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REQUIREMENTS CONCERNING MOBILE OFFSHORE DRILLING UNITS

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July

Publications P (Additional Rule Requirements), issued by Polski Rejestr Statków, complete or extend the Rules and are mandatory where applicable.



GDAŃSK

Publication No. 49/P – Requirements Concerning Mobile Offshore Drilling Units – July 2017, based on the IACS Unified Requirements D3 to D7, D9 to D11 and W22, is an extension of the requirements contained in *Part I – Classification Regulations of the Rules for the Classification and Construction of Mobile Offshore Drilling Units*.

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The present *Publication* replaces the *Publication No. 49/P – Requirements Concerning Mobile Offshore Drilling Units – January 2017*.

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1 GENERAL

1.1 *Publication No. 49/P – Requirements Concerning Mobile Offshore Drilling Units* (hereinafter referred to also as the *Publication*) is based on IACS Unified Requirements D3, D4, D5, D6, D7, D9, D10, D11 and W22.

1.2 The requirements set forth in IACS URs D1, D2, D8 and Z15 have already been incorporated into *Part I – Classification Regulations of the Rules for the Classification and Construction of Mobile Offshore Drilling Units*.

1.3 The present requirements together with those given in the *International Code for the Construction and Equipment of Mobile Offshore Drilling Units* will be applied by PRS for classification purposes for assigning a symbol of class *GKM or *GK as stated in *Part I – Classification Regulations of the Rules for the Classification and Construction of Mobile Offshore Drilling Units*.

The present *Publication* is valid until *Parts: II to VIII of the Rules for the Classification and Construction of Mobile Offshore Drilling Units* are issued.

2 GENERAL DESIGN PARAMETERS

2.1 Material

2.1.1 Unless otherwise specified, the requirements of the *Publication* apply to mobile offshore drilling units constructed of hull structural steel, manufactured and having the properties as specified in the *Rules for the Classification and Construction of Sea-going Ships, Part IX – Materials and Welding*. Where it is proposed to use steel or other material having properties differing from those specified in the above-mentioned *Rules*, the specification and properties of such material shall be submitted to PRS for consideration and special approval. Due consideration is to be given to the ratio of yield to ultimate strength of the materials to be used, and to their suitability with regard to structural location and to design temperatures.

2.2 Scantlings

2.2.1 Scantlings of the major structural elements of the unit are to be determined in accordance with the requirements as set forth herein. Scantlings of structural elements which are subject to local load only, and which are not considered to be effective components of the primary structural frame of the unit, shall comply with the relevant requirements of the *Rules for the Classification and Construction of Sea-going Ships, Part II – Hull* referred to, in this Chapter, as the *Rules*.

2.2.2 Surface type drilling units are to have scantlings that meet relevant requirements of the *Rules*. Also, special consideration is to be given to the items noted in Chapter 5.

2.2.3 Where the unit is fitted with an acceptable corrosion protection system, the scantlings may be determined from 2.4 in conjunction with allowable stresses given in 2.5, in which case no corrosion allowance is required. If scantlings are determined from the *Rules*, reductions for corrosion protection may be as permitted by the *Rules*.

2.2.4 Where no corrosion protection system is fitted or where the system is considered by PRS to be inadequate, an appropriate corrosion allowance will be required on scantlings determined from 2.4 and 2.5, and no reduction will be permitted on scantlings determined by the use of the *Rules*.

2.3 Structural design loadings

2.3.1 General

A unit's modes of operation are to be investigated using realistic loading conditions, including gravity loadings together with relevant environmental loadings due to the effects of wind, waves, currents, ice and, where deemed necessary by the owner (designer), the effects of earthquake, sea bed supporting capabilities, temperature, fouling, etc. Where applicable, the design loadings indicated herein are to be adhered to for all

types of mobile offshore drilling units. The owner (designer) shall specify the environmental conditions for which the unit is to be approved. Where possible, the design environmental criteria determining the loads on the unit and its individual elements should be based upon significant statistical information and should have a return period (period of recurrence) of at least 50 years for the most severe anticipated environment. If a unit is restricted to seasonal operations in order to avoid extremes of wind and wave, such seasonal limitations must be specified.

2.3.2 Wind loadings

Sustained and gust velocities, as relevant, are to be considered when determining wind loadings. Sustained wind velocities specified by the owner (designer) are not to be less than 25.8 m/s. However, for unrestricted service, the wind criteria for intact stability given in 2.7.2 are also to be applicable for structural design considerations, for all modes of operation, whether afloat or supported by the sea bed. Pressures and resultant forces are to be calculated to the satisfaction of PRS. Where wind tunnel data obtained from tests on a representative model of the unit by a recognized laboratory are submitted, these data shall be considered for the determination of pressures and resulting forces.

2.3.3 Wave loadings

2.3.3.1 Design wave criteria specified by the owner (designer) may be described either by means of design wave energy spectra or deterministic design waves having appropriate shape, size and period. Consideration is to be given to waves of less than maximum height where, due to their period, the effects on various structural elements may be greater.

2.3.3.2 The forces produced by the action of waves on the unit are to be taken into account in the structural design, with regard to forces produced directly on the immersed elements of the unit and forces resulting from heeled positions or accelerations due to its motion. Theories used for the calculation of wave forces and selection of relevant coefficients are to be acceptable to PRS.

2.3.3.3 Consideration is to be given to the possibility of wave induced vibration.

2.3.4 Current loadings

Consideration should be given to the possible superposition of current and waves. In those cases where this superposition is deemed necessary, the current velocity should be added vectorially to the wave particle velocity. The resultant velocity is to be used to compute the total force.

2.3.5 Loadings due to vortex shedding

Consideration should be given to the possibility of flutter of structural members due to von Karman vortex shedding.

2.3.6 Deck loadings

As indicated in 4.2.2.4 of *Part I – Classification Regulations of the Rules for the Classification and Construction of Mobile Offshore Drilling Units*, a loading plan is to be prepared for each design. This plan is to show the maximum design uniform and concentrated loadings for all areas for each mode of operation. Design loadings are not to be less than:

- .1 4.5 kN/m² for crew spaces (walkways, general traffic areas, etc.);
- .2 9 kN/m² for work areas;
- .3 13 kN/m² for storage areas;
- .4 2 kN/m² for helicopter platform.

2.4 Structural analysis

2.4.1 Method of analysis

The primary structure of the unit is to be analysed using the loading conditions stipulated below and the resultant stresses are to be determined. Sufficient conditions, representative of all modes of operation, are to be considered, to enable critical design cases to be determined. Calculations for relevant conditions

are to be submitted for review. The analysis should be performed using an appropriate calculation method and should be fully documented and referenced.

For each loading condition considered, the following stresses are to be determined for comparison with the appropriate allowable stresses given in 2.4.3 or 2.5:

- .1 stresses due to static loadings only, in calm water conditions, where the static loads include service load such as operational gravity loadings and weight of the unit, with the unit afloat or resting on the sea bed, as applicable;
- .2 stresses due to combined loadings, where the applicable static loads described in .1 are combined with relevant design environmental loadings, including acceleration and heeling forces.

2.4.2 Stresses analysis

- .1 Local stresses, including those due to circumferential loading on tubular members, are to be added to the primary stresses to determine total stress levels.
- .2 The scantlings are to be determined on the basis of criteria which combine, in a rational manner, the individual stress components acting on the various structural elements of the unit. This method is to be acceptable to PRS. (See 2.4.3)
- .3 The critical buckling stress of structural elements is to be considered, where appropriate, in relation to the computed stresses.
- .4 When computing bending stresses, the effective flange areas are to be determined in accordance with 'effective width' concepts acceptable to PRS. Where appropriate, elastic deflections are to be taken into account when determining the effects of eccentricity of axial loading, and the resulting bending moments superimposed on the bending moments computed for other types of loadings.
- .5 When computing shear stresses in bulkheads, plate girder webs of hull side plating, only the effective shear area of the web is to be considered. In this regard, the total depth of the girder may be considered as the web depth.

2.4.3 Design criteria

- .1 For plated structures, members may be designed according to the von Mises equivalent stress criterion, where the equivalent stress σ_e is defined as follows:

$$\sigma_e = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3\tau_{xy}^2}$$

where:

- σ_x – stress in the x direction,
- σ_y – stress in the y direction,
- τ_{xy} – shear stress in the x–y plane.

The equivalent stress in plate elements clear of discontinuities should generally not exceed 0.7 and 0.9 of the yield strength of the material, for the loading conditions given in 2.4.1.1 and 2.4.1.2, respectively.

- .2 Members of lattice type structures should be designed in accordance with accepted practice for such members; for example, they may comply with the American Institute of Steel Construction's Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings.

2.4.4 Fatigue analysis

2.4.4.1 The possibility of fatigue damage due to cyclic loading should be considered in the design of self elevating and column stabilized units.

2.4.4.2 The fatigue analysis will be dependent on the intended mode and area of operations to be considered in the unit's design.

2.4.4.3 The fatigue life is to be based on a period of time equal to the specified design life of the structure. The period is normally not to be taken as less than 20 years.

2.4.5 The effect of notches, stress raisers and local stress concentrations is to be taken into account in the design of load carrying elements.

2.4.6 Critical joints depending upon transmission of tensile stresses through the thickness of the plating of one of the members (which may result in lamellar tearing) are to be avoided wherever possible. Where unavoidable, plate material with suitable through-thickness properties and inspection procedures may be required.

2.5 Allowable stresses

2.5.1 For cases involving individual stress components and, where applicable, direct additions of such stresses, the stress is not to exceed the allowable individual stress σ_i^* or τ_i^* ,

where:

σ_i^* – $\eta\sigma Y$, for axial bending stress,

τ_i^* – $\eta\sigma Y$, for shear stress,

σY – specified minimum tensile yield stress of the material,

η – usage factor,

for static loadings (see 2.4.1.1)

η – 0.6 for axial stress,

0.6 for bending stress,

0.40 for shear stress,

for combined loadings (see 2.4.1.2)

η – 0.8 for axial stress,

0.8 for bending stress,

0.53 for shear stress.

2.5.2 In addition, the stress in structural elements, due to compression, bending, shear or any combination of the three, shall not exceed the allowable buckling stress σ_b^* or τ_b^* ,

where:

σ_b^* – $\eta \sigma_{cr}$, for compression or bending,

τ_b^* – $\eta \tau_{cr}$, for shear stress,

η – 0.6, for static loadings,

η – 0.8, for combined loadings,

σ_{cr} or τ_{cr} – critical compressive buckling stress or shear buckling stress, respectively, σY is as defined in 2.5.1.

2.5.3 In addition, when structural members are subjected to axial compression or combined axial compression and bending, the extreme fibre stresses shall comply with the following requirement:

$$\sigma_a / \sigma_a^* + \sigma_{ab} / \sigma_{ab}^* \leq 1.0$$

where:

σ_a – computed axial compressive stress,

σ_{ab} – computed compressive stress due to bending,

σ_{ab}^* – σ_i^* or σ_b^* for bending stress, as defined in 2.5.1 or 2.5.2,

σ_a^* – $\eta \sigma_{cr,i} (1 - 0.13 \lambda / \lambda_0)$ if $\lambda < \lambda_0$,

σ_a^* – $\eta \sigma_{cr,e} 0.87$ if $\lambda \geq \lambda_0$,

σ_a^* shall not exceed σ_{ab}^* ,

$\lambda = kl/r$,

$\lambda = \sqrt{2\pi^2 E / \sigma Y}$,

$\sigma_{cr,i}$ – inelastic column critical buckling stress,

$\sigma_{cr,e}$ – elastic column critical buckling stress,

η is as defined in 2.5.2,

kl – effective unsupported length,

r – governing radius of gyration associated with kl ,

E – modulus of elasticity of the material,

σY is as defined in 2.5.1.

2.5.4 Unstiffened or ring-stiffened cylindrical shells subjected to axial compression or compression due to bending, and having proportions which satisfy the following relationship:

$$D/t > E/9\sigma Y$$

where

D – mean diameter,

t – wall thickness,

(D and t expressed in the same units)

σY is as defined in 2.5.1,

E is as defined in 2.5.3,

(σY and E expressed in the same units)

are to be checked for local buckling in addition to the overall buckling as specified in 2.5.3.

2.5.5 Designs based upon novel methods, such as plastic analysis or elastic buckling concepts, will be specially considered.

Note 1

The allowable stresses as stated in 2.5 are intended to reflect uncertainties in environmental data, determination of loadings from the data and calculation of stresses which may exist at the present time. It is envisioned that the requirements may eventually allow for the adoption of separate load factors or usage factors for the above influences, so that allowance can be given for improvements in forecasting, load estimation or structural analysis, as the technology or expertise in any one of these areas improves.

Note 2

The specific minimum yield point may be determined, for the use of Chapter 2, by the drop of the beam or halt in the gauge in the testing machine or by the use of dividers or by 0.5% total extension under load. When no well defined yield phenomenon exists, the yield strength associated with a 0.2% offset or a 0.5% total extension under load is to be considered the yield strength.

2.6 Units resting on the sea bed

2.6.1 Units designed to rest on the sea bed are to have sufficient positive downward gravity loadings on the support footings or mat to withstand the overturning moment of the combined environmental forces from any direction, with a reserve against the loss of positive bearing of any footing or segment of the area thereof, for each design loading condition. Variable loads are to be considered in a realistic manner, to the satisfaction of PRS.

2.7 Stability

2.7.1 Intact stability

All units are to have positive stability in calm water equilibrium position, for the full range of draughts when in all modes of operations afloat, and for temporary positions when raising or lowering. In addition, all units are to meet the stability requirement set forth herein for all applicable conditions.

Lightweight is the displacement of a unit in tonnes without variable deck load, fuel lubricating oil, ballast water, fresh water and feedwater in tanks, consumable stores, and personnel and their effects.

The weight of mediums on board for the fixed fire-fighting systems (e.g. freshwater, CO₂, dry chemical powder, foam concentrate, etc.) shall be included in the lightweight.

