate means are provided to the satisfaction of the Society, account is not to be taken of counter-pressures from adjoining tanks and compartments. Minimum external counter-pressure may be considered where significant.

2.6.3 Attention is to be paid to the following loading cases:

- static pressure in relation with arrangement of overflow
- dynamic and sloshing pressures occurring in the tanks, in particular where partial fillings are contemplated
- testing condition, as defined in Ch 3, Sec 7
- damaged condition (refer to Article [4]).

2.7 Independent fuel oil tank loads

2.7.1 The provisions of the present requirements apply to fuel oil tanks and bunkers which are not part of the offshore unit structure.

2.7.2 The design of the independent tanks is to be based on an internal load equal to the height of the overflow or air pipe above the top of independent tank.

This internal load above the top of the independent tank is not to be taken less than:

- 3,60 m for fuel oil having a flash point lower than 60°C
- 2,40 m otherwise.

3 Environmental loads

3.1 General

3.1.1 Environmental loads are to be computed on the basis of specified environmental data. Where applicable, Rules prescribed minimum values are to be used.

3.1.2 Action of environment is to be also considered to assess loadings to apply for the overall calculation of the structure of the unit or a part of it and for fatigue analysis.

Action of environment is to be also considered, where relevant, to derive local pressures to be applied to platings and associated framing.

3.2 Evaluation of environmental loads

3.2.1 Environmental loads are to be computed using recognised techniques to the satisfaction of the Society.

3.2.2 Model tests

Design may be based upon model test results. The actual behaviour of the unit is to be adequately simulated. The testing procedures and methods used for the extrapolation to full scale data are to be to the satisfaction of the Society.

3.3 Wave loads

3.3.1 Wave loads are to be computed giving due consideration to the loading regime, according to water depth, wave characteristics and dimensions of the structural members of the unit.

3.3.2 Results derived from tank tests may be used if adequately documented.

3.3.3 For large bodies, the diffraction-radiation theory may be used to evaluate first order wave loads, and, as needed, second order loads.

Due account is to be taken of second order and other non-linear components, when having a significant effect.

3.3.4 Loads on structures made of slender elements may be evaluated using Morison's formula with an appropriate formulation of water particle kinematics.

3.3.5 The Society may require to consider the possibility of wave induced vibration of structural elements.

3.4 Current loads

3.4.1 For drag-dominated structures, the hydrodynamic forces are to be calculated considering the combination of current and wave particle velocity.

Current and wave are generally to be assumed to act simultaneously in the same direction, unless another combination might be more severe and liable to occur.

3.4.2 For large bodies, whenever possible, adequately documented results of tank or wind tunnel model tests are to be used.

3.5 Wind loads

3.5.1 Loads due to wind are to be taken duly into account for exposed structural elements considering, in particular, the influence of their shape and dimensions.

3.5.2 Whenever possible, adequately documented results from wind tunnel tests or data derived from tests are to be used.

3.5.3 Dynamic wind actions are to be considered where the unit's structure, or part of it, may be sensitive to these.

3.6 Inertia loads

3.6.1 The following inertia loads are to be considered:

- loads induced by unit's motions when in floating condition
- loads induced by support motions during dry tow condition, if contemplated
- other dynamic actions where relevant (refer to Part B, Chapter 3).

Note 1: Motion performance as such is not covered by classification. However, an accurate enough motion analysis is to be performed in order to evaluate above loads.

3.6.2 Loads sustained during transit are to be calculated taking into account the transit conditions (environmental data, loading conditions, possible dismantling or fastenings) specified in the Design Criteria Statement.

3.7 Ice and snow

3.7.1 For units intended for service in icy waters, ice loads on hull are to be evaluated with consideration of ice conditions and parameters specified in the Design Criteria Statement (refer to Ch 2, Sec 2, [7]).

Both maximum and cyclic loads are to be considered.

Numerical values for ice pressure are to be determined from recognised formulae and/or model tests in ice tanks. The design loads for level ice are to be taken as the maximum between the following possible ice sheet ruptures: crushing, buckling, bending.

3.7.2 For units intended for service in cold areas, the following loads are to be evaluated on the basis of relevant data:

- gravity loads corresponding to ice and snow accumulation
- gravity loads and increase in wind loads due to ice accretion on open structures, such as derrick, crane booms, etc.

3.7.3 For units not intended to operate in icy waters or cold areas, moderate snow loads may be generally considered in minimum design loads.

3.8 Vortex shedding

3.8.1 The Society may require to consider the possibility of flutter of structural members due to vortex shedding.

3.9 Local pressure on hull and exposed decks

3.9.1 Pressure on hull and exposed decks is to be evaluated from the maximum relative motions between hull and water surface with due allowance for:

- irregularities of actual wave profile
- water run-up along columns or walls
- green waters, etc.

Loads are to be calculated according to recognised standards to satisfaction of the Society.

3.9.2 For exposed decks not submitted to any particular load, a distributed load of 25 kPa is to be taken as a minimum.

3.10 Slamming

3.10.1 General

Slamming loads are to be considered for horizontal members located in the splash zone and for ship-shaped units with particular forward structural configuration. The loads are to be estimated using experimental data or techniques acceptable to the Society.

3.10.2 Surface units

For surface units, where more accurate information is not available, indications provided in Part D, Chapter 1 may be used.

3.10.3 Local loads on superstructure walls and decks

Design pressures induced by wind, water spray and wave action (green waters) on exposed walls and decks of superstructures are to be evaluated taking into account:

- their location, (height above water level, horizontal distance from the unit's sides and/or ends) and orientation
- environmental conditions liable to be met by the unit in various draughts or conditions of operation.

Where appropriate, reference is to be made to Part D, Chapter 1.

4 Accidental loads

4.1 Damaged condition

4.1.1 Hydrostatic pressure acting on hull and subdivision bulkheads and flats is to be evaluated for the unit in damaged condition.

4.1.2 For each item contributing to the watertight integrity of the unit, load height is to be taken as the greatest distance, for all possible damage cases, to the waterline in damaged condition, including wind, if any, as resulting from the application of Part B, Chapter 1.

4.1.3 For surface units, load height is to be taken equal to the vertical distance to the freeboard deck.

4.1.4 As necessary, the inclination of gravity loads from the vertical direction in damaged condition is to be taken into account, considering damage cases and wind resulting from the application of Part B, Chapter 1.

4.2 Loads from towing, mooring and anchoring equipment

4.2.1 For the evaluation of loads applied to fairleads, winches and other towing, mooring and anchoring equipment, the line is to be considered as loaded to its guaranteed breaking strength.

4.3 Impact loads

4.3.1 In application of Ch 2, Sec 1, [4.3], loads induced by collision or dropped objects are to be assessed, based on the kinetic energy of impacting object and on the relevant scheme of energy dissipation.

5 Testing loads

5.1 Tank testing loads

5.1.1 The pressure on walls of watertight and oiltight compartments and members of the structure, during pressure testing of such compartments, is to be taken as per the load heights specified in Ch 3, Sec 7.

5.1.2 The loads induced by testing of equipment such as lifting equipment, davits for life saving appliances, vessels and tanks, and other equipment, are to be duly considered for the design of supports and structure underneath.

Note 1: these testing loads may be, in some cases, much greater than operating loads; typical examples are given by load testing of davits, and hydrostatic testing of large capacities normally filled with gas, or with only a small amount of liquid.

6 Load combinations

6.1 General

6.1.1 The design loads derived from the design data specified by the party applying for classification and entered in the Design Criteria Statement are to be realistically combined to produce the maximum effect upon each component of the structure of the unit.

6.1.2 Load combinations listed in [6.3] are to be considered for each of the conditions of operation corresponding to the structural type and service(s) of the unit.

6.1.3 When a load combination liable to occur within the set of design specifications or at the specified site of operation is not considered for the design of the unit, adequate instructions are to be stated in the Operating Manual and/or appropriate procedures provided to prevent such combination from occurring.

The present requirement particularly relates to the direction of the applied environmental loading (refer to [6.2]) and to the distribution of operational loads (refer to Ch 2, Sec 1, [3.2]).

6.2 Combination of environmental loads

6.2.1 For the purpose of load combinations, the environmental elements (wind, wave and current) are to be assumed to act simultaneously in the same direction, unless combinations of environmental elements with different directions might be more severe and liable to occur.

The most unfavourable direction, or combination of directions, for each component of the structure is to be considered unless specific operational requirements are formulated in accordance with Ch 2, Sec 1, [3.1.2].

Limitations, if any, with respect to waves directions are to be clearly specified.

6.2.2 For each direction, the environmental elements (wind, waves and current) are to be combined with their design values or associated design values.

For wave loads, the most unfavourable combination of wave height, wave period and water level when relevant, is to be retained.

For wind loads, the 1 minute sustained velocity is to be used in combination with other environmental elements for the design of the primary structure of the unit.

6.2.3 Where spectral design procedures are used, wave height and period in [6.2.1] and [6.2.2] relate to the significant height and reference period of sea state, and direction relates to the direction of highest energy density.

Then design loads and stresses are to be taken as the maximum values over a 3 h period.

6.2.4 When this is possible, the extreme environmental loads and stresses may be evaluated through long term statistics, using suitable techniques, to the satisfaction of the Society.

6.3 Load cases for overall strength calculation

6.3.1 The structure of the unit is to be designed for at least the load cases defined in [6.3.2] to [6.3.5]. If necessary, other load conditions that might be more critical are also to be investigated.

6.3.2 Load cases 1 “static” (still water)

These load cases refer to the most unfavourable combinations of the fixed and operational loads.

The most severe arrangement of operational loads, in particular with respect to moving equipment and dynamic operational loads, is to be considered.

For these load cases no environmental load is taken into account.

6.3.3 Load cases 2 “design” (with environment)

These load cases refer to the most unfavourable combinations of the fixed, operational and environmental loads, including:

- the extreme (severe storm) environmental loads with fixed and associated operational loads
- environmental loads specified by the Operating Manual as constituting limits for a condition of operation of the unit or for the operation of a particular equipment or system, with corresponding fixed and operational loads.

6.3.4 Load cases 3 “accidental”

The accidental loads are to be combined with the fixed, operational and associated environmental loads corresponding to the nature of each accidental load.

6.3.5 Load cases 4 “testing”

Testing loads are to be considered for the design of structures being tested and of the structures supporting the items to be tested, and also, as necessary, for design of overall structure.

6.4 Load cases for fatigue evaluation

6.4.1 For fatigue evaluation a sufficient number of load cases is to be considered to correctly model loads acting on the unit during its whole life, giving due consideration to:

- the various conditions of operation of the unit
- the direction and the intensity of environmental actions, as resulting from the long term distributions of relevant environmental parameters with possible limitations corresponding to each of these conditions.

6.5 Local loads

6.5.1 Local loads of different natures are to be combined as relevant. Each combination is to be qualified as “static”, “design”, “accidental” or “testing” according to its contents, on the same principles as detailed in [6.3] for overall loads.

CHAPTER 3
STRUCTURE

Section 1 General

1 General

1.1 Application

1.1.1 The present Chapter contains requirements applicable to all offshore units for which the structural type notations and the service notations are defined in Pt A, Ch 1, Sec 2, [4] and Pt A, Ch 1, Sec 2, [5] respectively.

1.2 Construction materials

1.2.1 Provisions of the present Chapter are applicable to structures of units made of steel or other metallic materials.

1.2.2 Concrete structures

For concrete structures of offshore units, reference is to be made to the present Chapter as far as its requirements are applicable and, in addition, to other standards for the design of concrete structures in a marine environment, to the satisfaction of the Society, such as:

- Publication from American Concrete Institute
- ISO 19903 Fixed Concrete Offshore Structures
- Eurocode 2 (EN 1992)
- NS 3473.E (6^{th} edition) Concrete Structures Design and Detailing.

1.3 Foundations of equipment

1.3.1 As a rule, the fixed parts of ancillary structures and equipment and their connections to the hull structure are in the scope of classification, even when the certification of the equipment is not required.

1.3.2 Ancillary structures and equipment are in the scope of classification when specific additional class notations are granted.

Note 1: Any equipment the failure of which could induce major consequences upon the safety of the unit should be covered by classification.

1.3.3 In case of a bolted connection of such equipment to the hull, limit of classification includes the bolted flange on deck (bolts excluded). In case of a welded connection, the exact limit will be defined after special examination by the Society.