2.7.1.1 The stability of a unit in each mode of operation should meet the following criteria (see also figure 2.7.2.8):

- .1** For surface and self-elevating units the area under the righting moment curve to the second intercept or downflooding angle, whichever is less, should be not less than 40% in excess of the area under the wind heeling moment curve to the same limiting angle.
- .2** For column-stabilized units¹ the area under the righting moment curve to the angle of downflooding should be not less than 30% in excess of the area under the wind heeling moment curve to the same limiting angle.

¹ Refer to “An example of alternative intact stability criteria for twin-pontoon column-stabilized semi-submersible units”, adopted by IMO by resolution A.650(16).

- .3 The righting moment curve should be positive over the entire range of angles from upright to the second intercept.

2.7.1.2 Each unit should be capable of attaining a severe storm condition in a period of time consistent with the meteorological conditions. The procedures recommended and the approximate length of time required, considering both operating conditions and transit conditions, should be contained in the *Operating Booklet*. It should be possible to achieve the severe storm condition without the removal or relocation of solid consumables or other variable load.

However, PRS may permit loading a unit past the point at which solid consumables would have to be removed or relocated to go to severe storm condition under the following conditions, provided the allowable KG is not exceeded:

- .1 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
- .2 where a unit is required to support extra deck load 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 should be identified in the *Operating Booklet*.

2.7.1.3 Alternative stability criteria may be considered by PRS, 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, PRS should consider at least the following and take into account as appropriate:

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

2.7.2 Righting moment and heeling moment curves

2.7.2.1 Curves of righting moments and of wind heeling moments similar to figure 2.7.2.8 with supporting calculations should be prepared covering the full range of operating draughts, including those in transit conditions, taking into account the maximum loading of materials in the most unfavourable position applicable. The righting moment curves and wind heeling moment curves should be related to the most critical axes. Account should be taken of the free surface of liquids in tanks.

2.7.2.2 Where equipment is of such a nature that it can be lowered and stowed, additional wind heeling moment curves may be necessary and such data should clearly indicate the position of such equipment. Provisions regarding the lowering and effective stowage of such equipment should be included in the *Operating Booklet* under section 14.1.

2.7.2.3 The curves of wind heeling moments should be drawn for wind forces calculated by the following formula:

$$F = 0.5C_s C_H \rho V^2 A$$

where:

F = the wind force (newtons),

C_s = the shape coefficient depending on the shape of the structural member exposed to the wind (see table 2.7.2.8-1),

C_H = the height coefficient depending on the height above sea level of the structural member exposed to wind (see table 2.7.2.8-2),

ρ = the air mass density (1.222 kg/m³),

- V = the wind velocity (metres per second),
 A = the projected area of all exposed surfaces in either the upright or the heeled condition (square metres).

2.7.2.4 Wind forces should be considered from any direction relative to the unit and the value of the wind velocity should be as follows:

- .1** In general a minimum wind velocity of 36 m/s (70 knots) for offshore service should be used for normal operating conditions and a minimum wind velocity of 51.5 m/s (100 knots) should be used for the severe storm conditions.
- .2** Where a unit is to be limited in operation to sheltered locations (protected inland waters such as lakes, bays, swamps, rivers, etc.) consideration should be given to a reduced wind velocity of not less than 25.8 m/s (50 knots) for normal operating conditions.

2.7.2.5 In calculating the projected areas to the vertical plane, the area of surfaces exposed to wind due to heel or trim, such as under-deck surfaces, etc., should 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.

2.7.2.6 In calculating the wind heeling moments, the lever of the wind overturning force should be taken vertically from the centre of pressure of all surfaces exposed to the wind to the centre of lateral resistance of the underwater body of the unit. The unit is to be assumed floating free of mooring restraint.

2.7.2.7 The wind heeling moment curve should be calculated for a sufficient number of heel angles to define the curve. For ship-shaped hulls the curve may be assumed to vary as the cosine function of vessel heel.

2.7.2.8 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 paragraphs 2.7.2.3 to 2.7.2.7. Such heeling moment determination should include lift and drag effects at various applicable heel angles.

Table 2.7.2.8-1
Values of the coefficient C_s

Shape	C_s
Spherical	0.4
Cylindrical	0.5
Large flat surface (hull, deckhouse, smooth under-deck areas)	1.0
Drilling derrick	1.25
Wires	1.2
Exposed beams and girders under deck	1.3
Small parts	1.4
Isolated shapes (crane, beam, etc.)	1.5
Clustered deckhouses or similar structures	1.1

Table 2.7.2.8-2
Values of the coefficient C_H

Height above sea level (metres)	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

Height above sea level (metres)	C_H
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 259.0	1.80

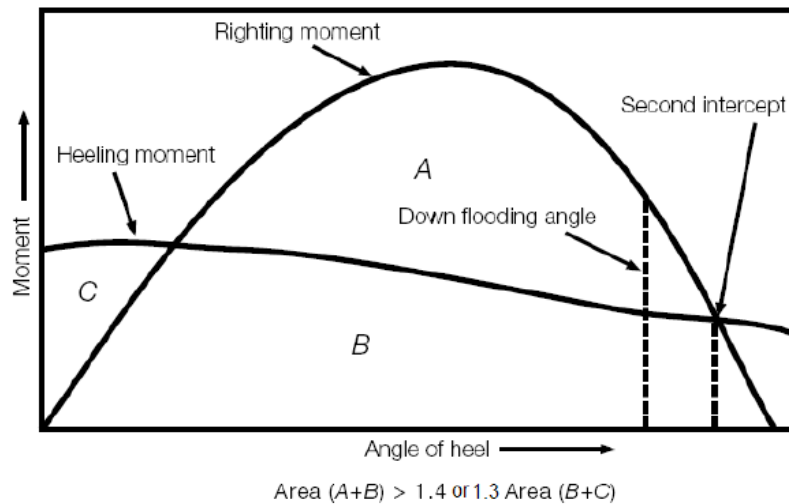


Figure 2.7.2.8. Righting moment and heeling curves

2.7.3 Damage stability

2.7.3.1 All units are to have sufficient stability to withstand the flooding from the sea of any compartment consistent with the damage assumption set out in 3.4.1, 4.6.1 and 5.4.1, for operating and transit modes of operation. The unit is to possess sufficient reserve stability in the damaged condition to withstand the additional overturning moment of a 25.8 m/s (50 knots) sustained wind superimposed from any direction.

2.7.3.2 Additionally, column stabilized units are to have sufficient stability to withstand, in any operating or transit condition, the flooding of any single watertight compartment located wholly or partially below the waterline in question, which is a pump room, a room containing machinery with a salt water cooling system or a compartment adjacent to the sea.

2.7.3.3 For all types of units, the ability to compensate for damage incurred, by pumping out or by ballasting other compartments, etc., is not to be considered as alleviating the above requirements. For the purpose of calculation, it is to be assumed that the unit is floating free of mooring restraints. However, possible detrimental effects of mooring restraints are to be considered.

2.7.4 Light ship weight and centre of gravity

An inclining test will be required for the first unit of a design when as near to completion as possible, to determine accurately the light ship weight and position of centre of gravity. An inclining test procedure is to be submitted to PRS for review prior to the test, which is to be witnessed by a PRS surveyor. For successive units of a design, which are basically identical with regard to hull form, with the exception of minor changes in arrangement, machinery, equipment, etc., and with concurrence by PRS that such changes are minor, detailed weight calculations showing only the differences of weight and centres of gravity will be satisfactory, provided the accuracy of the calculations is confirmed by a deadweight survey. The results of the inclining test, or deadweight survey and inclining experiment adjusted for weight differences, should be reviewed by PRS prior to inclusion in the *Operating Booklet*.

2.8 Subdivision and damage stability¹

2.8.1 Subdivision and damage stability of surface and self-elevating units

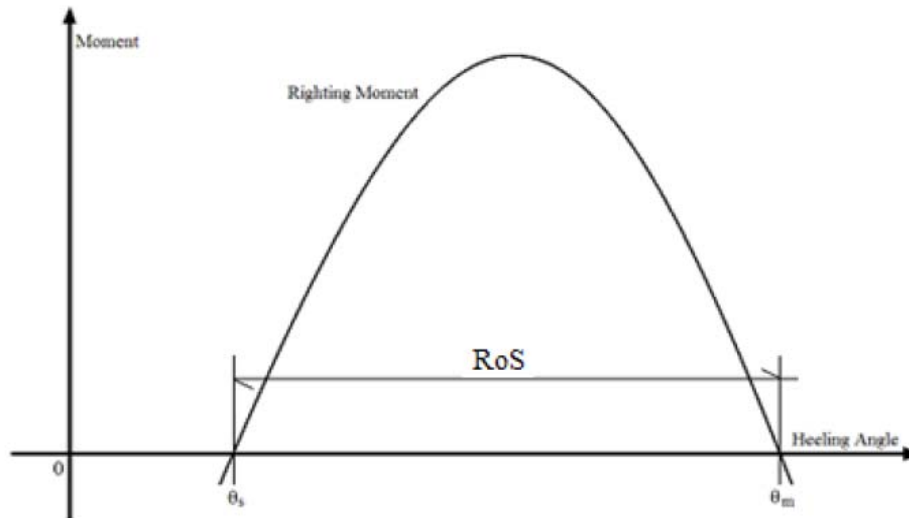


Figure 2.8.1. Residual stability for self-elevating units

2.8.1.1 The unit should have sufficient freeboard and be subdivided by means of watertight decks and bulkheads to provide sufficient buoyancy and stability to withstand:

- .1 In general, the flooding of any single compartment or any combination of compartments, in any operating or transit condition consistent with the damage assumptions set out in subchapter 5.4; and
- .2 for a self-elevating unit, the flooding of any single compartment with the assumption of no wind, while meeting the following criterion (see figure 2.8.1):

$$RoS = \theta_m - \theta_s \geq \text{Max}\left\{\left(7^\circ + 1.5\theta_s^\circ\right), 10^\circ\right\}$$

where:

RoS = range of stability, in degrees where:

θ_m = maximum angle of positive stability, in degrees

θ_s = static angle of inclination after damage, in degrees

The range of stability is determined without reference to the angle of downflooding. Refer to Fig.2.8.1.

2.8.1.2 The unit should have sufficient reserve stability in a damaged condition to withstand the wind heeling moment based on a wind velocity of 25.8 m/s (50 knots) superimposed from any direction. In this condition the final waterline, after flooding, should be below the lower edge of any downflooding opening.

2.8.2 Subdivision and damage stability of column-stabilized units

2.8.2.1 The unit should 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 velocity of 25.8 m/s (50 knots) superimposed from any direction in any operating or transit condition, taking the following considerations into account:

- .1 The angle of inclination after the damage set out in paragraph 4.6.1.2 should not be greater than 17°;
- .2 any opening below the final waterline should be made watertight, and openings within 4 m above the final waterline should be made weathertight;

¹ This subchapter applies to MODUs constructed on or after 1 January 2012, while IMO resolution A.649(16) applies to MODUs constructed on or after 1 May 1991 but before 1 January 2012 and IMO resolution A.414(XII) applies to those constructed before 1 May 1991.

- .3 within the provided extent of weathertight integrity the damage righting moment curve is to have a range of at least 7 degrees beyond its first intercept with the 25.8 (50 knots) wind heeling moment curve to its second intercept or downflooding angle – whichever is less. Within this range, the righting moment curve should reach a value of at least twice the wind heeling moment curve, both being measured at the same angle¹. See figure 2.8.2.1 below.

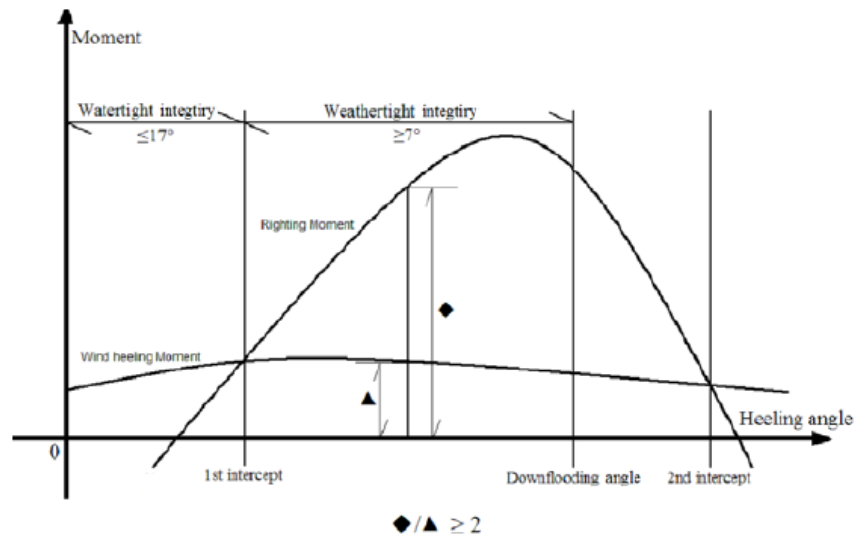


Figure 2.8.2.1. Righting moment and wind heeling moment curves

2.8.2.2 With the assumption of no wind, the unit should provide sufficient buoyancy and stability in any operating or transit condition to withstand the flooding of any watertight compartment wholly or partially below the waterline in question, 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:

- .1 the angle of inclination after flooding should not be greater than 25°;
- .2 any opening below the equilibrium waterline should be made watertight;
- .3 a range of positive stability¹ should 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 – of at least 7°.

2.8.3 Subdivision and damage stability of all types of units

2.8.3.1 Compliance with the provisions of paragraphs 2.8.1 to 2.8.2.2 should 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. In making these calculations, it should be assumed that the unit is in the worst anticipated service condition as regards stability and is floating free of mooring restraints.

2.8.3.2 The ability to reduce angles of inclination by pumping out or ballasting compartments or application of mooring forces, etc., should not be considered as justifying any relaxation of these provisions. However, possible detrimental effects of mooring restraints are to be considered.