Note 1: As a rule, this limit will be taken at the level where cutting would be performed in case of dismantling of the corresponding piece of equipment.

1.3.4 Adequate reinforcements are to be provided in way of the structural foundations of such equipment as:

- machineries
- fairleads, winches and other towing, mooring and anchoring equipment
- equipment corresponding to the particular service of the unit, such as the drilling equipment, crane foundations, and other concentrated loads.

Sufficient strength and stiffness are to be provided in these areas, in order to withstand the loads induced in all the conditions of operation, and avoid vibration that could lead to damage of the structure.

The foundations of lifting appliances are to comply with the applicable requirements of Ship Rules, Pt E, Ch 8, Sec 4.

2 Structural arrangement

2.1 General

2.1.1 The structural arrangement is to be compatible with the design, construction, operation and in-service inspection or maintenance of the unit. The arrangement is not to lead to unduly complicated design or fabrication procedures.

2.1.2 In compliance with provisions of Part A, Chapter 1, if the Builder contemplates construction procedures liable to affect the design strength of the unit (for instance by prestressing some areas), he is to provide the Society with all necessary additional information.

2.1.3 The structural arrangement is to ensure the possibility of adequate inspection during the construction phase as well as during the service life of the unit. Adequate markings and access are to be provided in particular for structural sensitive areas. Where the present requirement cannot be adequately achieved, alternative means (such as leakage detection) and/or additional strength are to be provided in agreement with the Society.

2.1.4 The structural arrangement is to take into account the possibility of accidental situations resulting from accidental loads or unexpected structural failure. In this respect, due consideration is to be given to subdivision, to accidental loadings defined in Part B, Chapter 2 and to the capability of the structure to provide for load redistribution.

3 Subdivision

3.1 Watertight subdivision

3.1.1 On all units, arrangement of watertight bulkheads and decks is to comply with the applicable requirements of Part B, Chapter 1.

3.1.2 On surface units, watertight transverse bulkheads are furthermore to comply with the applicable requirements of Part D, Chapter 1.

3.2 Wash bulkheads

3.2.1 The present requirement concerns ballast compartments, oil fuel bunkers and, generally, holds intended to carry liquids in any quantity of density less or equal to 1,025 t/m^2.

3.2.2 A transverse wash bulkhead is to be provided in compartments mentioned in [3.2.1], when:

- fillings between 0,50 H and 0,90 H are contemplated during service, and
- $\ell_c > 10$ where $L < 100$, or

  $\ell_c > 0{,}1\ L$ where $L \geq 100$, and
- $T_t < \sqrt{\dfrac{1{,}58\,\ell_c}{0{,}5 + 0{,}7\dfrac{H}{\ell_c}}}$

  in this last formula, the denominator is not to be taken greater than 1

where:

H : Depth of the tank, in m

ℓ_c : Length of the tank, in m

T_t : Minimum pitching period of the unit, in s; lacking more precise information, the value $T_t = L/19$, without being less than 6, is to be taken, L being the length of the unit.

This transverse wash bulkhead, where required, is to fulfil the following conditions:

- location about midway between watertight bulkheads
- $\alpha < 0{,}70$

where:

α : Ratio of the lightening holes sectional area to the total sectional area of the bulkhead.

3.2.3 A longitudinal wash bulkhead is to be provided in compartments mentioned in [3.2.1], when:

- fillings between 0,50 H and 0,90 H are contemplated during service, and
- $b > 21{,}5$

where:

b : Breadth of the tank, in m, measured at 0,8 H above its bottom

H : As defined in [3.2.2].

This longitudinal wash bulkhead, where required, is to fulfil the following conditions:

- location on the centre line of the tank
- $\alpha \leq 0{,}70$

where:

α : As defined in [3.2.2].

This wash bulkhead may be not required, where the hold or bunker includes sloping topside tanks extending down to 0,20 H at least from the tank top.

3.3 Cofferdam arrangement

3.3.1 Cofferdams are to be provided between:

- fuel oil tanks and lubricating oil tanks

- compartments intended for liquid hydrocarbons (fuel oil, lubricating oil) and compartments intended for fresh water (drinking water, water for propelling machinery and boilers)
- compartments intended for liquid hydrocarbons (fuel oil, lubricating oil) and tanks intended for the carriage of liquid foam for fire extinguishing.

3.3.2 Cofferdams separating:

- fuel oil tanks from lubricating oil tanks
- lubricating oil tanks from compartments intended for fresh water or boiler feed water
- lubricating oil tanks from those intended for the carriage of liquid foam for fire extinguishing

may not be required when deemed impracticable or unreasonable by the Society in relation to the characteristics and dimensions of the spaces containing such tanks, provided that:

- the thickness of common boundary plates of adjacent tanks is increased, with respect to the rule required thickness, by 2 mm in the case of tanks carrying fresh water or boiler feed water, and by 1 mm in all other cases
- the sum of the throats of the weld fillets at the edges of these plates is not less than the thickness of the plates themselves
- the structural test is carried out with a head increased by 1 m with respect to Ch 3, Sec 7.

3.3.3 Spaces intended for the carriage of flammable liquids are to be separated from accommodation and service spaces by means of a cofferdam. Where accommodation and service spaces are arranged immediately above such spaces, the cofferdam may be omitted only where the deck is not provided with access openings and is coated with a layer of material recognized as suitable by the Society.

The cofferdam may also be omitted where such spaces are adjacent to a passageway, subject to the conditions stated in [3.3.2] for fuel oil or lubricating oil tanks.

3.4 Fuel oil tank arrangement

3.4.1 The arrangements for the storage, distribution and utilisation of the fuel oil are to be such as to ensure the safety of the unit and persons on board.

3.4.2 As far as practicable, fuel oil tanks are to be part of the unit’s structure and are to be located outside machinery spaces of category A.

Where fuel oil tanks (other than double bottom tanks, if any) are necessarily located adjacent to or within machinery spaces of category A, at least one of their vertical sides is to be contiguous to the machinery space boundaries (they are preferably to have a common boundary with the double bottom tanks, if any) and the area of the tank boundary common with the machinery spaces is to be kept to a minimum.

Where such tanks are situated within the boundaries of machinery spaces of category A, they may not contain fuel oil having a flashpoint of less than 60°C.

3.4.3 Fuel oil tanks may not be located where spillage or leakage therefrom can constitute a hazard by falling on heated surfaces.

Precautions are to be taken to prevent any oil that may escape under pressure from any pump, filter or heater from coming into contact with heated surfaces.

Fuel oil tanks in boiler spaces may not be located immediately above the boilers or in areas subjected to high temperatures, unless special arrangements are provided in agreement with the Society.

3.4.4 Where a compartment intended for goods is situated in proximity of a heated liquid container, suitable thermal insulation is to be provided.

4 Access

4.1 Means of access

4.1.1 Each space within the unit is to be provided with at least one permanent means of access to enable, throughout the life of the unit, overall and close-up inspections and thickness measurements.

4.1.2 For the access to horizontal openings, hatches or manholes, the dimensions are to be sufficient to allow a person wearing a self-contained air-breathing apparatus and protective equipment to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of a confined space. The minimum clear opening is not to be less than 600 x 600 mm. When access to a hold is arranged through a flush manhole in the deck or a hatch, the top of the ladder is to be placed as close as possible to the deck or the hatch coaming. Access hatch coamings having a height greater than 900 mm are to be provided with steps on the outside in conjunction with the ladder.

4.1.3 For access to vertical openings or manholes in swash bulkheads, floors, girders and web frames providing passage through the length and breath of the space, the minimum opening is to be not less than 600 x 800 mm at a height not more than 600 mm from the bottom shell plate unless gratings or other footholds are provided.

4.1.4 Technical provisions of IMO Resolution MSC.158(78) and IACS UI MODU1, as amended, may be used as a reference for the design and arrangement of means of access.

4.1.5 Where a permanent means of access may be susceptible to damage during normal operations or where it is impracticable to fit permanent means of access, the Society may accept, on a case-by-case basis, the provision of movable or portable means of access, provided that the means of attaching, rigging, suspending or supporting the portable means of access forms a permanent part of the unit's structure. All portable equipment is to be capable of being readily erected or deployed by unit's personnel.

4.1.6 Equipment on deck is to be arranged such as to allow inspections of deck plating and to avoid permanent concentration of dust, mud and remaining water.

4.2 Access to holds, tanks, ballast tanks and other spaces

4.2.1 Safe access is defined in accordance with IMO Resolution A.864(20) Recommendations for entering enclosed spaces aboard ships.

4.2.2 Safe access to holds, cofferdams, tanks and other spaces are to be direct from the deck and such as to ensure their complete inspection. Safe access may be from a machinery space, pump room, deep cofferdam, pipe tunnel, hold, double-hull space or similar compartment not intended for the carriage of oil or hazardous materials, where it is impracticable to provide such access from an open deck.

4.2.3 Tanks or subdivisions of tanks having a length of 35 m or more are to be fitted with two access hatchways and ladders.

Tanks less than 35 m in length are to be served with at least one hatchway and ladder. When a tank is subdivided by one or more swash bulkheads or other obstructions which do not allow ready means of access, at least two hatchways and ladders are to be fitted.

When two hatchways are fitted, they are to be placed as far apart as practicable.

4.2.4 Each hold are to be provided with at least two means of access. Generally, these accesses are arranged diagonally.

4.2.5 In general, when two means of access are fitted, they are to be arranged as far apart as practicable.

4.3 Access manual

4.3.1 An access manual is to be incorporated in the operating manual of the unit. The access manual is to describe unit's means of access to carry out overall and close-up inspections and thickness measurements.

4.3.2 The access manual is to be updated as necessary, and an up-dated copy is to be maintained onboard.

4.3.3 The access manual is to include, for each space, the following information:

- plans showing the means of access to the space, with appropriate technical specifications and dimensions
- plans showing the means of access within each space to enable an overall inspection to be carried out, with appropriate technical specifications and dimensions; the plans are to indicate from where each area in the space can be inspected
- plans showing the means of access within each space to enable close-up inspection to be carried out, with appropriate technical specifications and dimensions; the plans are to indicate the position of structural critical areas, whether the means of access are permanent or portable and from where each area can be inspected

Note 1: Critical structural areas are locations identified from calculations to require monitoring, or, from the service history of similar or sister units, to be sensitive to cracking, buckling, deformation or corrosion which would impair the structural integrity of the unit.

- instructions for inspecting and maintaining the structural strength of all means of access and means of attachment, taking into account any corrosive atmosphere that may be within the space
- instructions for safety guidance when rafting is used for close-up inspections and thickness measurements
- instructions for the rigging and use of any portable means of access in a safe manner
- an inventory of all portable means of access
- records of periodical inspections and maintenance of the unit's means of access.

5 In-water surveys

5.1 General

5.1.1 When the additional class notation **INWATERSURVEY** is granted to the units, special constructional features are to be provided as defined in Pt A, Ch 2, Sec 8, [2.2].

Section 2 Structural Steels

1 General

1.1 Scope

1.1.1 The present Section defines the requirements governing the selection of structural steels.

1.1.2 At the very beginning of the project, the Society is to be informed of the materials intended to be used so that their characteristics, testing and manufacturing conditions may be examined.

1.1.3 The requirements of the present Section are formulated particularly for steels and products meeting the applicable requirements of NR216 Rules on Materials and Welding. for the Classification of Ships and Offshore Units.

Steels and products manufactured to other specifications may be accepted in specific cases provided that such specifications give reasonable equivalence to the requirements of these Rules.

1.1.4 The present Section is applicable to typical constructions and the Surveyor, where appropriate, may call for additional requirements to meet the intent of the Rules.

1.2 Steel selection parameters

1.2.1 The selected steels are to have mechanical properties satisfying the structural design of the unit and the requirements of this Section.

1.2.2 The steel grade for a structural element is to be selected in accordance with Article [3] on the basis of the:

- design service temperature defined in Ch 2, Sec 2, [6]
- structural category set out in Article [2]
- reference thickness of the element.

1.2.3 The reference thickness of the element to be considered in the steel selection diagrams depends on the type of material used:

- for flat products (plates and wide flats) and for tubulars, the reference thickness is the material thickness
- for sections, the reference thickness is the flange thickness
- for the steel forgings and castings, the reference thickness is to be previously determined in agreement with the Society (it is generally the average largest representative thickness).