2.8.3.3 Alternative subdivision and damage stability criteria may be considered for approval by PRS provided an equivalent level of safety is maintained. In determining the acceptability of such criteria, PRS should consider at least the following and take into account:

- .1 extent of damage as set out in subchapters 3.4.1, 4.6.1 and 5.4.1;
- .2 on column-stabilized units, the flooding of any one compartment as set out in paragraph 2.8.2.2;
- .3 the provision of an adequate margin against capsizing.

¹ Refer to 'An example of alternative stability criteria for a range of positive stability after damage or flooding for column-stabilized semi-submersible units', adopted by IMO by resolution A.651(16).

2.8.4 Wind heeling moments derived from authoritative wind tunnel tests on a representative model of the unit may be considered as alternatives to the method given herein. Such heeling moment determination is to include lift effects at various applicable heel angles, as well as drag effects.

2.8.5 Other stability criteria

2.8.5.1 Alternative stability criteria may be considered acceptable provided the criteria afford adequate righting moment to resist the heeling effect of operating and environmental forces and sufficient margins to preclude downflooding and capsizing in intact and damaged conditions.

2.8.5.2 The following will be considered in determining the adequacy of alternative criteria submitted for review:

- .1** environmental conditions representing realistic winds (including gusts) and waves appropriate for various modes of operations;
- .2** dynamic response of a unit. Where appropriate, the analysis should include the results of wind tunnel tests, wave tank model tests and nonlinear simulation. Any wind and wave spectra used should cover sufficient frequency ranges to ensure that critical motion responses are obtained;
- .3** potential for downflooding, taking into account dynamic responses and wave profile;
- .4** susceptibility to capsizing considering the unit's restoration energy, static inclination due to mean wind speed and maximum dynamic responses;
- .5** a safety margin consistent with the methodology to account for uncertainties;
- .6** damage assumptions at least equivalent to the requirements contained in Sections 3.4.1, 4.6.1 and 5.4.1;
- .7** for column stabilized units one compartment flooding assumptions at least equivalent to the requirement contained in 2.7.3.2.

2.9 Load line¹

2.9.1 General

2.9.1.1 The requirements of the 1988 LL Protocol, including those relating to certification, should apply to all units and certificates should be issued as appropriate. The minimum freeboard of units which cannot be computed by the normal methods laid down by that Protocol should be determined on the basis of meeting the applicable intact stability, damage stability and structural requirements for transit conditions and drilling operations while afloat. The freeboard should not be less than that computed from the Protocol where applicable.

2.9.1.2 The requirements of the 1988 LL Protocol with respect to weathertightness and watertightness of decks, superstructures, deckhouses, doors, hatchway covers, other openings, ventilators, air pipes, scuppers, inlets and discharges, etc., should be taken as a basis for all units in the afloat condition.

2.9.1.3 In general, heights of hatch and ventilator coamings, air pipes, door sills, etc., in exposed positions and their means of closing should be determined by consideration of the provisions regarding both intact and damage stability.

2.9.1.4 All downflooding openings which may become submerged before the angle of inclination at which the required area under the intact righting arm curve is achieved should be fitted with weathertight closing appliances.

2.9.1.5 With regard to damage stability, the provisions of paragraphs 2.8.2.1.2, 2.8.2.2 and 6.3.7 should apply.

¹ This subchapter applies to MODUs constructed on or after 1 January 2012, while IMO resolution A.649(16) applies to MODUs constructed on or after 1 May 1991 but before 1 January 2012 and IMO resolution A.414(XII) applies to those constructed before 1 May 1991.

2.9.1.6 Administrations should give special consideration to the position of openings which cannot be closed in emergencies, such as air intakes for emergency generators, having regard to the intact righting arm curves and the final waterline after assumed damage.

2.9.2 Load lines of surface units

2.9.2.1 Load lines should be assigned to surface units as calculated under the terms of the 1988 LL Protocol and should be subject to all the conditions of assignment of that Protocol.

2.9.2.2 Where it is necessary to assign a greater than minimum freeboard to meet the provisions regarding intact or damage stability or on account of any other restriction imposed by PRS, regulation 6(6) of the 1988 LL Protocol should apply. When such a freeboard is assigned, seasonal marks above the centre of the ring should not be marked and any seasonal marks below the centre of the ring should be marked. If a unit is assigned a greater than minimum freeboard at the request of the owner, regulation 6(6) need not apply.

2.9.2.3 Where moonpools are arranged within the hull in open communication with the sea, the volume of the moonpool should not be included in the calculation of any hydrostatic properties.

If the moonpool has a larger cross-sectional area above the waterline at 85% of the depth for freeboard than below, an addition should be made to the geometric freeboard corresponding to the lost buoyancy. This addition for the excess portion above the waterline at 85% of the depth for freeboard should be made as prescribed below for wells or recesses. If an enclosed superstructure contains part of the moonpool, deduction should be made for the effective length of the superstructure. Where open wells or recesses are arranged in the freeboard deck, a correction equal to the volume of the well or recess to the freeboard deck divided by the waterplane area at 85% of the depth for freeboard should be made to the freeboard obtained after all other corrections, except bow height correction, have been made. Free surface effects of the flooded well or recess should be taken into account in stability calculations.

2.9.2.4 The procedure described in paragraph 2.9.2.3 should also apply in cases of small notches or relatively narrow cut-outs at the stern of the unit.

2.9.2.5 Narrow wing extensions at the stern of the unit should be considered as appendages and excluded for the determination of length (L) and for the calculation of freeboards. PRS should determine the effect of such wing extensions with regard to the provisions relating to the strength of unit based upon length L .

2.9.3 Load lines of self-elevating units

2.9.3.1 Load lines should be assigned to self-elevating units as calculated under the terms of the 1988 LL Protocol. When floating, or when in transit from one operational area to another, units should be subject to all the conditions of assignment of that Protocol unless specifically excepted. However, these units should not be subject to the terms of that Protocol while they are supported by the seabed or are in the process of lowering or raising their legs.

2.9.3.2 The minimum freeboard of units which due to their configuration cannot be computed by the normal methods laid down by the 1988 LL Protocol should be determined on the basis of meeting applicable provisions regarding intact stability, damage stability and structure in the afloat condition.

2.9.3.3 Where it is necessary to assign a greater than minimum freeboard to meet intact or damage stability provisions or on account of any other restriction imposed by PRS, regulation 6(6) of the 1988 LL Protocol should apply. When such a freeboard is assigned, seasonal marks above the centre of the ring should not be marked and any seasonal marks below the centre of the ring should be marked. If a unit is assigned a greater than minimum freeboard at the request of the owner, regulation 6(6) need not apply.

2.9.3.4 Where moonpools are arranged within the hull in open communication with the sea, the volume of the moonpool should not be included in the calculation of any hydrostatic properties.

If the moonpool has a larger cross-sectional area above the waterline at 85% of the depth for freeboard than below, an addition should be made to the geometric freeboard corresponding to the lost buoyancy. This addition for the excess portion above the waterline at 85% of the depth for freeboard should be made as prescribed below for wells or recesses. If an enclosed superstructure contains part of the moonpool, deduction should be made for the effective length of the superstructure. Where open wells or recesses are arranged in the freeboard deck, a correction equal to the volume of the well or recess to the freeboard deck divided by the waterplane area at 85% of the depth for freeboard should be made to the freeboard obtained after all other corrections, except bow height correction, have been made. Free surface effects of the flooded well or recess should be taken into account in stability calculations.

2.9.3.5 The procedure described in paragraph 2.9.3.4 should apply in cases of small notches or relatively narrow cut-outs at the stern of the unit.

2.9.3.6 Narrow wing extensions at the stern of the unit should be considered as appendages and excluded for the determination of length (L) and for the calculation of freeboards. PRS should determine the effect of such wing extensions with regard to the requirements of the 1988 LL Protocol for the strength of unit based upon length (L).

2.9.3.7 Self-elevating units may be manned when under tow. In such cases a unit would be subject to the bow height and reserve buoyancy requirements which may not always be possible to achieve. In such circumstances, PRS should consider the extent of application of regulations 39(1), 39(2) and 39(5) of the 1988 LL Protocol, as amended, and give special consideration to such units, having regard to the occasional nature of such voyages on predetermined routes and to prevailing weather conditions.

2.9.3.8 Some self-elevating units utilize a large mat or similar supporting structure which contributes to the buoyancy when the unit is floating. In such cases the mat or similar supporting structure should be ignored in the calculation of freeboard. The mat or similar supporting structure should, however, always be taken into account in the evaluation of the stability of the unit when floating since its vertical position relative to the upper hull may be critical.

2.9.4 Load lines of column-stabilized units

2.9.4.1 The hull form of this type of unit makes the calculation of geometric freeboard in accordance with the provisions of chapter III of the 1988 LL Protocol impracticable. Therefore the minimum freeboard of each column-stabilized unit should be determined by meeting the applicable provisions for:

- .1 The strength of the unit's structure;
- .2 the minimum clearance between passing wave crests and deck structure (see paragraphs 4.4.1 to 4.5.2); and
- .3 intact and damage stability.

2.9.4.2 The minimum freeboard should be marked in appropriate locations on the structure.

2.9.4.3 The enclosed deck structure of each column-stabilized unit should be made weathertight.

2.9.4.4 Windows, sidescuttles and portlights, including those of the non-opening type, or other similar openings should not be located below the deck structure of column-stabilized units.

2.9.4.5 PRS will give special consideration to the position of openings which cannot be closed in emergencies, such as air intakes for emergency generators, having regard to the intact righting arm curves and the final waterline after assumed damage.

2.10 Helicopter deck

2.10.1 General

Plans showing the arrangement, scantlings and details of the helicopter deck are to be submitted. The arrangement plan is to show the overall size of the helicopter deck and the designated landing area. If the arrangement provides for the securing of a helicopter or helicopters to the deck, the predetermined

position(s) selected to accommodate the secured helicopter, in addition to the locations of deck fittings for securing the helicopter, are to be shown. The helicopter for which the deck is designed is to be specified, and calculations for the relevant loading conditions are to be submitted. The identification of the helicopter which is used for design purposes should be included in the *Operating Booklet*.

2.10.2 Structural design

Scantlings of helicopter decks and supporting structure are to be determined on the basis of the following design loading conditions in association with the allowable stresses shown in Table 2.10.2.

Table 2.10.2
Allowable stresses

Condition	Allowable stress		
	Plating	Beams	Girders, stanchions, truss supports, etc.
1. Overall distributed loading	$0.6\sigma Y$ (See Note 1)	$0.6\sigma Y$	$0.6\sigma Y^*$
2. Helicopter landing impact loading	**	σY	$0.9\sigma Y^*$
3. Stowed helicopter loading	σY	$0.9\sigma Y$	$0.8\sigma Y^*$

σY = specified minimum tensile yield strength of the material

* For members subjected to axial compression, the yield stress or critical buckling stress, whichever is less, is to be considered.

** To the satisfaction of PRS, in association with the method of analysis presented. PRS may consider an allowable stress that exceeds σY , provided the rationale of the analysis is sufficiently conservative.

Notes:

1. The thickness of plating for the overall distributed loading condition is not to be less than the minimum required by the *Rules*.
2. Helicopters fitted with landing gear other than wheels shall be specially considered by PRS.
3. Wind loadings and possible wave impact loadings on helicopter decks are to be considered in a realistic manner, to the satisfaction of PRS.

Overall distributed loading: A minimum distributed loading of 2 kN/m² is to be taken over the entire helicopter deck.

Helicopter landing impact loading: A load of not less than 75% of the helicopter maximum take-off weight is to be taken on each of two square areas, 0.3 m x 0.3 m. The deck is to be designed for helicopter landings at any location within the designated area. For the design of girders, stanchions truss supports, etc., the structural weight of the helicopter deck should be considered in addition to the helicopter impact loading. Where the upper deck of a superstructure or deckhouse is used as a helicopter deck and the spaces below are normally manned (quarters, bridge, control room, etc.) the impact loading is to be multiplied by a factor of 1.15.

Stowed helicopter loading: If provisions are made to accommodate helicopters secured to the deck in a predetermined position, the structure is to be designed for a local loading equal to the manufacturer's recommended wheel loadings at maximum take-off weight, multiplied by a dynamic amplification factor based on the predicted motions of the unit for this condition, as may be applicable for the unit under consideration. In addition, a uniformly distributed loading of 0.5 kN/m², representing wet snow or ice, is to be considered, if applicable. For the design of girders, stanchions, truss supports, etc., the structural weight of the helicopter deck should also be considered.

2.11 Position keeping systems and components

2.11.1 General

2.11.1.1 Units provided with position keeping systems equipment in accordance with 2.11 will be eligible to have a special optional notation included in the classification designation in accordance with the policy of PRS.

2.11.2 Anchoring systems

2.11.2.1 General

Plans showing the arrangement and complete details of the anchoring system, including anchors, shackles, anchor lines consisting of chain, wire or rope, together with details of fairleads, windlasses, winches, and any other components of the anchoring system and their foundations are to be submitted to PRS.

2.11.2.2 Design

2.11.2.2.1 An analysis of the anchoring arrangements expected to be utilized in the unit's operation is to be submitted to PRS. Among the items to be addressed are:

- .1 design environmental conditions of waves, winds, currents, tides and ranges of water depth;
- .2 air and sea temperature;
- .3 ice conditions (if applicable);
- .4 description of analysis methodology.

2.11.2.2.2 The anchoring system should be designed so that a sudden failure of any single anchor line will not cause progressive failure of remaining lines in the anchoring arrangement.

2.11.2.2.3 Anchoring system components should be designed utilizing adequate factors of safety (FOS) and a design methodology suitable to identify the most severe loading condition for each component. In particular, sufficient numbers of heading angles together with the most severe combination of wind, current and wave are to be considered, usually from the same direction, to determine the maximum tension in each mooring line. When a particular site is being considered, any applicable cross sea conditions are also to be considered in the event that they might induce higher mooring loads.