Note 1: The reference thickness relates to the as-built thickness including any corrosion allowance.

2 Structural categories

2.1 Categories to be considered

2.1.1 Structural elements in welded steel constructions are classed into three categories: second, first and special categories as listed:

- Second category:
  Second category elements are structural elements of minor importance, the failure of which might induce only localised effects.
- First category:
  First category elements are main load carrying elements essential to the overall structural integrity of the unit.
- Special category:
  Special category elements are parts of first category elements located in way or at the vicinity of critical load transmission areas and of stress concentration locations.

2.2 Design drawings

2.2.1 Structural categories are to be indicated on the design drawings submitted to the Society for approval.

2.3 Classification of elements

2.3.1 Guidance is provided for classification of elements into categories, according their nature and to the structural type of unit, in NR426 Construction Survey of Steel Structures of Offshore Units and Installations.

Nevertheless, the Society may, where deemed necessary, upgrade any structural element to account for particular considerations such as novel design features or restrictions regarding access for quality control and in-service inspections.

3 Toughness requirements

3.1 General

3.1.1 Steel toughness requirements are based on Charpy V-notch (KV) impact testing.

Reference is made to NR216 for the testing procedure.

3.1.2 Additional tests, such as crack tip opening displacement testing (CTOD) may be requested as complementary investigation.

3.1.3 The toughness requirements herein further assume that, during the fabrication process:

a) steel is not cold worked to a forming strain in excess of 5%, or

b) in such a case, a heat treatment is performed (unless otherwise demonstrated to be unnecessary)

c) normalised steel is not heated to a temperature exceeding 650°C, or any other value specified by the steel maker, whichever is less.

3.1.4 The Society reserves the right to upgrade toughness requirements herein when any of the above conditions is not met or for any particular manufacturing or construction process.

3.2 Charpy V-notch impact properties

3.2.1 The Charpy V-notch impact requirements for rolled products in normal, higher strength structural steels and high strength quenched and tempered steels are given in NR216, Chapter 3.

The Charpy V-notch impact requirements for steel forgings and castings are given in NR216, Chapter 5 and NR216, Chapter 6.

3.2.2 Transverse Charpy V-notch impact tests are required for rolled products in accordance with Tab 1.

3.2.3 Where no fatigue occurs on the structure and in case of low service stresses, some limited increase in the temperatures of the KV test may be accepted after examination by the Society of a documented request.

Table 1 : Requirements for transverse Charpy V-notch impact tests

Steel type	Structural category	Thickness range	Type of KV tests
R_{eH} < 420 N/mm²	All	t ≤ 49 mm	KVL or KVT
		t > 49 mm	KVT
420 N/mm² ≤ R_{eH} ≤ 690 N/mm²	Special and first	all t	KVT

Note 1:
R_{eH} : Minimum specified yield strength of the steel, in N/mm²
KVL : Charpy V-notch impact tests with specimens taken in longitudinal direction (refer to NR216, Ch 2, Sec 4)
KVT : Charpy V-notch impact tests with specimens taken in transverse direction (refer to NR216, Ch 2, Sec 4).

3.3 Selection of grades for weldable normal and higher strength steels

3.3.1 Fig 1 to Fig 3 provide the required selection criteria for each of the three structural categories.

Note 1: If the categories are not yet defined at the time of procurement, Fig 1 (special category) may be used for all structural steels.

3.3.2 Fig 1 to Fig 3 are applicable to non-alloyed, micro-alloyed or low-alloyed carbon-manganese steels only with minimum specified yield strength R_{eH} lower than or equal to 420 N/mm².

These general diagrams are applicable to rolled plates and sections, as well as welded and seamless tubes with R_{eH} < 420 N/mm².

These diagrams concern the Charpy V-notch impact test only. For requirements concerning other characteristics, refer to NR216.

3.3.3 Normal and higher strength hull structural steel grades A to FH in accordance with the requirements of NR216 are generally suitable for most applications requiring minimum specified yield strength R_{eH} lower than or equal to 420 N/mm², as shown on Fig 1 to Fig 3.

3.3.4 On Fig 1 to Fig 3, the temperature of the impact test (T_{KV}) or the required steel grade for a structural element is given as a function of the design temperature T_D and of the thickness of the element.

3.3.5 For important tonnage of steel, an interpolation in Fig 1 to Fig 3 may be authorised, upon request, by the Society. In such a case, the temperature T_{KV} may be obtained by interpolation between temperature T_{KV} at the lower and higher limits of the relevant zone of the diagram, for the same thickness.

Note 1: For the same example as in Note 1 of Fig 2, the value of T_{KV} obtained by interpolation between T_{KV} = –20°C and T_{KV} = –30°C is: T_{KV} = –23°C.

3.3.6 The grade selection curves on Fig 1 to Fig 3, are based on the following publications:

- IACS Recommendation No. 11 Material Selection Guideline for Mobile Offshore Drilling Units
- Sanz G., 1981. Proposal of a quantitative method for the choice of steel qualities with regards to the risk of brittle fracture, Normes et techniques - AFNOR, IRSID
- Charleux J., 1981. Selection of steel qualities for welded structural elements, SNAME / Artic Section inaugural session, Calgary (Canada). Dec 16.

3.4 Selection of grades for steel forgings and castings

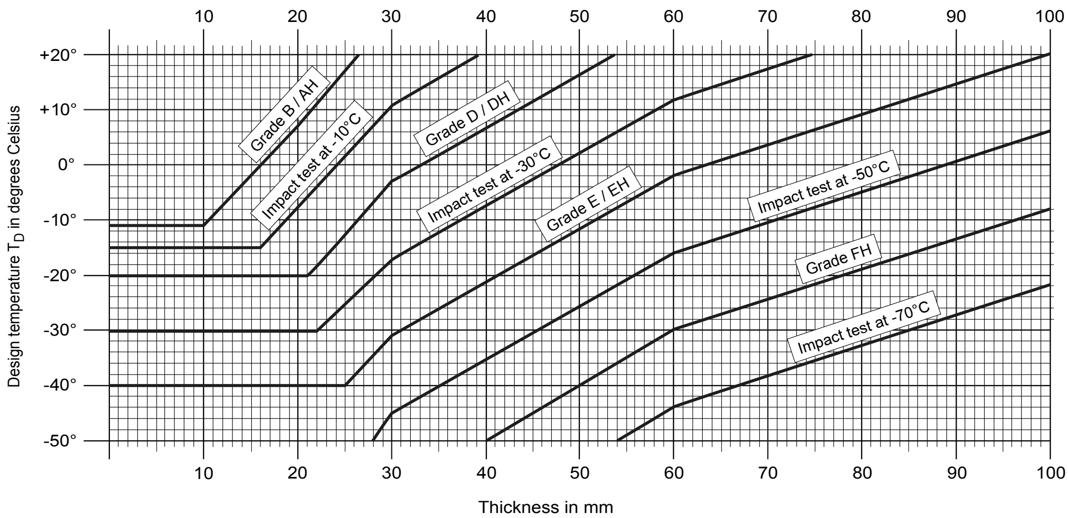
3.4.1 Fig 1 to Fig 3 provide the required selection criteria for steel forgings and castings.

Any deviation from the above requirement is to be submitted to the Society for approval.

3.4.2 These diagrams concern the Charpy V-notch impact test temperature only. For requirements concerning other characteristics, refer to NR216, Ch 5, Sec 2 and NR216, Ch 6, Sec 2.

3.4.3 Requirements for carbon and carbon-manganese steel forgings intended for non-welded components are given in NR216, Ch 5, Sec 3.

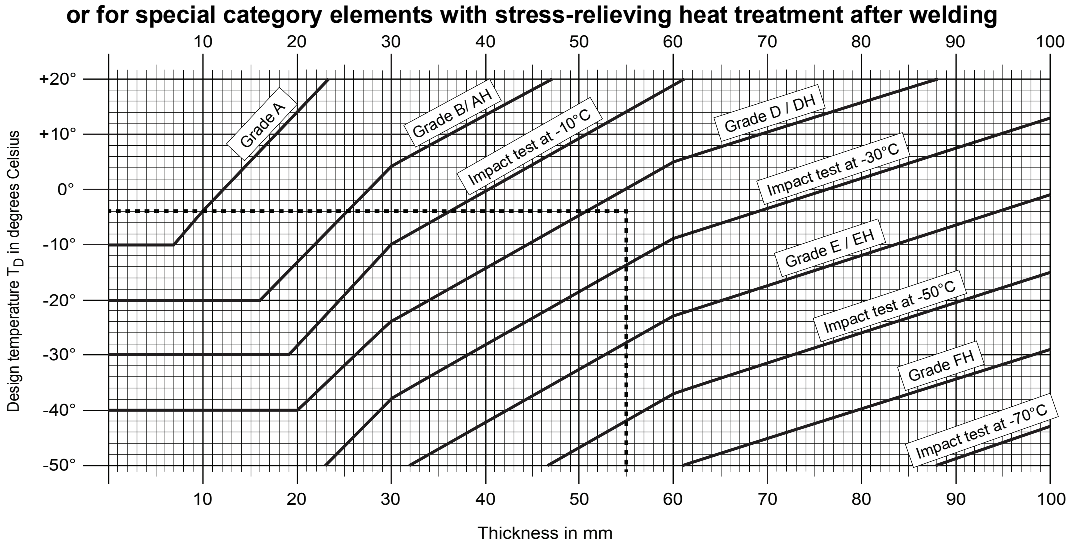
Figure 1 : Steel selection for special category elements as welded, without stress-relieving heat treatment after welding



Note 1:

- Valid for steels with minimum specified yield strength R_{eH} lower than or equal to 420 N/mm².
- For Charpy V-notch values, refer to [3.2].
- (T) means tested in transverse direction for rolled products, refer to [3.2].

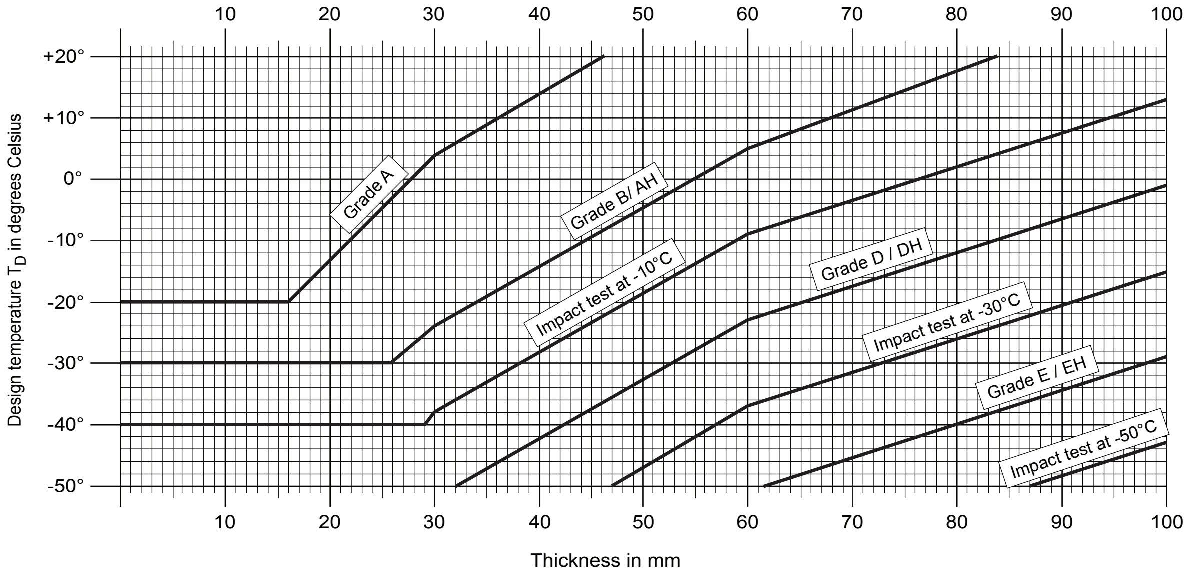
Figure 2 : Steel selection for first category elements as welded without stress-relieving heat treatment after welding or for special category elements with stress-relieving heat treatment after welding



Note 1: Example of selection: T_d = –4°C ; thickness = 55 mm

Steel grade is to be Charpy V-notch impact tested at –30°C. Steel grade E or EH being impact tested at –40°C can be selected.