2.11.2.2.4 When the Quasi Static Method is applied, the tension in each anchor line is to be calculated at the maximum excursion for each design condition defined in 2.11.2.2.5, combining the following steady state and dynamic responses of the unit:

- .1 steady mean offset due to the defined wind, current, and steady wave forces;
- .2 most probable maximum wave induced motions of the moored unit due to wave excitation.

For relatively deep water, the effect from damping and inertia forces in the anchor lines is to be considered in the analysis. The effects of slowly varying motions are to be included for MODUs when the magnitudes of such motions are considered to be significant.

2.11.2.2.5 When the Quasi Static Method outlined in 2.11.2.2.4 is applied, the following minimum factors of safety at the maximum excursion of the unit for a range of headings should be considered:

DESIGN CONDITION	FOS
Operating	2.7
Severe storm	1.8
Operating – one line failed	1.8
Severe storm – one line failed	1.25

where:

FOS – PB/T_{max} ,

T_{max} – characteristic tension in the anchor line, equal to the maximum value obtained according to 2.11.2.2.4,

PB – minimum rated breaking strength of the anchor line.

Operating: the most severe design environmental condition for normal operations as defined by the owner or designer.

Severe storm: the most severe design environmental condition for severe storm as defined by the owner or designer.

Operating – one line failed: following the failure of any one mooring line in the operating condition.

Severe storm – one line failed: following the failure of any one mooring line in the severe storm condition.

When a dynamic analysis is employed, other safety factors may be considered to the satisfaction of PRS.

The defined Operating and Severe Storm are to be the same as those identified for the design of the unit, unless PRS is satisfied that lesser conditions may be applicable to specific sites.

2.11.2.2.6 In general, the maximum wave induced motions of the moored unit about the steady mean offset should be obtained by means of model tests. PRS may accept analytical calculations provided that the proposed method is based on a sound methodology which has been validated by model tests.

In the consideration of column stabilized MODUs, the value of C_S and C_H , as indicated in 2.8.2, may be introduced in the analysis for position keeping mooring systems. The intent of 2.8.4 – *Wind tunnel tests*, and of 2.8.5 – *Other stability requirements*, may also be considered by PRS.

2.11.2.2.7 PRS may accept different analysis methodologies provided that it is satisfied that a level of safety equivalent to the one obtained by 2.11.2.2.4 and 2.11.2.2.5 is ensured.

2.11.2.2.8 PRS may give special consideration to an arrangement where the anchoring systems are used in conjunction with thrusters to maintain the unit on station.

2.11.3 Equipment

2.11.3.1 Windlasses

2.11.3.1.1 The design of the windlass is to provide for adequate dynamic braking capacity to control normal combinations of loads from the anchor, anchor line and anchor handling vessel during the deployment of the anchors at the maximum design payout speed of the windlass. The attachment of the windlass to the hull structure is to be designed to withstand the breaking strength of the anchor line.

2.11.3.1.2 Each windlass is to be provided with two independent power operated brakes and each brake is to be capable of holding against a static load in the anchor lines of at least 50 percent of its breaking strength. Where PRS so allows, one of the brakes may be replaced by a manually operated brake.

2.11.3.1.3 On loss of power to the windlasses, the power operated braking system should be automatically applied and be capable of holding against 50 percent of the total static braking capacity of the windlass.

2.11.3.2 Fairleads and sheaves

2.11.3.2.1 Fairleads and sheaves should be designed to prevent excessive bending and wear of the anchor lines. The attachments to the hull or structure are to be such as to withstand the stresses imposed when an anchor line is loaded to its breaking strength.

2.11.4 Anchor line

2.11.4.1 PRS is to be ensured that the anchor lines are of a type that will satisfy the design conditions of the anchoring system.

2.11.4.2 Means are to be provided to enable the anchor lines to be released from the unit after loss of main power.

2.11.4.3 Means are to be provided for measuring anchor line tensions.

2.11.4.4 Anchor lines are to be of adequate length to prevent uplift of the anchors under the maximum design condition for the anticipated area(s) of operation.

2.11.5 Anchors

2.11.5.1 Type and design of anchors are to be to the satisfaction of PRS.

2.11.5.2 All anchors are to be stowed to prevent movement during transit.

2.11.6 Quality control

2.11.6.1 Details of the quality control of the manufacturing process of the individual anchoring system components are to be submitted. Components should be designed, manufactured and tested in accordance with recognized standards insofar as possible and practical. Equipment so tested should, insofar as practical, be legibly and permanently marked with PRS's stamp and delivered with documentation which records the results of the tests.

2.11.7 Control stations

2.11.7.1 A manned control station is to be provided with means to indicate anchor line tensions at the individual windlass control positions and to indicate wind speed and direction.

2.11.7.2 Reliable means are to be provided to communicate between locations critical to the anchoring operation.

2.11.7.3 Means are to be provided at the individual windlass control positions to monitor anchor line tension, windlass power load and to indicate amount of anchor line payed out.

2.11.8 Dynamic positioning systems

2.11.8.1 Thrusters used as a sole means of position keeping should provide a level of safety equivalent to that provided for anchoring arrangements to the satisfaction of PRS.

2.12 Access¹

2.12.1 Means of access

2.12.1.1 Each space within the unit should be provided with at least one permanent means of access to enable, throughout the life of a unit, overall and close-up inspections and thickness measurements of the unit's structures to be carried out by the Administration, the company, and the unit's personnel and others as necessary. Such means of access should comply with the provisions of 2009 MODU Code, paragraph 2.2.4 and with the Technical provisions for means of access for inspections, adopted by the Maritime Safety Committee by resolution MSC.133(76), as may be amended by the Organization.

2.12.1.2 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 Administration may allow, in lieu thereof, the provision of movable or portable means of access, as specified in the Technical provisions, 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 should be capable of being readily erected or deployed by the unit's personnel.

2.12.1.3 The construction and materials of all means of access and their attachment to the unit's structure should be to the satisfaction of the Administration. The means of access should be subject to inspection prior to, or in conjunction with, its use in carrying out surveys in accordance with 2009 MODU Code, section 1.6.

2.12.2 Safe access to holds, tanks, ballast tanks and other spaces

2.12.2.1 Safe access ² to holds, cofferdams, tanks and other spaces should be direct from the open 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.

¹ Requirements of section 2.12 correspond with 2009 MODU Code, subchapter 2.2. Detailed interpretations of requirements – see IACS Unified Interpretation UI MODU 1

² Refer to Recommendations for entering enclosed spaces aboard ships, adopted by the Organization by Resolution A.864(20).

2.12.2.2 Tanks, and subdivisions of tanks, having a length of 35 m or more, should be fitted with at least two access hatchways and ladders, as far apart as practicable. Tanks less than 35 m in length should be served by at least one access hatchway and ladder. When a tank is subdivided by one or more swash bulkheads or similar obstructions which do not allow ready means of access to the other parts of the tank, at least two hatchways and ladders should be fitted.

2.12.2.3 Each hold should be provided with at least two means of access as far apart as practicable. In general, these accesses should be arranged diagonally, e.g., one access near the forward bulkhead on the port side, the other one near the aft bulkhead on the starboard side.

2.12.3 Access manual

2.12.3.1 A unit's means of access to carry out overall and close-up inspections and thickness measurements should be described in an access manual which may be incorporated in the unit's erating manual. The manual should be updated as necessary, and an updated copy maintained on board. The structure access manual should include the following for each space:

- .1 plans showing the means of access to the space, with appropriate technical specifications and dimensions;
- .2 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 should indicate from where each area in the space can be inspected;
- .3 plans showing the means of access within the space to enable close-up inspections to be carried out, with appropriate technical specifications and dimensions. The plans should indicate the positions of critical structural areas, whether the means of access is permanent or portable and from where each area can be inspected;
- .4 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;
- .5 instructions for safety guidance when rafting is used for close-up inspections and thickness measurements;
- .6 instructions for the rigging and use of any portable means of access in a safe manner;
- .7 an inventory of all portable means of access; and
- .8 records of periodical inspections and maintenance of the unit's means of access.

2.12.3.2 For the purpose of this paragraph "critical structural areas" are locations which have been 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.

2.12.4 General technical specifications

2.12.4.1 For access through horizontal openings, hatches or manholes, the dimensions should 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 provide a clear opening to facilitate the hoisting of an injured person from the bottom of a confined space. The minimum clear opening should not be less than 600 mm × 600 mm. When access to a hold is arranged through a flush manhole in the deck or a hatch, the top of the ladder should be placed as close as possible to the deck or hatch coaming. Access hatch coamings having a height greater than 900 mm should also have steps on the outside in conjunction with the ladder.

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

3 SELF-ELEVATING DRILLING UNITS

3.1 General

3.1.1 The requirements of Chapter 3 apply to the unit type as defined in para 1.2.1 of *Part I – Classification Regulations of the Rules for the Classification and Construction of Mobile Offshore Drilling Units*.

3.2 Hull scantlings

3.2.1 Scantlings of the hull structure, except as outlined below, are to meet the relevant requirements of the *Rules for the Classification and Construction of Sea-Going Ships, Part II – Hull* referred to, in this Chapter, as the *Rules*.

3.3 Design considerations

3.3.1 Legs

3.3.1.1 Leg types: Legs may be either shell type or truss type. Shell type legs may be designed as either stiffened or unstiffened shells. In addition, individual footings may be fitted or legs may be permanently attached to a bottom mat.

3.3.1.2 Legs without mats: Where footings or mats are not fitted, proper consideration should be given to the leg penetration of the sea bed and the end fixity of the leg.

3.3.1.3 Legs in the field transit condition: Legs are to be designed for a bending moment caused by a 6° single amplitude of roll or pitch at the natural period of the unit, plus 120% of the gravity moment caused by the legs' angle of inclination. The legs are to be investigated for any proposed leg arrangement with respect to vertical position during field transit moves, and the approved positions should be specified in the *Operating Booklet*. Such investigation should include strength and stability aspects.

3.3.1.4 Legs in the ocean transit condition: Legs should be designed for acceleration and gravity moments resulting from the motions in the most severe anticipated environmental transit conditions, together with corresponding wind moments. Calculation or model test methods, acceptable to PRS, may be used. Alternatively, legs may be designed for a bending moment caused by minimum design criteria of a 15° single amplitude of roll or pitch at a 10 second period, plus 120% of the gravity moment caused by the legs' angle of inclination. For ocean transit conditions, it may be necessary to reinforce or support the legs, or to remove sections of them. The approved condition should be included in the *Operating Booklet*.

3.3.1.5 Legs are to be designed to withstand the dynamic loads which may be encountered – while lowering to bottom – by their unsupported length just prior to touching bottom and also to withstand the shock of touching bottom while the unit is afloat and subject to wave motions.

The maximum design motions, bottom conditions and sea state while lowering legs shall be clearly indicated in the *Operating Booklet*, and the legs are not to be permitted to touch bottom when the site conditions exceed the allowable.

3.3.1.6 Unit in the elevated position: When computing leg stresses, the maximum overturning load on the unit, using the most adverse combination of applicable variable loadings together with the loadings as outlined in Chapter 2, is to be considered. Forces and moments due to lateral frame deflections of the legs are to be taken into account. (See 2.3.3.3 with respect to vibration).

3.3.1.7 Leg scantlings: Leg scantlings are to be determined in accordance with a method of rational analysis, to the satisfaction of PRS.

3.3.2 Structure in way of jacking or other elevating arrangements

Load carrying members which transmit loads from the legs to the hull are to be designed for the maximum design loads and are to be so arranged that loads transmitted from the legs are properly diffused into the hull structure.

3.3.3 Hull structure

The hull is to be considered as a complete structure having sufficient strength to resist all induced stresses while in the elevated position and supported by all legs. All fixed and variable loads are to be distributed, by an accepted method of rational analysis, from the various points of application to the supporting legs. The scantlings of the hull are then to be determined consistent with this load distribution, but are not to be less than those required by 3.2. Scantlings of units having other than rectangular hull configurations will be subject to special consideration.

3.3.4 Wave clearance

The unit is to be designed for a crest clearance of either 1.2 m, or 10% of the combined storm tide, astronomical tide and height of the maximum wave crest above the mean low water level, whichever is less, between the underside of the unit in the elevated position and the crest of the design wave. This crest elevation is to be measured above the level of the combined astronomical and storm tides.

3.3.5 Bottom mat

When the bottoms of the legs are attached to a mat, particular attention is to be given to the attachment and the framing and bracing of the mat, in order that the loads resulting from the legs are properly distributed. The envelope plating of tanks which are not vented freely to the sea is not to be less in thickness than would be required by the *Rules* for tanks, using a head to the design water level, taking into account the astronomical and storm tides. The effects of scouring on the bottom bearing surface should be considered. The effects of skirt plates, where provided, will be specially considered. Mats are to be designed to withstand the shock of touching bottom while the unit is afloat and subject to wave motions.

3.3.6 Preload capability

For units without bottom mats, all legs are to have the capability of being preloaded to the maximum applicable combined gravity plus overturning load. The approved preload procedure should be included in the *Operating Booklet*.

3.3.7 Sea bed conditions

Classification will be based upon the designer's assumptions regarding the sea bed conditions. These assumptions should be recorded in the *Operating Booklet*. It is the responsibility of the operator to ensure that actual conditions do not impose more severe loadings on the unit.

3.3.8 Deckhouses

Deckhouses are to have sufficient strength for their size, function and location, and are to be constructed to approved plans. Their general scantlings are to be as indicated in the *Rules*. Where they are close to the side shell of the unit, their scantlings may be required to conform to PRS's requirements for exposed front bulkheads of superstructure.

3.4 Damage stability

3.4.1 In assessing the damage stability of self-elevating drilling units as required by 2.8, the following extent of damage is to be assumed to occur between effective watertight bulkheads:

- .1 horizontal penetration: 1.5 m ;
- .2 vertical extent: bottom shell upwards without limit.

Where a mat is fitted, the above extent of damage should be applied to both the platform and the mat but not simultaneously, unless deemed necessary by the Administration due to their close proximity to each other.

The distance between effective watertight bulkheads or their nearest stepped portions which are positioned within the assumed extent of horizontal penetration should be not less than 3 m, where there is a lesser distance, one or more of the adjacent bulkheads should be disregarded. If damage of a lesser extent results in a more severe final equilibrium condition, such lesser extent shall be assumed.

All piping, ventilating systems, trunks, etc. within this extent are to be assumed damaged. Positive means of closure are to be provided to preclude progressive flooding of other intact spaces. In addition, the compartments adjacent to the bottom shell are also to be considered flooded individually.

3.5 Annex to Chapter 3 as Recommendations on Operation of Legs

3.5.1 Legs while lowering to bottom: Legs are to be designed to withstand the dynamic loads which may be encountered by their unsupported length just prior to touching bottom, and also to withstand the shock of touching bottom while the unit is afloat and subject to wave motions.

3.5.2 Instructions for lowering legs: The maximum design motions, bottom conditions and sea state while lowering legs should be clearly indicated in the *Operating Booklet*, and the legs are not to be permitted to touch bottom when the site conditions exceed the allowable.

4 COLUMN STABILIZED DRILLING UNITS

4.1 General

4.1.1 The requirements of Chapter 4 apply to the unit type as defined in para 1.2.1 of *Part I – Classification Regulations* of the *Rules for the Classification and Construction of Mobile Offshore Drilling Units*.

4.1.2 For units of this type, the highest stresses may be associated with less severe environmental conditions than the maxima specified by the owner (designer). Where considered necessary by PRS, account should be taken of the consequent increased possibility of encounter of significant stress levels, by either or both of the following:

- .1 suitable reduction of the allowable stress levels for combined loadings given in Chapter 2;
- .2 detailed investigation of the fatigue properties.

Particular attention should also be given to the details of structural design in critical areas such as bracing members, joint connections, etc.

4.1.3 Local structures in way of fairleads, winches, etc., forming part of the position mooring system, should be designed to the breaking strength of the mooring line.

4.2 Upper structure

4.2.1 The scantlings of the upper structure are not to be less than those required by the *Rules for the Classification and Construction of Sea-Going Ships, Part II – Hull* referred to, in this Chapter, as the *Rules* in association with the loadings indicated on the deck loading plan. (These loadings are not to be less than the minima specified in 2.3.6). In addition, when the upper structure is considered to be an effective member of the overall structural frame of the unit, the scantlings are to be sufficient to withstand actual local loadings plus any additional loadings superimposed due to frame action, within the stress limitations of Chapter 2.

4.2.2 When the upper structure is designed to be waterborne in any mode of operation or damaged condition, or to meet stability requirements, it will be subject to special consideration.

4.2.3 Deckhouses fitted to the upper structure are to be designed in accordance with the *Rules*, with due consideration given to their location and to the environmental conditions in which the unit will operate.

4.3 Columns, lower hulls and footings

4.3.1 Main stability columns, lower hulls or footings may be designed as either framed or unframed shells. In either case, framing, ring stiffeners, bulkheads or other suitable diaphragms which are used are to be sufficient to maintain shape and stiffness under all the anticipated loadings.

Portlights or windows including those of the non-opening type, or other similar openings, are not to be fitted in columns.

4.3.2 Design

- (a) Where columns, lower hulls or footings are designed with stiffened plating, the minimum scantlings of plating, framing, girders, etc., may be determined in accordance with the requirements for tanks as given in Chapter 6. Where an internal space is a void compartment, the design head used in association with the above is not to be less than that corresponding to the maximum allowable waterline of the unit in service. In general, the scantlings are not to be less than required for watertight bulkheads in association with a head equivalent to the maximum damaged waterline, and for all areas subject to wave immersion, a minimum head of 6.0 m (20 ft) should be used;
- (b) Where columns, lower hulls or footings are designed as shells, either unstiffened or ring stiffened, the minimum scantlings of shell plating and ring stiffeners are to be determined on the basis of established shell analysis using the appropriate usage factors and the design heads as given in (a);
- (c) Scantlings of columns, lower hulls or footings as determined in (a) and (b) are minimum requirements for hydrostatic pressure loads. Where wave and current forces are superimposed, the local structure of the shell is to be increased in scantlings as necessary, to meet the strength requirements of 2.4.1.2;
- (d) When the column, lower hull or footing is an effective member of the overall structural frame of the unit, the scantlings are to be sufficient to meet the requirements of 4.3 plus any additional stresses superimposed due to frame action, within the stress limitations of Chapter 2;
- (e) Particular consideration is to be given to structural details, reinforcement, etc., in areas subject to high local loadings, or to such loadings that may cause shell distortion; for example:
 - .1 bottom bearing loads, where applicable;
 - .2 partially filled tanks;
 - .3 local strength against external damage;
 - .4 continuity through joints;
 - .5 wave impacts;
- (f) For units designed to rest on the sea bed, the effect of scouring action (loss of bottom support) is to be considered. The effects of skirt plates, where provided, will be specially considered.

4.3.3 Bracing members

4.3.3.1 Stresses in bracing members due to all anticipated loadings are to be determined in accordance with the following requirements in conjunction with the relevant requirements of Chapter 2.

4.3.3.2 Bracing members are to be designed to transmit loadings and to make the structure effective against environmental forces and, when the unit is supported by the sea bed, against the possibility of uneven bearing loads. Although designed primarily as brace members of the overall structure under the designated loadings, the bracing must also be investigated, if applicable, for superimposed local bending stresses due to buoyancy, wave and current forces.

4.3.3.3 Where relevant, consideration is to be given to local stresses due to wave impact.

4.3.3.4 When bracing members are of tubular section, ring frames may be required to maintain stiffness and roundness of shape.

4.3.3.5 When bracings are watertight, they are to be suitably designed to prevent collapse from external hydrostatic pressure.

4.4 Wave clearance

4.4.1 Afloat condition

Unless deck structures are designed for wave impact, to the satisfaction of PRS, reasonable clearance between the deck structures and the wave crests is to be ensured for all afloat modes of operation, taking into account the predicted motion of the unit relative to the surface of the sea. Calculations, model test results, or prototype experiences are to be submitted for consideration.

4.4.2 On-bottom condition

For on-bottom modes of operation, clearances are to be in accordance with those specified in 3.3.4 for self-elevating units.

4.5 Structural redundancy

4.5.1 When assessing structural redundancy for column stabilized units, the following assumed damage conditions shall apply:

- .1** the unit's structure shall be able to withstand the loss of any slender bracing member without causing overall collapse of the unit's structure;
- .2** structural redundancy will be based on the applicable requirements of 2.3, 2.4, 2.5, and 2.6, except:
 - .2.1** maximum calculated stresses in the structure remaining after the loss of a slender bracing member are to be in accordance with 2.5 in association with usage factors not exceeding 1.0. This criteria may be exceeded for local areas, provided redistribution of forces due to yielding or buckling is taken into consideration;
 - .2.2** when considering environmental factors, a one year return period may be assumed for intended areas of operations (see 2.3.1).

4.5.2 The structural arrangement of the upper hull is to be considered with regard to the structural integrity of the unit after the failure of any primary girder.

4.6 Damage stability

4.6.1 In assessing the damage stability of column stabilized drilling units as required by 2.8, the following assumed damage conditions apply.

- .1** only those columns, underwater hulls and braces on the periphery of the unit should be assumed to be damaged and the damage should be assumed in the exposed portions of the columns, underwater hulls and braces;
- .2** columns and braces should be assumed to be flooded by damage having a vertical extent of 3.0 m occurring at any level between 5.0 m above and 3.0 m below the drafts specified in the *Operating Manual*. Where a watertight flat is located within this region, the damage should 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 taking into account the actual operating conditions. However, the extent of required damage region should be at least 1.5 m above and below the draft in question;
- .3** no vertical bulkhead should 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 should be disregarded;
- .4** horizontal penetration of damage should be assumed to be 1.5 m;
- .5** underwater hulls or footings should be assumed to be damaged when operating in a transit condition in the same manner as indicated in .1, .2, .4 and having regard to their shape, either .3 or between effective watertight bulkheads;
- .6** all piping, ventilation systems, trunks, etc., within the extent of damage should be assumed to be damaged. Positive means of closure should be provided to preclude the progressive flooding of other spaces which are intended to be intact.

5 SURFACE TYPE DRILLING UNITS

5.1 General

5.1.1 The requirements of Chapter 5 applies to the unit type as defined in para 1.2.1 of *Part I – Classification Regulations of the Rules for the Classification and Construction of Mobile Offshore Drilling Units*.

5.2 Ship type drilling units

5.2.1 Scantlings of the hull structure are to meet the relevant requirements of the *Rules for the Classification and Construction of Sea-Going Ships, Part II – Hull* referred to, in this Chapter, as the *Rules*. Special consideration is, however, to be given to items which may require some deviation or additions to the *Rules*, in particular the items indicated in 5.2.2 to 5.2.5.

5.2.2 The required strength of the unit is to be maintained in way of the drilling well, and particular attention is to be paid to the transition of fore and aft members so as to maintain continuity of the longitudinal material. In addition, the plating of the well is to be suitably stiffened to prevent damage due to foreign objects which may become trapped in the well while the unit is under way.

5.2.3 The deck area in way of large hatches is to be suitably compensated where necessary to maintain the strength of the unit.

5.2.4 The structure in way of heavy concentrated loads resulting from the drilling derrick, pipe rack, set back, drilling mud storage, etc., is to be suitably reinforced.

5.2.5 Local structure in way of fairleads, winches, etc., forming part of the position mooring system, should be designed to the breaking strength of the mooring line.

5.3 Barge type drilling units

5.3.1 Scantlings of the hull structure are to meet the relevant requirements of the *Rules*. Special consideration, where applicable, is to be given to items listed in 5.2.

5.4 Damage stability

5.4.1 Extent of damage¹

5.4.1.1 In assessing the damage stability of surface units, the following extent of damage should be assumed to occur between effective water tight bulkheads:

- .1 horizontal penetration: 1.5 m; and
- .2 vertical extent: from the base line upwards without limit.

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

5.4.1.3 Where damage of a lesser extent than in paragraph 3.5.1 results in a more severe condition, such lesser extent should be assumed.

5.4.1.4 All piping, ventilation systems, trunks, etc., within the extent of damage referred to in paragraph 3.5.1 should be assumed to be damaged. Positive means of closure should be provided at watertight boundaries to preclude the progressive flooding of other spaces which are intended to be intact.

6 WATERTIGHT INTEGRITY

6.1 Watertight boundaries

6.1.1 All units are to be provided with watertight bulkheads as may be required by the *Rules for the Classification and Construction of Sea-Going Ships, Part II –Hull* referred to, in this Chapter, as the *Rules* and by this *Publication*. In all cases, the plans submitted are to clearly indicate the location and extent of the bulkheads. In the case of column stabilized drilling units, the scantlings of the watertight

¹ This subchapter applies to MODUs constructed on or after 1 January 2012, while IMO resolution A.649(16) applies to MODUs constructed on or after 1 May 1991 but before 1 January 2012 and IMO resolution A.414(XII) applies to those constructed before 1 May 1991.

flats and bulkheads are to be made effective to that point necessary to meet the requirements of damage stability and are to be indicated on the appropriate plans.

6.1.2 All surface type units are to be fitted with a collision bulkhead as may be required by the *Rules* and this *Publication*. Sluice valves, cocks, manholes, watertight doors, etc., are not to be fitted in the collision bulkhead. Elsewhere, watertight bulkheads are to be fitted as necessary to provide transverse strength and subdivision.

6.2 Tank boundaries

6.2.1 Tanks for fresh water or fuel oil, or any other tanks which are not intended to be kept entirely filled in service, are to have divisions or deep swashes as may be required to minimize the dynamic stress on the structure. Tight divisions and boundary bulkheads of all tanks are to be constructed in accordance with the requirements of the *Rules*. The arrangement of all tanks, together with their intended service and the height of the overflow pipes, is to be clearly indicated on the plans submitted for approval. Consideration is to be given to the specific gravity of the liquid in the tank.

6.2.2 Tanks are to be tested in accordance with the *Publication No 21/P – Testing of the Hull Structures*.

6.3 Boundary penetrations¹

6.3.1 Where watertight boundaries are required for damage stability, they are to be made watertight throughout, including piping, ventilation, shafting, electrical penetrations, etc. For compliance with the requirements of damage stability in 2.8, where individual lines, ducts or piping systems serve more than one compartment or are within the extent of damage, satisfactory arrangements are to be provided to preclude the possibility of progressive flooding through the system to other spaces, in the event of damage.

The number of openings in watertight subdivisions should 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 should be made to maintain the watertight integrity of the enclosed compartments.

6.3.2 Piping systems and ventilation ducts designed to watertight standards of the type mentioned in 6.3.1 are to be provided with valves in each compartment served. These valves are to be capable of being remotely operated from the weather deck, pump room or other normally manned space. Valve position indicators are to be provided at the remote control stations.

Where valves are provided at watertight boundaries to maintain watertight integrity, these valves should be capable of being locally operated. Remote operation 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 would be the central ballast control station. Valve position indicators should be provided at the remote control station.

6.3.3 Non-watertight ventilation ducts as mentioned in 6.3.1 are to be provided with watertight valves at the subdivision boundaries and the valves are to be capable of being operated from a remote location, with position indicators on the weatherdeck, or in normally manned space. For self-elevating units, ventilating systems which are not used during the transit operations may be secured by alternative methods, subject to special consideration.

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

Watertight doors should be designed to withstand water pressure to a head up to the bulkhead deck or freeboard deck respectively. A prototype pressure test should 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 should be carried out before the door is fitted. The installation method and

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procedure for fitting the door on board should correspond to that of the prototype test. When fitted on board, each door should 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 watertightness at the design pressure, with a proper margin of resistance. After installation, every such door, hatch or ramp should be tested by means of a hose test or equivalent.