Figure 3 : Steel selection for second category elements with or without stress-relieving treatment after welding or first category elements with stress-relieving heat treatment after welding



3.5 Selection of grades for high strength quenched and tempered steels

3.5.1 Fig 4 to Fig 6 provide the required selection criteria for each of the three structural categories.

3.5.2 Fig 4 to Fig 6 are applicable to weldable high strength quenched and tempered steels with minimum yield strength R_{eH} within the range of 420 N/mm² to 690 N/mm² as defined in NR216, Ch 3, Sec 3.

3.5.3 The requirements apply to carbon-manganese and low alloyed steels.

The steels are classed into six groups indicated by minimum yield strength R_{eH} (N/mm²) 420, 460, 500, 550, 620 and 690.

Each group is further subdivided into four grades A, D, E and F based on the impact test temperature, as defined in NR216, Ch 3, Sec 3.

The letters A, D, E and F mean impact test at 0, –20, –40 and –60°C, respectively.

Figure 4 : Steel selection for special category high strength quenched and tempered elements

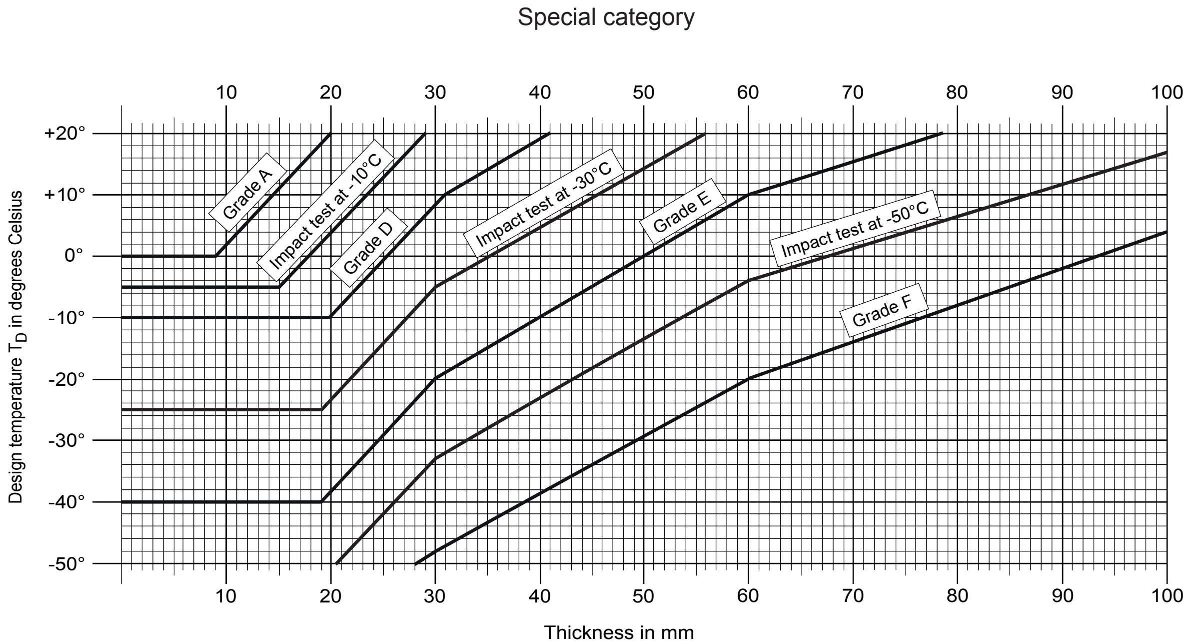


Figure 5 : Steel selection for first category high strength quenched and tempered elements

1st category

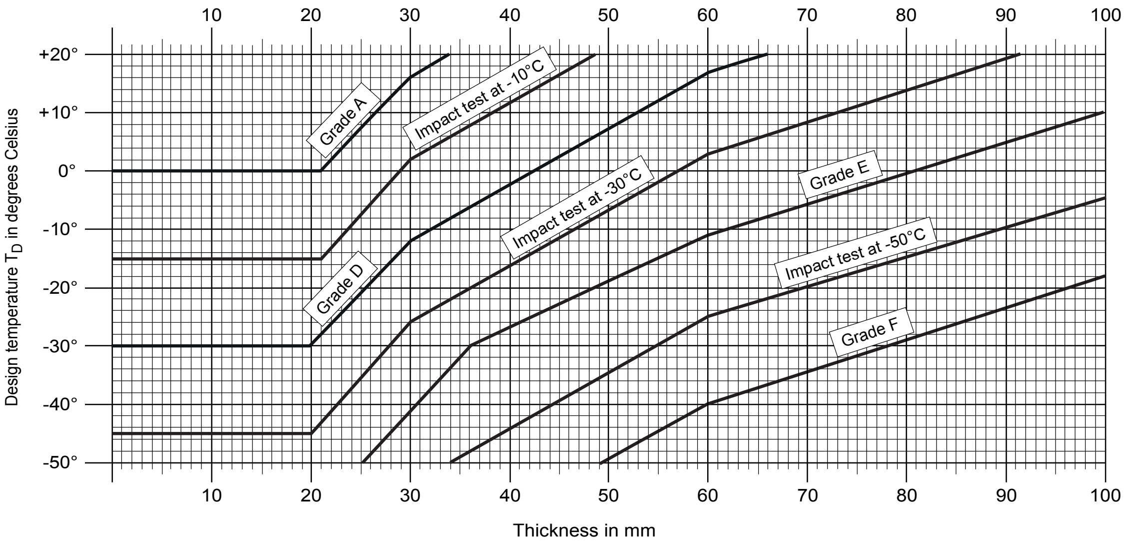
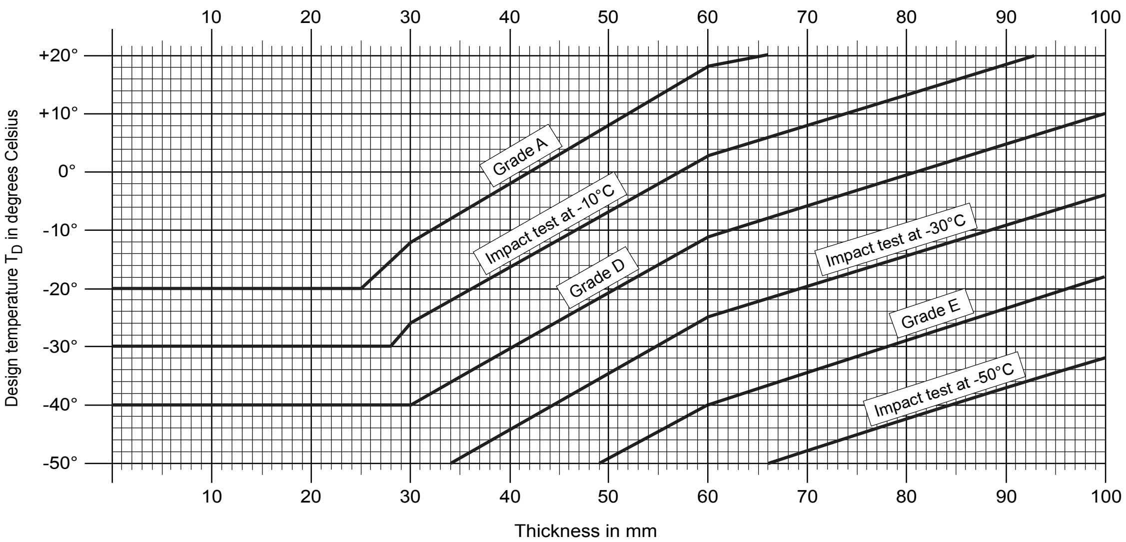


Figure 6 : Steel selection for second category high strength quenched and tempered elements

2nd category



4 Through-thickness ductility

4.1 Steels with specified through-thickness properties

4.1.1 The designer is to evaluate the risk of lamellar tearing, which is dependent on multiple parameters like shrinkage stresses during cooling due to assembly stiffness, clamping of the structure close to the joint, material thickness, material inclusions level, distribution and size of weld runs.

4.1.2 Where normal tensile loads induce out-of-plane stress greater than $0,5R_{eH}$ in steel plates:

- for plates with t < 15 mm:

  ultrasonic testing is to be performed
- for plates with t ≥ 15 mm:

  Z-quality steel is to be used or ultrasonic testing is to be performed in order to prevent laminar tearing.

Ultrasonic testing of the plate on which the weld is to be deposited is to be carried out before and after welding along a strip of 100 mm in width centred on the weld axis to detect any possible lamination of the plate located below the weld.

4.2 Use of Z plates

4.2.1 Where, as a result of service or residual stresses, tensile loads are induced normal to the steel plates, the use of Z steel plates is to be specified and adequate structural detail design and special welding techniques may need to be implemented to minimise through thickness loads and weld shrinkage strains.

Note 1: Tensile loads induced normal to the steel plates can happen in the following cases: e.g. intersection of tubular elements with large fillet or full penetration welds, or cruciform type joints of heavy elements, or connections of the flange type, or reinforcements of cut-outs and penetrations in way of structural elements subject to large tensile stresses.

4.3 Selection of type of Z grade

4.3.1 The requirements for Z grade are given in NR216, Ch 3, Sec 11.

4.3.2 The type of Z grade (Z25 or Z35) is to be determined with respect to the following factors:

- structural category of joint
- level of anticipated tensile stress
- geometric configuration and weld parameters.

Note 1: In general, Z 25 grade can be used in most restraint welding situations. For applications involving special category connections of elements subject to large service tensile stresses with thickness exceeding 40 mm, Z 35 grade is to be considered.

Section 3 Structure Strength Requirements

1 General

1.1 Application

1.1.1 The present Section is applicable to all structures of offshore units constructed of steel or other metallic material and of any structural type other than surface-type.

For surface units, self-elevating units and column stabilized units, Ch 3, Sec 8 is also applicable.

1.1.2 Strength requirements herein formulated are to be considered together with:

- loading conditions defined in Part B, Chapter 2
- construction with materials properties and workmanship defined in Ch 3, Sec 2 and Ch 3, Sec 6
- testing according to provisions of Ch 3, Sec 7
- particular requirements of Ch 3, Sec 8.

1.2 Principles

1.2.1 The structure is to have adequate strength to resist overall and local failure of its components. Relevant modes of failure to be considered include excessive deformations and yielding, general and local instability, fatigue, brittle failure, corrosion damage and occurrence of excessive vibrations.

1.2.2 The design of primary structural elements is to take into account the design life of the unit and for all of its conditions of operation. The design life of the structure is to be specified by the party applying for classification. It is normally to be taken not less than 20 years.

The design life of the structure is to be indicated in the Design Criteria Statement.

1.3 Design format

1.3.1 The deterministic linear design format or allowable stresses format is used to formulate the strength criteria of the present Rules.

1.3.2 Other design formats may be used if duly justified and adequately documented to the satisfaction of the Society.

The Owner's agreement may be required in cases where the Society deems it appropriate.

1.3.3 The limit state (load and resistance factor) design format may be used, in lieu of the format of the present Rules, if supported by suitable calibration for same type of structure and same type of climate, demonstrating that proposed load and resistance factors result in a level of safety equivalent to that afforded by the direct use of the Rules requirements, to the satisfaction of the Society.

Note 1: Attention is drawn that partial load factors may be not applicable to loads which are not independent; In such case, only a global load factor can be used.

1.3.4 The strength criteria of the present Rules take into account factors such as non-linearities, initial imperfections, residual stresses, etc., to the extent typically encountered. Their use then requires compliance with the Rules materials and workmanship requirements.

1.4 Corrosion allowances

1.4.1 The strength criteria of the present Rules also take into account a moderate and progressive corrosion, up to an amount of 4% in 20 years, except otherwise specified by applicable rules.

Any additional corrosion allowance, as may be provided in accordance with the provisions of Ch 3, Sec 5, is to be deduced from actual nominal thicknesses prior to application of strength criteria.

1.4.2 When the unit is converted from an existing unit, the assessment of strength is to be based on actual measured thicknesses reduced by any specified corrosion prediction or corrosion allowance. For a ship conversion into an offshore surface unit or redeployment of an offshore surface unit, the Guidance Note NI593 may be applied.