6.4 Closures

6.4.1 General

External closing appliances are to be as prescribed by applicable load line requirements. Special consideration will be given to openings in the upper deck of column stabilized units.

6.4.2 General requirements related to watertight integrity

6.4.2.1 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 of 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 submerged¹. Such openings are not to be regarded as emergency exits. Where flooding of chain lockers or other buoyant volumes may occur, the openings to these spaces should be considered as downflooding points.

6.4.2.2 External openings fitted with appliances to ensure watertight integrity, which are kept permanently closed while afloat, are to comply with the requirements of 6.4.3.2.

6.4.2.3 Internal openings fitted with appliances to ensure watertight integrity are to comply with the following:

- .1** Doors and hatch covers which are used during the operation of the unit while afloat should be remotely controlled from the central ballast control station and should also be operable locally from each side. Open/shut indicators should 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 shall be provided with an individual hand-operated mechanism. It shall be possible to open and close the door by hand at the door itself from both sides;
- .2** Doors or 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 should 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 should be affixed to each such door or hatch cover stating that it is not to be left open while the unit is afloat;
- .3** The closing appliances are to have strength, packing and means for securing which are sufficient to maintain watertightness under the design water pressure of the watertight boundary under consideration.

6.4.2.4 Internal openings fitted with appliances to ensure watertight integrity, which are to be kept permanently closed while afloat, are to comply with the following:

- .1** a signboard to the effect that the opening is always to be kept closed while afloat is to be fitted on the closing appliance in question;
- .2** opening and closing of such closure devices should be noted in the unit's logbook, or equivalent;

¹ Such openings are not allowed to be fitted in the column-stabilized units (See 4.3).

- .3 manholes fitted with bolted covers need not be dealt with as under .1;
- .4 the closing appliances are to have strength, packing and means for securing which are sufficient to maintain watertightness under the design water pressure of the watertight boundary under consideration.

6.4.2.5 Remotely operated doors should meet SOLAS regulation II-1/25-9.2.

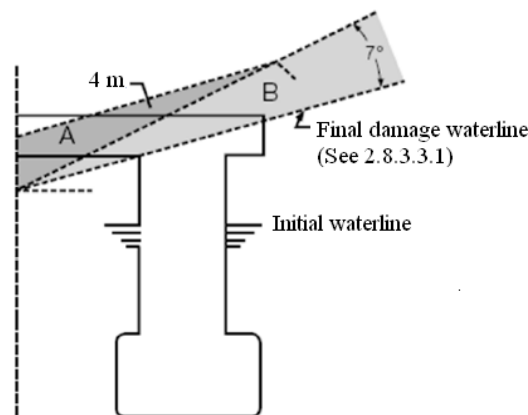
6.4.2.6 All downflooding external openings the lower edge of which is submerged when the unit is inclined to the first intercept between the righting moment and wind heeling moment curves in any intact or damaged condition should be fitted with a suitable watertight closing appliance, such as closely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

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

6.4.3 General requirements related to weathertight integrity

6.4.3.1 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 .1 or .2 below, is to be fitted with a weathertight closing appliance to ensure the weathertight integrity, when:

- .1 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 2.8.1 during the intact condition of the unit while afloat; and
- .2 a column-stabilized unit is inclined to the range:
 - a) necessary to comply with the requirements of 2.8.3.2.2 and with a zone measured 4.0 m perpendicularly above the final damaged waterline per 2.8.3.2.1 referred to Fig.6.4.3.1 and
 - b) necessary to comply with the requirements of 2.8.3.3.2.



A – 4 m zone of weathertightness
 B – 7 degrees zone of weathertightness

Fig. 6.4.3.1. Minimum weathertight integrity requirements for column-stabilized units

6.4.3.2 External openings fitted with appliances to ensure weathertight integrity, which are kept permanently closed while afloat, are to comply with the requirements of 6.4.2.4.1 and 6.4.2.4.2.

6.4.3.3 External openings fitted with appliances to ensure weathertight integrity, which are secured while afloat, are to comply with the requirements of 6.4.2.3.1 and 6.4.2.3.2.

7 MACHINERY

7.1 General

7.1.1 The requirements of Chapter 7 apply to the machinery essential to the safe operation of the unit. They do not apply to equipment and systems used solely for the drilling operation, except in so far as safety is concerned.

Systems and equipment that are used solely for drilling and that may affect the safety of the unit on which they are installed may be designed to the alternative requirements of recognized standards acceptable to PRS.

7.1.2 Self-propelled and non-self-propelled units

All propulsion and auxiliary machinery, steering arrangements, pressure vessels, pumps and piping systems necessary for the safe operation of the unit are to be constructed and installed in accordance with the relevant requirements of the *Rules for the Classification and Construction of Sea-Going Ships, Part VI – Machinery Installations and Refrigerating Plants* and *Part VII –Machinery, Boilers and Pressure Vessels* referred to, in this Chapter, as the *Rules* and as specified herein.

7.1.3 Machinery installations – inclinations

7.1.3.1 All units: All machinery, components and systems essential to the safe operation of a unit are to be designed to operate under the following static conditions of inclination:

- .1 when column stabilized units are upright and inclined to an angle up to 15° in any direction;
- .2 when self-elevating units are upright and inclined to an angle up to 10° in any direction;
- .3 when surface units are upright and level trim and when inclined to an angle of list up to 15° either way and simultaneously trimmed to an angle up to 5° by the bow or stern.

PRS may permit or require deviations from these angles, taking into consideration the type, size and service conditions of the unit.

7.1.3.2 Self propelled units: Main propulsion machinery and all auxiliary machinery essential to the propulsion and the safety of the unit should, as fitted in the unit, be capable of operating under the static conditions required by 7.1.3.1 and the following dynamic conditions:

- .1 column stabilized units: 22.5° in any direction;
- .2 self-elevating units: 15° in any direction;
- .3 surface units: 22.5° rolling and simultaneously pitching 7.5° by bow or stern.

PRS may permit deviation from these angles, taking into consideration the type, size and service conditions of the unit.

7.1.3.3 Emergency source of power: On all units, the emergency generator and its prime mover and any emergency accumulator battery are to be capable of supplying the power required by 8.4.2 when upright and when inclined to the greater of the first intercept angles at which compliance with the intact and damage stability criteria of 2.8 are satisfied. However, in no case need the equipment be designed to operate when inclined more than:

- .1 25° in any direction on a column stabilized unit;
- .2 15° in any direction on a self-elevating unit; and
- .3 about the longitudinal axis and/or when inclined 10° about the transverse axis on surface unit.

7.2 Jacking systems

7.2.1 The jacking system is to be designed and constructed to maintain the safety of the unit in the event of failure of a critical component during operation of the jacking system. Suitable monitoring is to be provided at a manned control station to indicate such failure.

7.3 Piping systems

7.3.1 General

Pipes are to be arranged inboard of the zone of assumed damage penetration unless special consideration has been taken in the damage stability review. (See Chapters 2 to 5).

7.3.2 Piping systems carrying non-hazardous fluids are generally to be separate from piping systems which may contain hazardous fluids. Cross connection of the piping systems may be permitted where means for avoiding possible contamination of the non-hazardous fluid system by the hazardous medium are provided.

7.3.3 Where air or steam is used to atomize well bore fluids prior to flaring, a nonreturn valve is to be fitted in the air or steam line. This valve should be part of the permanently installed piping, readily accessible and as close as possible to the burner boom. Alternative arrangements shown to provide an equivalent level of safety may be accepted by PRS.

7.4 Valve arrangements

7.4.1 General

Where valves of piping systems are arranged for remote control and are power operated, a secondary means of operating the valves which may be manual control, is to be provided.

7.4.2 Remote operation of sea-water inlet and discharge valves

Inlet and discharge valves in compartments situated below the assigned load line (normally unattended compartments) are to be provided with remote controlled valves. Where remote operation is provided by power actuated valves for sea-water inlets and discharges for operation of propulsion and power generating machinery, power supply failure of the control system is not to result in:

- .1 closing of open valves;
- .2 opening of closed valves.

Consideration will be given to accepting bilge alarms in lieu of remote operation for surface type and self-elevating units only.

7.5 Ballast systems for column stabilized units

7.5.1 General

Each ballast tank is to be capable of being pumped out by at least two power-driven pumps, arranged so that tanks can be drained at all normal operating and transit conditions. The ballast pumps are to be of the self-priming type or be provided with a separate priming system.

7.5.2 Capacity

The system is to be capable of raising the unit, starting from a level trim condition at deepest normal operating draft, to the severe storm draft, or a greater distance as may be specified by PRS, within three hours.

7.5.3 System arrangement

The ballast system is to be arranged to prevent the inadvertent transfer of ballast water from one quadrant to any other quadrant of the unit. The system is also to be arranged so that the transfer of ballast water from one tank to any other tank through a single valve is not possible except where such a transfer could not adversely affect the stability of the unit.

7.5.4 Operation in damaged condition

The ballast system is to be arranged so that even with any one pump inoperable, it is capable of restoring the unit to a level trim condition and draft acceptable to PRS with respect to stability, when subject to the damage conditions specified in 2.7.3.

7.5.5 Control features

Ballast pumps, ballast tank valves and sea chest valves are to be provided with a means of remote control from a central ballast control station. Pumps are also to be provided with a means of local control in the pump room. A manually operated independent means of control of the valves is also to be provided. This ballast control station and any backup stations are to be readily accessible and protected from the weather when the unit is subject to the assumed conditions of severe storm and damage. Additionally, these stations are not to be located within the assumed damaged penetration zone. The central ballast control station is to include the following:

- .1 valve position indicating system;
- .2 tank level indicating system;
- .3 draft indicating system;
- .4 means of communication between the central ballast control station and those spaces containing the alternative means of control for the ballast pumps and valves.

The control and indicating systems are to function independently of each other so that a failure in any one system will not affect the operation of the other systems. The ballast pump and ballast valve control systems are to be arranged so that the loss of any one of their components will not cause the loss of operation to the other pumps or valves.

To ensure that uncontrolled transfer of ballast water will not continue upon loss of power, ballast tank valves are to close automatically upon loss of power or be provided with an arrangement considered equivalent to the satisfaction of PRS.

7.6 Bilge systems

7.6.1 General

In general, the bilge system is to be in accordance with the *Rules*. Compartments below deck containing essential equipment for operation and safety of the unit are to have a permanently installed bilge or drainage system. These compartments are to be drained with at least two bilge pumps, or equal.

All distribution boxes and manually operated valves in connection with the bilge pumping arrangements are to be in positions which are accessible under normal circumstances. Where such valves are located in normally unmanned spaces below the assigned load line and not provided with high bilge water level alarms, they are to be operable from outside the space.

7.6.2 Size of bilge main

The cross-sectional area of the main bilge line is not to be less than the combined areas of the two largest branch suction.

7.6.3 Size of bilge branch suction

The internal diameter of branch suction from each compartment is not to be less than stipulated by the following formula, to the nearest 5 mm.

$$d = 2,15\sqrt{A} + 25 \quad [\text{mm}]$$

where A is wetted surface in m^2 of the compartment, excluding stiffening members when the compartment is half filled with water. The internal diameter of any bilge line is not to be less than 50 mm.

7.6.4 Size of bilge pumps

Each bilge pump is to be capable of giving a speed of water through the bilge main of not less than 2 m per second. When more than two pumps are connected to the bilge system, their aggregate capacity is not to be less effective.

7.6.5 Chain lockers

Chain lockers are to be capable of being drained by a permanently installed bilge or drainage system or by portable means. Means are to be provided for removal of mud and debris from the bilge or drainage system.

7.6.6 Void compartments

Void compartments adjacent to the sea or to tanks containing liquids, and void compartments through which piping conveying liquids passes, are to be drained by permanently installed bilge or drainage systems or by portable means. If portable pumps are used, two are to be provided and both pumps and arrangements for pumping are to be readily accessible. Void compartments as defined above which are not provided with bilge or drainage systems in compliance with the above are to be accounted for in the units stability analysis.

7.6.7 Bilge alarm

Propulsion rooms or pump rooms in lower hulls of column stabilized units which normally are unattended are to be provided with two independent systems of high level detection.

7.6.8 Bilge suctions from hazardous areas

Hazardous and non-hazardous areas are to be provided with separate drainage or pumping arrangements.

7.6.9 Additional requirements for column stabilized units

7.6.9.1 Chain lockers which, if flooded, could substantially affect the unit's stability are to be provided with a remote means to detect flooding and a permanently installed means of dewatering. Remote indication of flooding is to be provided at the central ballast control station.

7.6.9.2 At least one of the pumps referred to in 7.6.1 and all pump-room bilge suction valves are to be capable of both remote and local operation.

7.7 Tank vents and overflows

7.7.1 Tank vents and overflows are to be located giving due regard to damage stability and the location of the final calculated immersion line in the assumed damage condition. Tank vents and overflows which could cause progressive flooding are to be avoided unless special consideration has been taken in the damage stability review.

In cases where tank vents and overflows terminate externally or in spaces assumed flooded, the vented tanks are to be also considered flooded. In cases where tanks are considered damaged, the spaces in which their vents or overflows terminate are also to be considered flooded.

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

7.7.2 Vent size

The size of the vents is to be in accordance with the *Rules* with due consideration being given to the design pressure of the tank.

7.8 Sounding arrangements

7.8.1 General

All tanks are to be provided with separate sounding pipes, or approved remote level indicating system. Where a sounding pipe exceeds 20 m in length, the minimum internal diameter 38 mm as required by the *Rules* is to be increased to at least 50 mm.

7.8.2 Additional sounding

Where a remote level indicating system is used, an additional sounding system is to be provided for tanks which are not always accessible.

7.8.3 Void compartments

Void compartments adjacent to the sea or tanks containing liquids, and void compartments through which piping carrying liquids passes are to be fitted with separate sounding pipes, approved tank liquid

level indicating apparatus or be fitted with means to determine if the void tanks contain liquids. Voids as defined above which do not comply with this requirement are to be accounted for in the unit's stability analysis.

7.9 Low flash point fuels

7.9.1 General

Where it is intended to burn fuels of a flash point below 60°C but not less than 43°C, closed cup test, this fact is to be indicated clearly on the arrangement submitted. Vent heads of an approved type with flame arresters are to be fitted to vent pipes. Consideration may be given to other arrangements. The use of fuels of a flash point lower than 43°C closed cup test will require special consideration of storage and handling facilities and controls as well as the electrical installation and ventilation provisions.

7.9.2 Fuel storage for helicopter facilities

Areas where such fuel tanks are situated and fuelling operations conducted are to be suitable isolated from enclosed spaces or other areas which contain a source of vapour ignition. Vent heads of an approved type with flame arresters are to be fitted to vent pipes. Fuel storage tanks are to be of approved metallic construction and are to be adequate for the installation. Special attention is to be given to the design, mounting and securing arrangements and electrical bonding of the tank and fuel transfer system. The storage and handling area is to be permanently marked. Coamings or other arrangements are to be provided to contain fuel-oil spills.

7.10 Machinery installations in hazardous areas

7.10.1 Combustion engines in hazardous areas

Generally, combustion engines are not to be installed in hazardous areas. When this cannot be avoided, special consideration may be given to the arrangement.

7.10.2 Boilers in hazardous areas

Fired boilers are not to be installed in hazardous areas.

7.11 Installation of internal combustion engines and boilers

7.11.1 Exhaust outlets

Exhaust outlets of internal combustion engines are to be fitted with efficient spark arresting devices and shall discharge outside the hazardous areas. Exhaust outlets of fired boilers are to discharge outside hazardous areas.

7.11.2 Exhaust pipes

Exhaust piping is to be installed in accordance with the *Rules*. Exhaust pipe insulation is to be protected against possible oil absorption.

7.11.3 Air intakes

Air intakes for internal combustion engines shall be not less than 3 m from the hazardous areas as delineated in para 1.2.2 of *Part I – Classification Regulations* of the *Rules for the Classification and Construction of Mobile Offshore Drilling Units*.

7.12 High pressure piping for drilling operations

7.12.1 General

Permanently installed piping systems for drilling operations are to comply with an acceptable standard or code.

7.13 Initial start arrangement

7.13.1 General

Provision is to be made for initial starting on board with the unit in a "dead ship" mode without the use of external aid.

7.14 Control and monitoring

7.14.1 General

Where propulsion machinery spaces are normally unattended during transit, the control and monitoring systems are to be constructed and installed in accordance with the applicable requirements of the *Rules for the Classification and Construction of Sea-Going Ships, Part VIII – Electrical Equipment and Automation*.

8 ELECTRICAL INSTALLATIONS

8.1 General

8.1.1 The requirements of Chapter 8 apply to electrical equipment essential to the safe operation of the unit. They do not apply to electrical equipment and systems used solely for the drilling operation except in so far as safety is concerned. Attention should, however, be given to any relevant statutory regulation of the National Authority of the country in which the unit is to be registered.

8.2 Design and construction

8.2.1 Every unit is to be provided with a main source of electrical power which is to include at least two generators. Electrical propelling machinery and associated equipment together with auxiliary services essential for the safety of the unit are to be constructed and installed in accordance with the relevant requirements of the *Rules for the Classification and Construction of Sea-Going Ships, Part VIII – Electrical Equipment and Automation* referred to, in this Chapter, as the *Rules* and as specified herein. The following equipment is regarded as essential:

- .1 for ventilation of hazardous areas and those areas maintained at an overpressure to exclude the ingress of dangerous gases;
- .2 navigation and special purpose lights;
- .3 lights for all machinery spaces, control stations, alleyways, stairways and exits;
- .4 fire pumps;
- .5 propulsion equipment;
- .6 bilge pumps;
- .7 ballast pumps for column stabilized units.

8.2.2 The design and installation of other equipment including that used for drilling operations is to be such that there is minimal risk of fire due to its failure. It must, as a minimum, comply with an acceptable specification, standard or code, revised where necessary, for ambient conditions.

8.2.3 Essential lighting should be supplied from at least two final sub-circuits in such a way that failure of any one of the circuits does not leave the space in darkness. For lighting in hazardous areas or spaces, switches are to be of the two-pole type and wherever practicable located in a non-hazardous area.

8.3 Cables and types of electrical equipment permitted in hazardous areas

8.3.1 Electrical equipment in hazardous areas

8.3.1.1 Zone 0 areas:

- certified intrinsically safe circuits or equipment and associated wiring.

8.3.1.2 Zone 1 areas:

- certified intrinsically safe circuits or equipment and associated wiring;

- certified flameproof (explosion proof) equipment;
- certified increased safety equipment; for increased safety motors due consideration should be given to the protection against overcurrent;
- pressurized enclosure type equipment which is acceptable to PRS;
- through runs of cables.

8.3.1.3 Zone 2 areas:

- all equipment approved for Zone 1 areas;
- any equipment of a type which ensures absence of sparks or arcs and of “hot spots” during normal operation and which is acceptable to PRS.

8.3.2 Cables in hazardous areas

8.3.2.1 Zone 0 areas:

- cables associated with intrinsically safe circuits.

8.3.2.2 Zone 1 areas – all cables shall be sheathed as follows:

- nonmetallic impervious sheath plus metal screening or braiding for earth detection;
- copper sheath plus nonmetallic outer sheath for earth detection (for mineral insulated cable only).

8.3.2.3 Zone 2 areas – all cables are to be sheathed as follows:

- as for Zone 1 areas;
- nonmetallic sheath without metal screening or braiding, provided the cable is adequately protected against mechanical damage.

8.4 Emergency source of power

8.4.1 A self-contained emergency source of power is to be installed in a non-hazardous space and should be located on or above the uppermost continuous deck and above the worst damage waterline and inboard of the damage conditions specified in 2.8. Its location and arrangement in relation to the main source of electric power is to be such as to ensure that a fire, flooding or other failure in the space containing the main source will not interfere with the supply or distribution of emergency power.

8.4.2 The power available is to be sufficient to supply for at least 18 hours all services necessary for the safety of all on board in an emergency, particular attention being given to:

- .1 navigation and special purpose lights and warning system;
- .2 emergency lighting for machinery spaces, control stations, alleyways, stairways and exits;
- .3 general alarm and communications systems;
- .4 fire and gas detection systems and their alarms;
- .5 fire extinguishing systems;
- .6 permanently installed diving equipment necessary for the safe conduct of diving operations, if dependent upon the unit’s electrical power;
- .7 abandonment systems dependent on electric power including lighting for embarkation stations;
- .8 emergency lighting for personnel lift cars and personnel lift trunks;
- .9 emergency lighting in all spaces from which control of the drilling process is performed and where controls of machinery essential for this process, or devices for emergency switching-off of the power plant are located;
- .10 emergency lighting at the storage position(s) for firemen’s outfits;
- .11 emergency lighting at the sprinkler pump if any, at one of the fire pumps if dependent upon the emergency generator for its source of power, at the emergency bilge pump if any, and at their starting positions;
- .12 emergency lighting on helicopter decks;
- .13 the capability of closing the blow-out preventer and of disconnecting the unit from the well head arrangement, if electrically controlled, unless it has an independent supply from an accumulator battery suitably located for use in an emergency and sufficient for the period of 18 hours;

- .14 on column stabilized units: ballast valve control system, ballast valve position indicating system, draft level indicating system, tank level indicating system, and the largest single ballast pump required by 7.5.1.

8.4.3 Where the emergency source of power is a generator not fitted with an automatic starting device and an automatic connection to the emergency switchboard, a transitional source of emergency power is to be installed.

This is to be storage batteries of sufficient capacity to supply for at least 30 minutes:

- emergency lighting;
- fire detection system;
- general alarm and communications systems;
- blow-out preventer.

8.4.4 Arrangements are to be such that the transitional source of emergency power will come into operation automatically in the event of failure of the main electrical supply.

8.5 Emergency shutdown facilities

8.5.1 Emergency conditions due to drilling operations

In view of exceptional conditions in which the explosion hazard may extend outside the areas defined in para 1.2.2 of *Part I – Classification Regulations* of the *Rules for the Classification and Construction of Mobile Offshore Drilling Units*, special arrangements should be provided to facilitate the selective disconnection of shutdown of :

- ventilating system;
- all electrical equipment outside Zone 1 areas, except where of a certified safe type for Zone 1 applications;
- main electrical generators and prime movers;
- emergency equipment except those items listed in 8.5.2;
- emergency generators.

Initiation of the foregoing shutdown of facilities will be the operator's responsibility. The initiated action may vary according to the nature of the emergency. A recommended sequence of shutdowns should be included in the *Operating Booklet* (see para 4.6 of *Part I – Classification Regulations* of the *Rules for the Classification and Construction of Mobile Offshore Drilling Units*).

8.5.2 Equipment to remain operational after emergency shutdown

At least the following facilities are to be operable after an emergency shutdown. Equipment which is located in spaces other than enclosed spaces and arranged to be operated after complete shutdown as given 8.5.1 is to be suitable for installation in Zone 2 locations. Such equipment, when located in enclosed spaces, is to be suitable for its intended application to the satisfaction of PRS:

- emergency lighting required by 8.4.2 for half an hour;
- blow-out preventer control system;
- general alarm system;
- public address system; and
- battery supplied radio communication installations.

8.6 Earthing (grounding) arrangements

8.6.1 Where not obtained through normal construction, arrangements are to be provided to effectively earth (ground) all machinery, metal structures of derricks, masts and helicopter platforms.

8.6.2 Cathodic protection

Details of impressed-current cathodic protection systems, including installation and locations, are to be submitted when such systems are installed.

9 SAFETY FEATURES

9.1 Fire protection and extinction

9.1.1 General

Fire protection arrangements and fire extinguishing systems are to be in accordance with the Rules as specified herein. Fire control plans are to be submitted for review, on which the following, as a minimum, shall be clearly shown:

- a) locations of fire control stations;
- b) various fire sections enclosed by various classes of fire divisions;
- c) arrangement of fire detectors and manual fire alarm stations;
- d) arrangement of combustible gas detectors;
- e) arrangement of hydrogen sulphide gas detectors;
- f) locations of respiratory protection equipment for hydrogen sulphide;
- g) general alarm actuating positions;
- h) arrangement of various fire-extinguishing appliances;
- i) locations of Fire-fighters' Outfits;
- j) location of Helicopter Crash Kit;
- k) arrangement of water spray nozzles and sprinklers (if fitted);
- l) locations of emergency shutdown (such as oil fuel source shutdown, engine shutdown, etc.) stations;
- m) ventilating system including fire dampers positions, ventilating fans control positions with indication of identification numbers of ventilating fans serving each section;
- n) arrangement of fire/watertight doors and their remote control positions;
- o) blowout preventer control positions;
- p) escape route and means of access to different compartments, decks, etc.;
- r) locations of Emergency Escape Breathing Devices (EEBD);
- s) arrangement of emergency muster stations and life-saving appliances.

9.1.2 Governmental authority

Attention is directed to the appropriate governmental authority in each case, as there may be additional requirements, depending on the size, type and intended service of the units as well as other particulars and details. Consideration will be given to fire protection arrangements and fire extinguishing systems which comply with the published requirements of the governmental authority of the country in which the unit is to be registered.

Also, attention is directed to Chapter IX of the *IMO Code for the Construction and Equipment of Mobile Offshore Drilling Units*, which contains minimum requirements for structural fire protection.

9.2 Fire fighting water supply

9.2.1 Fire pumps

There are to be at least two independently driven fire pumps. The pumps, their source of power and piping and valves are to be so arranged that a fire in any one compartment will not put all fire pumps out of action.

9.2.2 Pressure

Each fire pump is to be able to maintain a pressure of at least 350 kPa (50 lb/in²) at any hydrants with two 19 mm (3/4 in.) nozzles in action. In addition, where a foam system is provided for protection of the helicopter deck, the pump shall be capable of maintaining a pressure of 700 kPa (100 lb/in²) at the foam installation and the water consumption used for foam system is to be added to the pump capacity. If the water consumption for any other fire protection or fire-fighting purpose shall exceed the rate of the helicopter deck foam installation, this consumption shall be the determining factor in calculating the required capacity of the fire pumps.

9.2.3 Nozzles

Dual purpose jet spray nozzles are to be fitted throughout the unit with a minimum nozzle diameter of 12 mm (1/2 in.) for accommodation and service spaces and with a maximum diameter of 19 mm (3/4 in.) for machinery spaces and exterior locations.

9.2.4 Supply

9.2.4.1 At least two water supply sources (sea chests, valves, strainers and pipes) are to be provided and so arranged that one supply source failure will not put all supply sources out of action.

9.2.4.2 For the self-elevating units, the following additional fire water supply measures are to be provided:

- .1 Water is to be supplied from sea water main filled by at least two submersible pumping systems. One system failure will not put the other system(s) out of function, and
- .2 Water is to be supplied from drill water system while unit lifting or lowering. Water stored in the drill water tank(s) is not less than 40 m³ plus engine cooling water consumption before unit lifting or lowering. Alternatively, water may be supplied from buffer tank(s) in which sea water stored is not less the quantity as the above mentioned.

9.2.5 Tank capacity

The intermediate tanks are to be of such size and so operated that the lowest water level permitted will ensure that the supply of water is adequate for two hoses at a minimum of 350 kPa nozzle pressure at the uppermost hydrant for at least 15 minutes (minimum tank capacity of 10 m³). The intent is to allow for sufficient time for bringing a replenishment pump into service. Valves and pumps serving the intermediate tank which are not readily accessible are to be provided with means for remote operation.