1.5 Plastic design

1.5.1 The strength criteria of the present Rules are based on loads and stresses being determined by elastic analysis, except where otherwise stated in Articles [4] and [5].

1.5.2 Plastic analysis may be used subject to a satisfactory demonstration of the following:

- other modes of failure such as elastic buckling are not liable to occur
- the postulated collapse mechanism (number and location of plastic hinges) results in the smallest ultimate load
- incremental collapse is not liable to occur under progressive and alternating loads (shakedown effect).

Note 1: Attention is to be paid to possible effects, under dynamic loads, of the changes in stiffness of members subject to plastic strains.

2 Materials

2.1 General

2.1.1 Materials including fabrication consumables are to be specified in order to present at least the strength properties considered in the design with due allowance for the service and fabrication requirements.

2.1.2 Structural steels are to be in accordance with the requirements of Ch 3, Sec 2, in particular with respect to brittle failure. Alternative criteria based upon fracture mechanics testing may be accepted by the Society after consideration on a case by case basis.

2.2 Use of high strength steels

2.2.1 Where higher strength steel is used, special care is to be exercised in detail design to ensure an adequate high cycle structural behaviour.

2.2.2 As a general rule, ordinary stiffeners welded on a plate and contributing to the overall strength of the unit are to be in a steel having the same reference stress than the corresponding plate.

As a general rule, connections are to be made of a steel having the same reference stress than the connected elements.

2.2.3 When high strength steel is used in some members or areas of the structure, and a lower strength steel is used in adjacent parts, attention is to be given to avoid a weak zone at transition.

For surface units only, extent of use of high strength steel, if used for hull, bottom and deck, is to comply with the relevant requirements of the Ship Rules.

2.3 Other materials

2.3.1 Metallic materials, other than steel, are to be of a type suitable for use in a marine environment, and are to be specified following recognised standards. Reference may be made also to other Rules and Guidance Notes published by the Society.

3 Overall strength

3.1 General

3.1.1 The loads and stresses in the overall structure are to be determined by an overall analysis of the structure.

3.1.2 The use of a particular method of structural analysis is not required provided that the selected methodology is appropriate to the nature of the loads, the geometry, the mode of operation (bottom-supported or floating) of the unit and to the nature of the response of the structure.

3.1.3 The party applying for classification is to demonstrate that recognised techniques are used consistently and result in the Rule prescribed level of structural safety.

3.1.4 Same provisions generally apply to overall fatigue analysis and to analysis of any specific part of the structure.

3.2 Structural analysis

3.2.1 The structural modelling is to take satisfactorily into account the geometric and mechanical properties of the unit, the distribution of inertia and the boundary conditions.

3.2.2 The method of analysis is to take adequately into account the nature of loads and load application, in particular:

a) The dynamic effects, where significant, are to be considered in the analysis.

b) Possible resonances of environmental loads with the structure are to be adequately investigated. Both full dynamic analysis and simplified methods may be used, provided that the computation assumptions, parameters and procedures can be realistically substantiated.

c) Non-linearities, e.g. due to loads, geometry or materials, are to be considered where significant.

3.2.3 The structural response of the unit is to be, at least, determined for the combined load cases defined in Part B, Chapter 2, taking into account specific requirements of Ch 3, Sec 8 applicable to particular structural types of units.

The verifications of the strength and stability of the structure are to be performed in accordance with the provisions of Article [4].

4 Local strength

4.1 General

4.1.1 The local strength of the structure is to be assessed using loads calculated according to Part B, Chapter 2, subject to particular requirements of Ch 3, Sec 8.

4.1.2 The local strength of the structure is to be assessed according to methods, codes or standards recognised to the satisfaction of the Society.

4.1.3 Stresses in the elements of the structure may be classed into three categories, each of these being usually obtained by separate calculation:

- overall stresses, resulting from the overall loading of the main structure
- grillage stresses, which are the stresses resulting from loads applied to girders and stiffeners
- plate bending stresses, which are the stresses in plates resulting from local pressure loadings.

4.1.4 Overall and grillage stresses are to be combined as relevant.

Resulting stresses are to satisfy the allowable stresses criteria specified in Article [5], and the buckling strength criteria specified in Article [6].

As necessary, fatigue evaluations, as provided for in Article [7], are to be carried out.

4.1.5 Strength of plating under pressure loads is to be separately evaluated, using recognised codes or standards to the satisfaction of the Society.

4.1.6 Strength of lattice type structures is to be assessed using codes or standards recognised by the Society, such as American Institute of Steel Construction - Specification for Structural Steel for Buildings (AISC).

4.1.7 For tubular members, the stresses due to circumferential loading are to be combined with the overall stresses to determine the total stress levels.

4.1.8 When the shear stress in girder webs or bulkheads is calculated through simplified methods, only the effective shear area of the web is to be considered. In this regard, the total depth of the girder is to be taken as the depth of the web or bulkhead.

4.1.9 In accordance with [1.5], plastic design may be considered for local design of elements not contributing to the overall strength of the unit and subject to occasional loading, when energy absorption is a primary concern in the design.

4.1.10 The local strength of the independent fuel oil tank is to be assessed using local loads calculated according to Ch 2, Sec 3, [2.7].

4.2 Detailing

4.2.1 Due attention is to be paid to the quality of detail design which is to be performed according to sound engineering practices corresponding to the present state-of-the-art.

4.2.2 Structural connections are to be adequately designed to ensure, as direct as possible, stress transmission avoiding eccentricity of joints.

4.2.3 Stress raisers, notches and local stress concentrations are to be kept to a minimum.

4.2.4 Detail design of highly stressed areas is to take duly into account the residual restraint stresses that may result from fabrication process.

Due precautions are to be given to avoid constraint triaxiality.

4.2.5 The possibility of lamellar tearing is to be minimised, where practicable, by avoiding the transmission of tensile loads through the thickness of plate. Where required, plate materials are to be specified with the through thickness properties prescribed in Ch 3, Sec 2, [4].

4.2.6 The compatibility between design, manufacture and construction is to be ascertained having due regard to practical fabrication techniques and available materials. Where necessary, tolerances are to be clearly stated on detail design drawings.

5 Allowable stresses

5.1 General

5.1.1 The present Article specifies the allowable stress criteria, with respect to yielding or breaking of the elements of structure.

For particular calculations or loading cases, the values of the allowable stresses are to be given specific consideration by the Society.

5.2 Material strength

5.2.1 The reference stress of material, R_f, is defined by:

$$R_f = \min\left(R_e, \frac{R_m}{1,2}\right)$$

where:

R_e : Minimum specified yield stress of the material

R_m : Specified minimum tensile strength of the material.

5.2.2 For hull steels, as defined in NR216, R_f is equal to the minimum specified yield strength of steel.

5.2.3 For light alloy materials (aluminium), when used in non-welded constructions, R_f is to be defined taking into account the material properties in the specified condition of delivery. For welded aluminium, R_f is to be taken based on R_e in the annealed condition (refer to NR216).

5.3 Equivalent stresses

5.3.1 For uniaxial stress condition (e.g. obtained by beam calculation), the equivalent stress σ_c, at each point, is given by:

$$\sigma_c = \sqrt{\sigma^2 + 3\tau^2}$$

where:

σ : Normal stress

t : Shear stress.

Above stresses are the result of the addition of overall stresses and grillage stresses, as defined in [4.1.3].

5.3.2 For biaxial stress condition (e.g. obtained by finite element calculation with plate elements), the equivalent stress, at each point, is given by:

- when $\sigma_1 \cdot \sigma_2 > 0$:

  $\sigma_c = \max(|\sigma_1|, |\sigma_2|)$
- when $\sigma_1 \cdot \sigma_2 < 0$:

  $$\sigma_c = \sqrt{\sigma_1^2 + \sigma_2^2 + |\sigma_1 \sigma_2|}$$

where

σ_1, σ_2 : Principal stresses in the element under study, including the effects of both overall and local loads.

5.4 Criteria

5.4.1 The equivalent stress is not to exceed the allowable stress σ_a, for the loading condition considered, according to the following formula:

$\sigma_c \leq \sigma_a$

where:

σ_a : Allowable stress, given by: $\sigma_a = 1,1\ \alpha\ R_f$

α : Basic allowable stress factor defined in [5.4.2].

5.4.2 The basic allowable stress factor α is to be taken as follows:

a) In general:
- for load case 1 ("static"):

  $\alpha = 0,6$
- for load case 2 ("design"):

  $\alpha = 0,8$
- for load case 3 ("accidental"):

  $\alpha = 1,0$

with the load cases 1, 2 and 3 as defined in Ch 2, Sec 3, [6.3].

b) For specific calculations:
- for load case 4 ("testing"):

  $\alpha = 0,9$ with the load case 4 as defined in Ch 2, Sec 3, [6.3]
- for wash bulkheads:

  $\alpha = 0,9$

- for foundation of towing, mooring and anchoring equipment:
  $\alpha = 1,0$ with the design loads defined in Ch 2, Sec 3, [4.2]
- for outer shell and subdivision bulkheads and decks in damaged condition:
  $\alpha = 1,0$
- for the foundations of offshore handling systems (e.g. winches, sheaves, chain jacks, strand jacks, etc.) used for risers and mooring lines installation, reference is made to NR595 Classification of Offshore Handling Systems.

5.4.3 When the stresses are obtained through a fine mesh Finite Element Model, the Society may give consideration to small hot spot areas not satisfying above stress criteria, providing that the following criteria are fulfilled:

- The Von Mises stress σ_{VM} at the centroid of elements of a peak stress region of no more than 2t x 2t, with t being the thickness of the elements, is to comply with the following criteria:
  $\sigma_{VM} \leq 1,3\ \alpha\ R_f$
- Outside the peak stress region of 2t x 2t, the Von Mises stress is to comply with [5.4.1].
- For areas where the stress is higher than σ_a a plastic stress redistribution should be demonstrated to the satisfaction of the Society or obvious from engineering judgement.

6 Buckling

6.1 General

6.1.1 The stability of the structure is to be checked, as needed, using methods recognised to the satisfaction of the Society.

6.1.2 As possible, the risk of instability (buckling) of structural elements is to be avoided or minimised by adequate structural arrangement (e.g. by avoiding large unstiffened panels or members with high slenderness, by the proper orientation of stiffeners with respect to direction of compressive stresses, etc.) and by detailing (e.g. by providing lateral restraint by tripping brackets, or additional members).

6.1.3 The buckling strength of structural elements is to be ascertained considering the most unfavourable combinations of loads likely to occur, with respect to possible modes of failure.

6.1.4 For unstiffened or ring-stiffened cylindrical shells, both local buckling and overall buckling modes are to be considered for buckling strength assessment.

6.1.5 For stiffened panels, buckling check is to be performed with NR615 Buckling Assessment of Plated Structures.

The buckling of tubular members is to be checked according to recognized codes or standards.

6.2 Buckling strength criteria

6.2.1 The buckling strength of structural elements is to be ascertained for the effect of stresses resulting from:

- compression induced by axial loads
- compression induced by bending in flanges and web of members
- shear
- external pressure
- localised compression loads.

6.2.2 The buckling capacity of structural elements for each failure mode is to be evaluated following recognised techniques, taking into account:

- potential overall and local failure mode(s)
- due allowance for the manufacturing and/or construction tolerances and residual stresses
- interaction of buckling with yielding
- when relevant, the interaction between overall and local buckling.

6.2.3 A structural element is considered to have an acceptable buckling capacity if its buckling utilisation factor η satisfies the following criterion:

$\eta \leq \eta_{ALL}$

with:

$\eta_{ALL} = \alpha$

α : Basic allowable stress factor defined in [5.4.2].

The buckling utilisation factor η of the structural member is defined as the highest value of the ratio between the applied loads and the corresponding ultimate capacity or buckling strength obtained for the different buckling modes.

6.3 Members

6.3.1 In structural members subject to simultaneous compression and bending, due account is to be given to beam-column effect.

6.3.2 Special attention is to be paid to the boundary connections of structural members for which buckling is a possible mode of failure, and to the design of arrangements and items intended to prevent buckling.

7 Fatigue

7.1 General

7.1.1 Structural elements for which fatigue is a probable mode of failure are to be adequately designed to resist the effects of cumulative damage caused by repeated application of fluctuating stresses.

The predominant cause of fluctuating stresses leading to crack propagation and fatigue failure is normally wave loading. However, other sources of cyclic loads such as wind, rotating machinery or cranes may also induce significant fatigue loadings and are to be given due consideration where relevant.

7.1.2 Fatigue evaluations are to be carried out according to recognised methods to the satisfaction of the Society.

7.2 Fatigue life

7.2.1 The design is to ensure a design fatigue life at least equal to the design life mentioned in [1.2.2].

7.2.2 A further increase in the design fatigue life is to be considered for elements in uninspectable areas or areas where repair within the expected life time is not possible or practical.

7.2.3 When a unit is converted from an existing unit or an existing unit undergoes a redeployment or life extension, due consideration is to be given to fatigue accumulation during the life time already elapsed and to information that can be obtained from the observation of structure. For surface unit, guidelines defined in NI593 Ship Conversion into Offshore Units - Redeployment and Life Extension of Offshore Units, are to be considered.

7.3 Design

7.3.1 The level of fluctuating stress is to be adequately limited.

A suitable fatigue life is best achieved by adequate joint detail design and fabrication quality control. Joint detail design is to avoid, as far as possible, joint eccentricities introducing secondary stresses and local restraints, abrupt section changes, re-entrant corners, notches and other stress raisers.

In fatigue sensitive areas, improved joint performance is to be achieved through, as necessary, a combination of reduction in nominal stresses, obtained by increased thicknesses, improved detailing, providing smooth transitions and suitable shape of weld joints.

7.3.2 Fatigue strength is also affected by fabrication induced (residual) stresses and by stress raisers caused by inherent weld defects, particularly surface defects.

This is normally accounted for by joint classifications, provided however that standard quality control procedures are adequately implemented.

7.3.3 Where it is not possible to improve fatigue life by another method, the Society will examine, in each separate case, weld profile improvement techniques such as grinding, shot blasting, TIG dressing and other post-welding treatments.

Where a joint performance depends upon particular fabrication and quality control requirements, adequate procedures are to be drawn up providing the necessary specifications concerning workmanship and inspection.

7.3.4 Due attention is to be given to attachment of fittings onto primary structural members. Unavoidable cut-outs or openings are to be, as far as possible, located outside high stress areas and superposition of notches is to be avoided.

7.4 Fatigue analysis

7.4.1 The long term distribution of fluctuating stresses is to be obtained from an overall structural analysis, for the relevant load cases, in accordance with Ch 2, Sec 3, [6.4].

Spectral analysis is generally to be used. Time domain analysis is to be preferred when both non-linearities and dynamic effects are significant. Deterministic analysis may be used when appropriate.

7.4.2 Geometrical stress concentrations result from openings, transitions in properties or geometry of members, end connections and other discontinuities. When not modelled in the overall analysis, such geometrical stress concentrations may be accounted for by appropriate Stress Concentration Factors (SCF).

Proposed SCF's are to be duly documented to the satisfaction of the Society. SCF's may be obtained from analytical solutions, in some cases, or from adequately calibrated parametric equations or by direct stress analysis. The Society reserves the right to call for such analysis if found necessary.

7.4.3 Local effects, resulting from residual stresses and from weld surface defects, are to be accounted for through joint classification.

7.4.4 The cumulative fatigue damage at each spot is to be calculated using the Palgren-Miner Rule and an appropriate S-N curve, taking into account joint classification, thickness effect and the degree of corrosion protection.

7.4.5 Fracture mechanics methods may also be used for fatigue analysis subject to adequate consideration of the stress history, of the joint geometric configuration and of the following, to the satisfaction of the Society:

- selection of initial crack geometry and size
- crack propagation rate, taking into account corrosion factors
- toughness parameters governing final crack instability for which a verification by appropriate fracture mechanics testing may be required.

Section 4 Other Structures

1 Superstructures and deckhouses

1.1 Surface units

1.1.1 For surface units, the relevant provisions of Pt D, Ch 1, Sec 13 are applicable.

1.2 Self-elevating units and column stabilized units

1.2.1 For self-elevating and column stabilized units, deckhouses are to have sufficient strength for their size, function and location, with due consideration given to the environmental conditions to which the unit may be exposed. The requirements of Pt D, Ch 1, Sec 13 may be applied as far as practicable.

2 Bulwarks, guard rails and gangways

2.1 Surface units

2.1.1 For surface units, the relevant provisions of Part D, Chapter 1 are applicable, in addition to those of the present Article [2], which are applicable to all types of units.

Alleviations may be considered by the Society when the application of these requirements would interfere with the operation of the unit, provided that equivalent arrangements for protection are provided.

2.2 Bulwarks and guard rails

2.2.1 Efficient bulwarks or guard rails are to be fitted on all exposed parts of the freeboard and superstructure decks. Their height is to be at least 1,0 m from the deck.

Alleviations may be considered by the Society when the application of these requirements would interfere with the operation of the unit, provided that equivalent arrangements for protection are provided.

2.2.2 As a rule, the spacing of bulwark stanchions is not to exceed 1,8 m or, when the stanchions are close to the gangway ports, 1,2 m. As far as practicable, stanchions are to coincide with beams.

2.2.3 Where guard rails are provided, the opening below the lowest course is not to exceed 230 mm. The other courses are not to be more than 380 mm apart.

The guard rail supports are not to be spaced more than 1,35 m.

2.3 Gangways – Surfaces

2.3.1 Satisfactory means (gangways, etc.) are to be provided for safe move of personnel on board, in particular between accommodation and work areas.

Gangways, stairs and passages exposed to environment are to be provided with a non-slip surface and, except when contiguous structures provide an equivalent protection, fitted with guard rails in compliance with [2.2].

3 Freeing ports

3.1 Surface units

3.1.1 For surface units, the relevant provisions of Pt B, Ch 11, Sec 12, [6] of the Ship Rules are applicable, in addition to the provisions of [3.2], which are applicable to all types of units.

3.2 Exposed decks

3.2.1 Adequately distributed freeing ports of sufficient section, with lower edges located as near the deck as practicable, or other equivalent means, are to be provided for efficient drainage of water from exposed decks, in particular for areas limited by bulwarks.

4 Helicopter deck

4.1 General

4.1.1 Units having the additional class notation **HEL** are to comply with the present Article.

4.2 Reference standards

4.2.1 The design and arrangement of the helicopter facilities are to be in accordance with the Civil Aviation Publication 437 "Offshore Helicopter Landing Areas – Guidance on Standards" (CAP 437).

4.3 Structure

4.3.1 The scantlings of the structure are to comply with the requirements of Pt D, Ch 1, Sec 14, [3]

4.4 Helideck safety net

4.4.1 A 1500 mm wide safety net, with flexible netting is to be provided around helideck.

5 Moonpool area

5.1 General

5.1.1 Applicable requirements for moonpool assessment are detailed in Guidance Note NI621 Guidelines for Moonpool Assessment.

Section 5 Corrosion Protection

1 General

1.1 Protection methods

1.1.1 General

The structure of the unit is to be effectively protected against corrosion damage using either one or a combination of the following methods:

- cathodic protection
- application of protective coatings
- selection of material.

1.2 Design of corrosion protection systems

1.2.1 The design of the corrosion protection systems is to consider the possible effects of environmental and galvanic corrosion, stress corrosion and corrosion fatigue.

1.2.2 Corrosion protection systems for steel structures are to be designed according to a recognised methodology such as the one developed in NI423 Corrosion Protection of Steel Offshore Units and Installations.

Design specification and calculation notes of corrosion protection system are to be submitted to the Society for approval.

If the design is conducted without reference to a recognised standard, the methodology and all the values utilized are to be documented and justified to the satisfaction of the Society.

1.2.3 It is the responsibility of the party applying for classification to inform the Society when the environment at an intended site of operation includes unusual corrosive conditions or when the structural elements are exposed to corrosive agents with consideration of the activities of the unit.

1.2.4 Both sacrificial and impressed current anodes are to be designed for a minimum service life in accordance with contemplated intervals between surveys in dry condition, unless particular arrangements are made for their replacement afloat.

Note 1: The attention of the Designer and the Owner is drawn upon requirements of Part A, Chapter 2 concerning maximum intervals between two surveys in dry condition.

1.3 Cathodic protection systems

1.3.1 Material certificates covering the corrosion protection equipment are to be submitted to the attending Surveyor.

1.3.2 Electrical continuity is to be ensured between anodes and the unit's steel structure. The anodes are to be fitted by welding.

Welding of sacrificial anode supports, or any device, onto structural members is to be carried out by qualified welders in accordance with approved procedures.

1.3.3 Anodes are to be properly installed, in such a way that:

- they do not induce unacceptable local stresses in the structure of the unit
- their efficiency is not impaired.

1.3.4 Prior to unit's delivery, corrosion protection systems are to be inspected.

1.3.5 For cathodic protection systems, in addition to inspection provided for in [1.3.4], installation effectiveness are to be checked apart from any annual in-service survey:

- for sacrificial anodes cathodic protection system, three months after the system has been put into operation for bare steel structures or one year after the system has been put into operation for coated structures
- for impressed current cathodic protection system, one month after the system has been put into operation.

2 Requirements applicable to particular areas

2.1 Submerged zone

2.1.1 Exposed steel surfaces in the submerged zone are to be provided with a cathodic protection system. This system may be complemented by a coating system.

2.2 Internal zone

2.2.1 Internal parts of tanks intended for sea water ballast are to be protected by coating, possibly complemented by cathodic protection.

2.2.2 A coating system for corrosion protection is normally considered to be a full hard coating. Other coating systems (e.g. soft coating) may be considered acceptable as alternative, provided that:

- they are applied and maintained in compliance with the Manufacturer's specification
- they give a protection against corrosion equivalent to those given by a hard coating for a minimum period of 3 years.

Coating is to be applied according to coating manufacturer recommendations.

2.2.3 Sacrificial anodes may be of aluminium or zinc types. The use of magnesium is limited to the conditions described in NI423 Corrosion Protection of Steel Offshore Units and Installations.

The amount of sacrificial material and location of anodes are to be chosen in accordance with:

- NI423 Corrosion Protection of Steel Offshore Units and Installations
- NI409 Guidelines for Corrosion Protection of Seawater Ballast Tanks and Hold Spaces.

or other recognised codes or standards.

The design life of the cathodic protection system is not to be less than 5 years.

2.3 Thickness increments

2.3.1 A thickness increment of platings and, where relevant, of stiffeners, is to be added to the Rules prescribed thickness where the concerned structural members are left unprotected or are not sufficiently protected against corrosion.

Thickness increments are to be also provided, if necessary, in special areas subject to mechanical wastage due to abrasion or in areas of difficult maintenance.

Thickness increments are to be evaluated on the basis of an anticipated rate of corrosion in the corresponding areas, and of the design life of the structure.

2.3.2 The party applying for classification is to notify the Society where thickness increments are provided. Adequate indications are to be given in the relevant structural drawings.

2.3.3 The Society reserves the right to require thickness increments, where deemed appropriate.

Section 6 Construction Survey

1 General

1.1 Document approval

1.1.1 When a construction is planned, the Builder has to contact the Society in order to submit the necessary documentation and to provide the information needed to allow Surveyors to carry out construction surveys in satisfactory conditions. It includes the approval of welding procedures, the qualification of welders, the welding inspection and the survey of testings.

1.2 Inspections and testings

1.2.1 As a general rule, construction and all necessary inspections and testings are to be carried out by the Builder and surveyed by the Society to the satisfaction of the attending Surveyors.

2 Construction survey scheme

2.1 Reference documents

2.1.1 A construction survey scheme is to be established in compliance with NR426, or, subject to a preliminary written agreement, in accordance with other particular specifications based upon recognised principles or construction codes - in particular relevant National Codes.

2.1.2 The codes and standards which are proposed as per [2.1.1] are to be specifically suitable for the type of construction and are to be considered by the Society as similar to the NR426, as specified in [2.1.1].

2.1.3 Where appropriate, the Surveyor may call for adaptation of these documents, or additional requirements, to meet the intent of the Rules.

2.2 Construction survey scheme applicable to several constructions

2.2.1 Instead of a construction survey scheme applied case by case, an equivalent construction survey scheme applying to all constructions of the same Builder with minor alterations, may be approved by the Society upon particular request.

3 Application of construction survey code

3.1 Forming

3.1.1 Forming of rolled steel products is to comply with the relevant requirements of the construction survey code which is used (refer to [2.1]).

3.2 Welding

3.2.1 Welding of steel and qualifications of welding procedures and welders are to comply with the relevant requirements of the construction survey code which is used (refer to [2.1]).

3.3 Welding inspection

3.3.1 Weld inspection is to comply with the relevant requirements of the construction survey code which is used (refer to [2.1]).

3.4 Conflicts between reference documents

3.4.1 If requirements mentioned in [3.1] to [3.3] are not similar, or are less stringent than those of NR426 Construction Survey of Steel Structures of Offshore Units and Installations, requirements of NR426 prevail.

Section 7 Tests and Trials

1 General

1.1 Application

1.1.1 The present Section deals with the tests of the various compartments and watertight members of the hull structure. The object of such tests is to check the strength of the structure or the watertightness of the compartments or both simultaneously.

1.1.2 The tests are to be carried out in the presence of the Surveyor at a sufficiently advanced stage in the building to prevent later modifications from endangering the strength or watertightness of the parts tested.

1.1.3 The present Section is applicable to wholly welded parts of the unit. For the other parts, additional tests may be called for by the Surveyor.

1.1.4 The test loads shown in the following are to be increased to the satisfaction of the Society in the case of heavy density liquids.

1.1.5 Where the tests stated in the present Section are proving impossible or inopportune, the Society may accept other testing methods, provided it be proved that the later enable the checking of the strength and watertightness of the compartments concerned under conditions deemed equivalent.

1.2 Water tests

1.2.1 Where a water test is required, it may be carried out before or after the unit is afloat.

1.2.2 Water testing of the double bottom compartments and peaks is to be made before cementing.

1.2.3 A coat of primary paint may be applied before testing. Where the tightness of the compartment has been checked before the water test, the latter may be carried out after the application of the preservative coating.

1.2.4 No water test is required for compartments the sides of which have been checked while water testing the adjoining compartments.

1.3 Air tests

1.3.1 Where an air test is required, the effective air pressure is not to exceed 0,24 bar.

The staff being under cover, the maximum pressure is maintained a few minutes at the beginning of the test, then reduced to 0,12 bar while the welded joints connecting prefabricated members are being examined. These joints are to be tested with an appropriate soapy liquid.

1.3.2 The air pressure is to be clearly shown by means of a water-column pressure gauge. Furthermore, an efficient safety system against overpressures is to be provided in the compartment under testing.

1.3.3 Where the air test concerns a capacity for which a preservative coating is intended, it is to be carried out before applying the coating on the welds which connect the prefabricated members.

1.4 Documents to be submitted

1.4.1 The detail of the tests foreseen by the Builder is to be specified by the test plan of the various compartments as called for in Part A, Chapter 1.

2 Watertight compartments

2.1 Double bottom compartments

2.1.1 All the double bottom compartments intended to contain liquid are to undergo a water test under the load height relating to the highest of the following levels:

- overflow
- load waterline.

Furthermore, for compartments intended to contain fuel oil, the test load height is not to be less than 2,40 m above the compartment top.

2.1.2 Liquid mains that are parts of the double bottom structure are to undergo a water test under a load height to be determined in agreement with the Society.

2.2 Peaks and ballast compartments

2.2.1 A collision bulkhead not bounding a ballast compartment or liquid tank is to undergo a water test under the load height relating to the waterline.

2.2.2 Peaks, deep tanks and other compartments used for ballast purposes are to undergo a water test under the load height relating to the highest of the following levels:

- overflow
- load waterline
- 2,40 m above the compartment top.

Testing of the aft peak is to be performed after the sterntube has been fitted, if applicable.

2.3 Fuel oil bunkers and independent fuel oil tanks

2.3.1 Fuel oil bunkers and independent fuel oil tanks are to undergo a water test under the load height relating to the overflow, being not less than 2,40 m above the compartment top.

2.4 Other liquid storage compartments

2.4.1 Integrated fresh water compartments are to be tested according to [2.2.2].

2.4.2 Independent fresh water compartments are to be water tested under the load height relating to the higher of the following levels:

- overflow
- 0,90 m above tank top.

2.4.3 Tanks intended to carry products with a density greater or equal to 1 are to be tested taking into account this density; test program is to be submitted to the Society's approval.

2.5 Shaft tunnel

2.5.1 The shaft tunnel, if one exists, is to be hose tested.

3 Miscellaneous

3.1 Rudder

3.1.1 After completion, rudders of watertight construction, if any, are to undergo a water test under the load height the value of which is equal to the scantlings draught without being less than 2,40 m.

3.1.2 The preceding test may be replaced by an air test under a pressure of 0,2 bar.

3.1.3 Rudder shaft is to be magnetic particle inspected before installation (or after any repair).

3.2 Doors on watertight bulkheads

3.2.1 Doors on watertight bulkheads are to be hose tested, where such bulkheads are not water tested.

Hatch covers on weatherdecks, if any, are to be hose tested.

3.3 Shell openings closures

3.3.1 Shell openings closures are to be hose tested.

Section 8 Particular Unit Types

1 Scope

1.1 Particular types of units

1.1.1 The present Section defines the particular requirements for the design of units, which are depending on their structural types:

- surface units
- self-elevating units
- column stabilized units.

In addition, the provisions related to specific service notations are to be duly considered. The Society reserves the right to require that some of these provisions are referred to, where deemed relevant, even if the corresponding service notation is not granted.

2 Surface units

2.1 Mobile units

2.1.1 Surface units which are mobile offshore units are to satisfy the requirements of the present Section.

2.1.2 Design and strength of hull structure are to comply with the requirements of Part D, Chapter 1, as applicable to the construction of the subject vessel, in lieu of the provisions of the present Chapter.

2.1.3 The required strength of the unit is to be maintained in way of the moon-pool and in way of large hatches.

In this respect, consideration is to be given to the required main hull girder section modulus and particular attention is to be given to the continuity of fore and aft members.

The design of moon pool walls is to ensure an adequate strength for pressure loadings and particular attention is to be given to possible impact loading due to waves or trapped objects during transit.

The detail design of hatch beams and corners is to comply with the applicable requirements of the Ship Rules.

2.1.4 Additional structures not covered by the Ship Rules such as drillfloor, crane pedestal, etc., are to be designed in accordance with the requirements of Part B, Chapter 2 and Part B, Chapter 3.

For the calculation of dynamic loads induced by the motions of the unit, accelerations are to be taken not less than those defined by the Ship Rules, for a probability of 10^{-8}.

In the case of floating units for production and/or storage, refer to Pt D, Ch 1, Sec 4.

2.2 Permanent installations

2.2.1 Surface units which are permanent installations are to comply with the requirements of Part D, Chapter 1, or of NR542 Classification of Floating Gas Units, as relevant.

3 Self-elevating units

3.1 General

3.1.1 Additional structural requirements and guidance for the classification of self-elevating units are given in NI534 Rules for the Classification of Self-Elevating Units - Jack-ups and Liftboats.

4 Column stabilized units

4.1 General

4.1.1 Additional structural requirements and guidance for the classification of column stabilized units are given in NR571 “Classification of Column Stabilized Units”.

Section 9 Local Structural Improvements

1 General

1.1 Application

1.1.1 The present Section provides requirements and guidance for local structural reinforcements.

1.1.2 Depending on the type and service of the unit, a risk analysis may be required to assess the risk of explosion, collision and dropped objects.

2 Protection to explosion

2.1 General

2.1.1 Scope

The scope of the present Article is to provide guidance for the verification of the structure safety with respect to explosion.

The requirements are eligible for the verification of the resistance of hull structure components submitted to a shock pressure wave.

The types of explosions to be assessed are:

- from an open air cloud (external explosion)
- between main deck and process deck (tunnel explosion)
- inside closed capacities (internal explosion).

2.1.2 Safety criteria

The safety principle is that the structural elements may suffer permanent deformations without any rupture allowing the transmission of the pressure waves and hot gases or liquids through the steel panels.

For internal explosions the above principle can be fulfilled in two ways:

- the boundary structure of the tank resists to the extreme possible pressure wave
- the tank is equipped by a system allowing a limitation of the maximum pressure such as relief valves or sacrificial panels.

2.1.3 Explosion characteristics

The explosion is characterized by 2 parameters:

- the equivalent exploded TNT mass
- the distance from the explosion location to the verified ship structural component.

The explosion is considered occurring with stoechiometric conditions.

Note 1: 1 kg hydrocarbon (gas or liquid) is equivalent to 1 kg of TNT.

2.1.4 Structural detail design

To improve the resistance to explosion loads, structural details have to be designed to allow a good transmission of the in-plane forces.

Details have to be designed to allow in plane deformation with as low as possible punching effect and shear failure of welds.

2.1.5 Calculation to be submitted

The following documents are to be submitted to the Society for information:

- Equivalent exploded TNT mass calculation.
- Pressure profile and maximum pressure of the shock wave justifications. The pressure wave can be determined either by test results or either a recognized computation fluid dynamic tool.
- The finite element model with the modelling hypothesis (element types, boundary conditions, damping, loading cases, load phases, etc.).
- Response and resistance of the structural elements calculation.
- Arrangement of the maximum pressure limitation system and operating assessment.

2.2 Areas to be considered

2.2.1 Turret and turret moonpool

Leakage can occur inside such spaces with generation of an explosive atmosphere.

In case of explosion, the spaces boundaries with the surrounding hull structure should have to resist to the internal explosions. For the protection principles see [2.1.2].

2.2.2 Main deck

The main deck may have parts below the process deck or in open air.

For the parts below the process deck, due to possible leakage, it can be exposed to explosions of type tunnel explosion.

For the parts in open air, they can be exposed to explosions occurring outside the topside equipment. The type of explosion to be considered is aerial explosions.

2.2.3 Superstructure front

The superstructure front can be exposed to explosions occurring outside the topside equipment.

When specified superstructure front resistance has to be assessed. The type of explosion to be considered is aerial explosions.

2.2.4 Tanks

Except otherwise specified no assessment is required for tank boundary resistance to internal explosions.

2.3 Criteria

2.3.1 Criteria for the shell and bulkheads

The ultimate strength of structural components is defined in terms of non rupture of the component after the shock load action.

For shell and bulkhead panels the maximum strains in model elements have to be determined.

The following criteria are to be fulfilled, versus the modelling (see [2.4.3]):

- the maximum element deformation $\in_M$ for elasto-plastic calculations:

  $\in_M \leq 0,8\ \in_{Ult}$

  where $\in_{Ult}$ is the material ultimate strength elongation

- the maximum stress σ_M for elastic calculations

  $\sigma_M \leq 0,8\ E\ \in_{Ult}$

  where E is the material Young modulus.

2.3.2 Sacrificial panel

Under the maximum specified pressure, the opening of the area covered by the sacrificial panel is to be sufficient to allow a gas flow stopping the shock wave pressure increase.

When structural elements exist in the gas flow their resistance to the drag forces has to be assessed.

2.3.3 Relief valves

Under the maximum specified pressure, the relief valve openings are to be sufficient to allow a gas flow stopping the shock wave pressure increase.

2.4 Methodology

2.4.1 General

Explosion is a transient dynamic phenomenon. The response can be assessed by an adequate finite element software.

At a pre-design stage, 1 Degree Of Freedom (DOF) mass-spring modelling can be used to assess the elastic response of the structural components. A finite element model is to be done to determine the free modes from which the 1DOF models will be selected.

At design stage, the assessment is to be done using a finite element model either elastic or elastoplastic.

2.4.2 Free mode determination

The boundary conditions are to be carefully determined.

In particular the boundaries are to be located in way of continuous bulkheads or floors.

2.4.3 Modelling

a) 1 DOF mass-spring model

The free modes, which half periods are in the vicinity of the pressure shock wave durations, can be represented by a 1 DOF system.

The 1 DOF system is characterised by:

- free frequency equal to the represented component free mode period
- spring stiffness so that the displacement of the 1 DOF system under a static unit force is equal to the maximum deflection of the structural component under a uniform static pressure corresponding to the unit force
- for the transient response calculation, the damping can be neglected.

b) Finite element model

The finite element model is to take into account:

- the dynamic response of the panel under impulsive loads
- the liquid added mass effects for wet components
- the structural damping and, when relevant, the hydrodynamic damping (see [2.4.4])
- the large deformation effects
- the material plastification effects, when elasto-plastic calculations are carried out.

The model size and finite element types have to be able to determine accurately:

- the correct component deformation under static and impulsive transient pressure
- the correct stress fields, in particular in way of areas with stress concentration
- at least the 2 first free vibration modes of the components of highest free frequencies
- the plastification characteristics of the elements, when elasto-plastic calculations are carried out.

2.4.4 Damping

The structural damping ratio (in percent of critical damping) can be taken equal to 10%.

The hydrodynamic damping ratio is to be determined by a recognized method.

2.4.5 Model response calculation

The response has to be computed during the explosion wave pressure duration and after on a time length corresponding, at least, to 2 times the largest period of the structural component first mode.

For panels and structural components response, the response has to be computed taking into account the shock wave pressure (see [2.5]).

a) 1 DOF mass-spring model

The equivalent static pressure is determined taking into account the maximum displacement of the 1 DOF model.

Elastic calculation under static loads allows to assess the stresses and strains of the model.

b) Finite element model

The stresses and strains calculated through a finite element model are to comply with the criteria given in [2.3].

2.5 Explosion pressure wave loads

2.5.1 Definitions

W : Equivalent exploded TNT mass, in kg

D : Minimum distance from the plating component to the explosion location, in m.

2.5.2 External explosion

The shock wave pressure, at a given location versus time is given by the following equation:

$P = P_M \exp(-n\, t)$

where:

P_M : Maximum shock wave pressure, in kN/m², given by:

$$P_M = 730\frac{W^{0,527}}{D^{1,58}}$$

n : Decay shock wave pressure parameter, in sec, given by:

$$\frac{1}{n} = 0,48W^{0,196}D^{0,38}10^{-3}$$

2.5.3 Internal explosion

For internal explosion, the pressure profile is to be a triangle, which characteristics: maximum pressure, rise time, decay time to 0, are functions of the dynamic boundary characteristics and are to be duly justified.

The pressure profile characteristics can be determined from results of tests or a computational fluid dynamic tool.

2.5.4 Tunnel explosion

For tunnel explosion, the pressure profile is to be a triangle, which characteristics: maximum pressure, rise time, decay time to 0, are to be duly justified.

The pressure profile characteristics can be determined from results of tests or a computational fluid dynamic tool.

3 Collision

3.1 General

3.1.1 Scope

The present Article provides guidance for the verification of the structure in case of collision.

3.1.2 Design against collision

When required by the risk analysis, the effect of collision is to be evaluated in order to assess the damages likely to occur.

Impact energy absorption capability through plastic deformations is to be obtained by the correct use of ductile materials and by avoiding abrupt section changes, notches and other stress raisers.

For units intended to operate in areas where icebergs or ice-islands are expected, an evaluation of resistance to collision may be required in agreement with the party applying for classification.

3.1.3 Definitions

- Minor collision:

  Collision between the offshore unit and a vessel which dimensions are small compared to the dimensions of the offshore unit. e.g. supply vessel.

- Major collision:

  Collision between the offshore unit and a vessel which dimensions are significant compared to the dimensions of the offshore unit. e.g. shuttle tanker.

- Hourglass energy:

  Hourglass energy generating Hourglass modes represent nonphysical, zero-energy modes of deformation that produce zero strain and no stress and which occur only in under-integrated finite element models.

3.1.4 Safety principles

The consequence of a collision is to be limited as defined below.

- Minor collision:

  The collision energy is to be absorbed by the colliding vessel and the side shell of the offshore unit without risk of flooding. Therefore the safety criterion is that the side shell may suffer permanent deformations but without any rupture.

  For protectors, the collision energy is to be absorbed by the colliding vessel and the protector with no contact with the protected item.

- Major collision:

  The collision energy is to be absorbed by the colliding vessel, the side shell and the internal structure of the offshore unit without any impairment of the watertightness integrity of the inner hull.

3.1.5 Documents to be submitted

The following documents are to be submitted to the Society for information:

- Risk analysis:

  When collision analysis is performed, a risk analysis is taking into account the boats operating around the unit, such as supply boats, shuttle tanker, etc is to be submitted.

  The risk analysis is to determine, for each vessel operating around the unit, the speed, the mass and the associated probability of collision. For permanent offshore units: list of shuttle tankers and supply vessels intended to be operated during the unit life with the characteristics of these vessels.

- Colliding speeds and justification.
- Colliding energy calculation.
- Collision analysis report.

3.2 Collision hypothesis

3.2.1 General

As a rule, the collision analysis is to consider the results of the risk analysis.

3.2.2 Collided areas

The following areas of the unit should be considered:

- free side shell between two transverse bulkheads
- free side shell at the level of the first transverse ring from a transverse bulkhead
- side shell in way of offloading area.

When protectors are verified, the following areas should be considered, as relevant:

- side shell at spread mooring zones
- side shell at the offloading line protection zones
- side shell at the riser zones.

3.2.3 Collision scenarii

The colliding vessel is considered hitting the side shell by the bow at 90°.

Note 1: Other collision angle may be required when deemed necessary.

- The colliding vessel sizes and bow shapes (with or without bulb) to be considered are selected from the list of shuttle tankers and supply vessels intended to be operated during the unit life.
- The colliding vessel speed is to be specified considering the operation instructions.

Without any information, for minor collision, displacement and speed of the colliding vessel are to be taken equal respectively to 5000 t and 2,0 m/s.

3.2.4 Colliding energy

The colliding vessel energy E_c, in kJ, is to be taken equal to:

$$E_c = \frac{1}{2}(M + M_a)V^2$$

where:

M and M_a: Displacement and added mass of the colliding vessel

As a rule, hydrodynamic added mass M_a is to be taken equal to 0,1M for bow/stern impact and 0,4M for side impact.

V : Speed of the colliding ship, in m/s.

3.3 Methodology

3.3.1 General

Collisions may be assessed using one of the methods defined here under. Safety factors are defined on a case-by-case basis.

3.3.2 Colliding ship

The bow of the colliding ship is in general considered as non-deformable. Therefore the geometrical contour of the bow defines the indented area of the unit.

3.3.3 Finite Element Method

For collision analysis using Finite Element Method, following recommendations are to be respected.

a) Meshing:

In general, only the studied area is modelled and meshed with shell finite elements. The rest of the ship is taken into account by defining a rigid body, stitched to the deformable model and characterized by a mass and inertia matrix associated to the center of gravity of the ship. A particular attention is to be paid in the transition area between different meshing sizes and boundary conditions are to be as far as possible and not influence the deformation modes of the structure.

In the impacted area, dimensions of shell elements are not to be greater than 100 mm x 100 mm and a minimum of 3 elements between 2 ordinary stiffeners is recommended. A converging analysis may be performed to ensure that the crushing force does not change substantially when the mesh size is refined.

Element aspect ratio is to be as close to 1 as possible, and not to exceed 3. Element's corner angles are to be greater than 60° and less than 120°. Triangular elements and elements having dimensions less than their thickness are to be avoided.

In the deformation area, the mesh sizes of the colliding vessel and the offshore unit are to be identical.

A minimum of 5 integration points in the plate thickness is to be considered to ensure a correct plastic behaviour of the plate element.

b) Material's law and rupture criteria

The elasto-plastic material and the erosive laws are to be considered in the non-linear computation.

The elasto-plastic material characteristics and the failure strain criteria used in the erosive law are to be provided for information.

c) Computation

Finite element calculations are to be performed until the limit state is reached, using a non-linear elasto-plastic recognized software based on a step by step time integration approach.

If under-integrated elements are used, hourglass energy is to be checked and to be less than 5% of the global internal energy.

As a rules, the total energy (sum of kinematic energy, deformation energy,…) should remain constant during the computation.

When deemed necessary, global movements of the offshore unit should be taken into account in case of major collision.

3.3.4 Analytical Methods

As an alternative, following analytical methods can be applied.

a) Empirical method

Analytical methods, developed to assess the energy absorbed during a collision, such as Mc Dermott (1) or Rosenblatt (2) methods, in case of minor collision and Minorsky (3) or Pedersen and Zhang (4) methods, in case of major collision, can be applied.

b) Super-element method

The analytical method based on the decomposition of the structure into large structural entities and called super-element method, developed by M. Lutzen (5) or H. Le Sourne (6) and L. Buldgen (7), can be used for minor and major collisions.

c) Critical strain

For analytical methods, the values of critical strain in Tab 1 are to be considered.

Note 1:

(1) McDermott, J.F., et al, 'Tanker Structural Analysis for Minor Collisions', SNAME Transactions, Vol. 82, pp. 382-414, 1974.

(2) Rosenblatt & Son, Inc, 'Tanker Structural Analysis for Minor Collision', USCG Report, CG-D-72-76, 1975.

(3) MINORSKY, V.U., 'An Analysis of Ship Collisions with Reference to Protection of Nuclear Power Plants', Journal of Ship Research, 1959.

(4) PEDERSEN, P.T., ZHANG, S., 'On Impact Mechanics in Ship Collisions', Marine Structures, 1998.

(5) LUTZEN, M., SIMONSEN, B.C., PEDERSEN, P.T., 'Rapid Prediction of Damage to Struck and Striking Vessels in a Collision Even', Int. Conf. of Ship Struct. for the new Millennium: Supporting Quality in Shipbuilding, Arlington, 2000.

(6) Hervé Le Sourne, 'A ship Collision Analysis Program Based on Super-element Method Coupled with Large Rotational Ship Movement Analysis', in 4th International Conference on Collision and Grounding of Ships, Hamburg, 2007.

(7) Loïc Buldgen, Hervé Le Sourne, Nicolas Besnard, and Philippe Rigo , 'Extension of the super-element method to the analysis of the oblique collision between two ships', Marine Structures, vol. 29, 2012.

Table 1 : Critical strain

Steel grade	critical strain
Normal Strength steel (Yield strength less than or equal to 235 Mpa)	20%
High Strength steel (Yield strength less than or equal to 355 Mpa)	15%

3.4 Verification criteria

3.4.1 Criteria

For minor collision, the considered limit state is the first rupture of the side shell elements.

For minor collision in way of protectors, the considered limit is the contact with the protected item.

For major collision, the limit state is the first rupture of the inner hull.

For finite element methods, the justification of the critical strain values is to be submitted.

3.4.2 Results

The results to be provided are:

- the absorbed deformation energy versus penetration
- the deformed structure at the end of the simulation
- the list of cracked plates.

4 Dropped objetcs

4.1 General

4.1.1 Scope

The present Article provides guidance for the verification of the deck structure in case of dropped objects.

4.1.2 Safety principle

The safety principle is that the structural elements may suffer permanent deformations but without any rupture.

4.1.3 Calculations to be submitted

The following documents are to be submitted to the Society for information:

- equipment considered that may fall on the deck with mass
- maximum dropped height and justification
- deck areas to be assessed
- deck modelling
- dropping object modelling
- deck response and extreme deformations.

4.2 Methodology

4.2.1 Dropping object

The dropping object is modelled in such a way that its contact area and stiffness behaviour are respected.

4.2.2 Deck structure

Depending on the size of the dropping object, the deck structure to be modelled is a panel between primary supporting members, or bulkheads/side shell.

4.2.3 Procedure

The dropping object is considered as deforming the deck structure by step by step static indentation, both being deformable, taking into account the relative stiffness.

The indentation is performed until the limit state is reached, as defined in [4.2.4].

4.2.4 Criteria

The energy of the dropping object at the moment of the contact with the deck is to be lower than the absorbed energy by the deck deformation at the limit state.

The limit state is to be defined as follows:

- for hull decks constituting the top of tanks in the cargo area, the limit state corresponds, generally, to a strain of maximum 5% in the deformed area
- for other decks, including laydown areas, the limit state corresponds to the first rupture of a plate in the deformed deck area.

Different definitions of the limit state may be considered if specified by the Owner.

4.2.5 Finite element calculation

Finite element calculations are to be performed until the limit state is reached, using a non-linear elastoplastic recognized software.

4.2.6 Results

The results to be provided are:

- the absorbed deformation energy versus indentation steps, until the limit state is reached
- the deformed structure at the limit state
- the list of the cracked deck plates.

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