9.2.6 Features

The following features are to be incorporated in a system using an intermediate tank:

- .1 a low water level alarm;
- .2 two reliable and adequate means to replenish water in the intermediate tank. These pumps are to be arranged in accordance with 9.2.1 and 9.2.2. At least one of the replenishment pumps is to be arranged for automatic operation;
- .3 if the unit is intended to operate in cold weather, the entire fire-fighting system is to be protected from freezing. This would include tanks used as water reservoirs.

9.3 Fire extinguishing systems

9.3.1 Fixed and portable fire extinguishing systems are to be provided in accordance with the *Rules*, except the requirements of 9.3.2 and 9.3.3.

9.3.2 Fixed fire extinguishing systems on drilling end areas:

- .1 A fixed water spray system is to be provided to protect drilling area. The minimum water application rate is not less than 20.4 l/min·m², or
- .2 At least two dual-purpose (jet/spray) fire monitors are to be installed to cover drilling and well test areas. The minimum capacity of each monitor is not less than 100 m³/h. The monitors may be operated either remotely or locally. Monitor arranged for local operation shall be sited on an accessible protected position.

9.3.3 Fixed fire extinguishing systems on mud processing area

A suitable fixed foam system is to be provided. The system is to be capable of delivering foam solution at a rate of not less than 6.5 l/min·m² (4.1 l/min·m² for Aqueous Film Forming Foam or Film-Forming Fluoroprotein Foam) for 15 minutes. Alternatively, a gas fixed fire extinguishing system may be used for enclosed mud processing spaces.

9.4 Fire fighting equipment for helicopter facilities

9.4.1 General

Where areas of a unit are designated for helicopter facilities, the fire fighting equipment as given in 9.4.2 and 9.4.3 are to be provided and so arranged as to adequately protect both the helicopter deck and fuel storage areas.

9.4.2 Portable fire extinguishers

There shall be 2 types of extinguishers:

- .1** Primary extinguishers: dry powder extinguishers of a total capacity of not less than 45 kg (100 lb);
- .2** Back-up extinguishers: CO₂ extinguishers of a total capacity of not less than 18 kg or equivalent, one of these extinguishers being so equipped as to enable it to reach the engine area of any helicopter using the deck. The back-up extinguishers are to be located so that they would not be vulnerable to the same damage as the primary extinguishers.

9.4.3 Fixed fire fighting systems

There shall be 2 types of fixed fire fighting systems:

- .1** Fire water system: at least two approved nozzles of jet/spray type and hoses sufficient in length to reach any part of the helicopter deck;
- .2** Fixed foam system: A suitable foam application system consisting of monitors or hose streams or both is to be installed. The system is to be capable of delivering foam solution at a rate of not less than 6 l/min·m² (4.1 l/min·m² for Aqueous Film Forming Foam or Film-Forming Fluoroprotein Foam) for at least 5 minutes.

9.5 Alarms and public address system

9.5.1 General alarms

9.5.1.1 A general alarm system is to be provided and so installed as to be clearly perceptible in all parts of the unit. Alarm signal devices are to be provided which will produce a distinctive and strong tone.

The signals used should be limited to: general emergency, toxic gas (hydrogen sulphide), combustible gas, fire alarm and abandon unit signals.

The signals given over the general alarm system should be supplemented by instructions over the public address system.

9.5.1.2 At least in the following spaces general alarm is to be capable of being operated from:

- a) main control station;
- b) drilling console;
- c) navigating bridge (if any); and
- d) fire control station (if any).

9.5.2 Mud system level alarms

A suitable audible and visual alarm to indicate significant increase or decrease in the level of the contents of the mud pit is to be provided at the control station for drilling operations and at the mud pit. Equivalent means to indicate possible abnormal conditions in the drilling system may be considered by PRS.

9.5.3 Ventilation system alarm

For openings, access and ventilation conditions affecting the extent of hazardous Zones, see requirements given in 1.2.2.5, *Rules for Classification and Construction of MODU's, Part I – Classification Regulations, 2006*.

9.5.4 Public address system

9.5.4.1 The public address system is to be a loudspeaker installation enabling the broadcast of messages into all spaces where personnel are normally present and muster stations. It is to allow for the

broadcast of messages from navigation bridge, central control room, emergency response centre, engine control room, ballast control station, jacking control station and drilling console. It is to be installed with regard to acoustically marginal conditions and not require any action from the addressee. It is to be protected against unauthorized use.

9.5.4.2 The minimum sound pressure levels for broadcasting emergency announcements are to be:

- a) in interior spaces 75dB(A) and at least 20dB(A) above the speech interference level;
- b) in exterior spaces 80dB(A) and at least 15dB(A) above the speech interference level.

9.6 Emergency control stations

9.6.1 General

At least two emergency control stations are to be provided. One of the stations is to be located near the drilling console and the second station is to be at a suitable manned location outside the hazardous areas.

The control stations are to be provided with:

- .1 manually operated contact makers for actuating the general alarm system;
- .2 an efficient means of communication between these stations and all locations vital to the safety of the unit;
- .3 emergency shut-down facilities (see 8.5.1).

9.7 Fire detection and alarm systems

9.7.1 General

9.7.1.1 Spaces having a fire risk, in principle, should be provided with an automatic fire detection and alarm system.

9.7.1.2 In selecting the type of detectors, their following features should be taken into account:

- a) capability to detect fire at the incipient stage;
- b) ability to avoid spurious alarm and trias;
- c) suitability to the located environment.

9.7.1.3 The fire detection main indicator board is to be at a manned control station and is to clearly indicate where fire has been detected.

9.7.2 Machinery spaces

Fire detectors are to be fitted in normally unattended machinery spaces.

Detection systems using only thermal detectors, in general, are not to be permitted.

9.7.3 Accommodation and service spaces

An automatic fire detection and alarm system is to be provided in all accommodation and service spaces.

Accommodation space is to be fitted with smoke detectors.

Thermal detectors are to be fitted in galleys.

9.7.4 Electrical rooms and control stations

Smoke detectors are to be provided in all electrical rooms and control stations.

9.7.5 Drilling and mud processing areas

Flame or thermal detectors are to be installed in open drilling and/or mud processing areas.

Smoke detectors may be used in enclosed mud processing areas.

9.7.6 Manually operated alarm system

Sufficient manual fire alarm stations are to be installed throughout the accommodation spaces, service spaces and control stations. One manually operated call point is to be located at each exit. Manually operated call points are to be readily accessible in the corridors of each deck such that no part of the corridor is more than 20 m from a manually operated call point.

Measures are to be taken to prevent inadvertent operation of the manual call alarm system.

9.8 Combustible gas detection and alarm systems

9.8.1 Areas for protection

Fixed automatic combustible gas detection and alarm systems are to be provided for the following areas:

- (a) cellar deck;
- (b) drill floor;
- (c) mud pit area;
- (d) shale shaker area;
- (e) enclosed spaces containing the open components of mud circulation system from the bell nipple to the mud pits;
- (f) ventilation intakes of enclosed machinery spaces contiguous to hazardous areas and containing internal combustion engines and boilers;
- (g) ventilation intakes and areas near other openings of accommodation spaces.

9.8.2 Alarms

The gas detectors are to be connected to an audible and visual alarm system with indicators on the drill floor and in the main control station. The alarm system is to clearly indicate the location and concentration of the gas hazard. The combustible gas detectors are to alarm at not more than 25% and at 60% of the lower explosive limit (LEL).

9.8.3 Portable combustible gas detectors

In addition to the fixed automatic gas detection system, two portable combustible gas detectors are to be provided on the unit.

9.9 Hydrogen sulphide detection and alarm system

9.9.1 Areas for protection

A fixed automatic hydrogen sulphide gas detection and alarm system are to be provided for the following areas:

- a) drill area;
- b) mud processing area;
- c) well test area.

9.9.2 Alarms

The detectors are to be connected to an audible and visual alarm system with indicators in main control room. The system is to clearly indicate where gas has been detected.

Low level alarm set at 10 ppm and high level alarm set not higher than 300 ppm are to be designed. The high level alarm is to activate an evacuation alarm.

If the alarm at the main control point is unanswered within 2 min, the toxic gas (hydrogen sulphide) alarm and the helideck status light is to be automatically activated.

9.9.3 Portable hydrogen sulphide gas detectors

At least two portable hydrogen sulphide gas monitoring devices should be provided on the unit.

9.10 Respiratory protection equipment for hydrogen sulphide

9.10.1 A self-contained breathing apparatus (SCBA) positive-pressure/ pressure-demand breathing equipment with full-face piece and rated for a minimum of 30 minutes is to be provided for each person in working areas where hydrogen sulphide may be encountered, and each person in other areas is to be provided with a SCBA rated for a minimum of 15 minutes.

9.10.2 Alternatively, positive-pressure/pressure-demand air line breathing equipment coupled with a SCBA equipped low pressure warning alarm and rated for a minimum of 15 minutes is to be provided for each person on board the unit.

Breathing air supply line stations are to be provided at least in the following areas:

- a) living quarter;
- b) muster/evacuation area;
- c) drilling areas;
- d) mud processing areas;
- e) other working areas.

10 OFFSHORE MOORING CHAIN

10.1 General requirements

10.1.1 Scope

10.1.1.1 The requirements of Chapter 10 apply to the materials, design, manufacture and testing of offshore mooring chain and accessories intended to be used for application such as: mooring of mobile offshore units, mooring of floating production units, mooring of offshore loading systems and mooring of gravity based structures during fabrication.

10.1.1.2 Mooring equipment covered are common stud and studless links, connecting common links (splice links), enlarged links, end links, detachable connecting links (shackles), end shackles, **subsea connectors**, swivels and swivel shackles.

10.1.1.3 Studless link chain is normally deployed only once, being intended for long-term permanent mooring systems with pre-determined design life.

10.1.1.4 Requirements for chafing for single point mooring arrangements are given in 10.6.

10.1.2 Chain grades

10.1.2.1 Depending on the nominal tensile strength of the steels used for manufacture, chains are to be subdivided into five grades: R3, R3S, R4, R4S and R5.

10.1.2.2 Manufacturers propriety specifications for R4S and R5 may vary subject to design conditions and the acceptance of PRS.

10.1.2.3

Each grade is to be individually approved. Approval for a higher grade does not constitute approval of a lower grade. **If it is demonstrated to the satisfaction of PRS that the higher and lower grades are produced to the same manufacturing procedure using the same chemistry and heat treatment, consideration will be given to qualification of a lower grade by a higher. The parameters applied during qualification are not to be modified during production.**

10.1.3 Approval of chain manufacturers

10.1.3.1 Offshore mooring chains are to be manufactured only by works approved by PRS. For this purpose approval tests are to be carried out, the scope of which is to include proof and breaking load tests, measurements and mechanical tests including fracture mechanics tests.

10.1.3.2 Manufacturers are to submit for review and approval the sequence of operations from receiving inspection to shipment and details of the following manufacturing processes:

- .1 bar heating and bending including method, temperatures, temperature control and recording,
- .2 flash welding including current, force, time and dimensional variables as well as control and recording of parameters, **maintenance procedure and programme for welding machine,**
- .3 flash removal including method and inspection,
- .4 stud insertion method, for stud link chain,
- .5 heat treatment including furnace types, means of specifying, controlling and recording of temperature and chain speed and allowable limits, quenching bath and agitation, cooling method after exit,
- .6 proof and break loading including method/machine, means of horizontal support (if applicable), method of measurement and recording,
- .7 non-destructive testing procedures,
- .8 the manufacturer's surface quality requirement of mooring components is to be submitted.
- .9 **The manufacturer's procedure for removing and replacing defective links without heat treatment of the entire chain.**

10.1.3.3 For initial approval, CTOD (Crack Tip Opening Displacement) tests are to be carried out on the particular mooring grade of material. CTOD tests are to be carried out in accordance with a recognized standard such as EN ISO 15653. The CTOD test piece is to be a standard 2 x 1 single edge notched bend piece, test location as shown in Figure 10.1.3.5. **The notch of the CTOD specimen is to be located as close to the surface as practicable.** The minimum **cross section of the** test piece size shall be 50 × 25 mm for chain diameters less than 120 mm and 80 × 40 mm for diameters 120 mm and above. CTOD specimens are to be taken from both the side of the link containing the weld and from the opposite side. Three links are to be selected for testing, a total of six CTOD specimens. The tests are to be taken at minus 20°C and **the lowest CTOD of each set of 3 specimen** shall meet the minimum values indicated below:

**Table 10.1.3.3
Minimum values for CTOD specimens**

Chain Type	R3 [mm]		R3S [mm]		R4 [mm]		R4S & R5 [mm]	
	BM	WM	BM	WM	BM	WM	BM	WM
Stud link	0.20	0.10	0.22	0.11	0.24	0.12	0.26	0.13
Studless link	0.20	0.14	0.22	0.15	0.24	0.16	0.26	0.17

10.1.3.4 Calibration of furnaces shall be verified by measurement and recording of a calibration test piece with dimensions equivalent to the maximum size of link manufactured. **The manufacturer shall submit a procedure for furnace temperature surveys which shall include the following requirements:**

- a) **the temperature uniformity of furnaces is to be surveyed whenever approval of manufacturer is requested and at least annually during normal operating conditions,**
- b) **furnaces are to be checked by conveying a monitoring link instrumented with two thermocouples through the furnaces at representative travel speed,**
- c) **one thermocouple shall be attached on the straight part and one thermocouple shall be imbedded in a drilled hole located at the mid thickness position of the straight part of the calibration block.,**
- d) **The time-temperature curves shall show that the temperatures throughout the cross section and the soaking times are within specified limits as given in the heat treatment procedure.**

10.1.3.5 For R4S and R5 chains and accessories, prior to approval, the manufacturer shall undertake experimental tests or have relevant supporting data to develop the chain and accessory material. The tests and data may include: fatigue tests, hot ductility tests (no internal flaws are to develop whilst bending in the link forming temperature range), welding parameter research, heat treatment study, strain age resistance, temper embrittlement study, stress corrosion cracking (SCC) data and hydrogen embrittlement (HE) study, using slow strain test pieces in hydrated environments. Reports indicating the results of experimental tests are to be submitted.

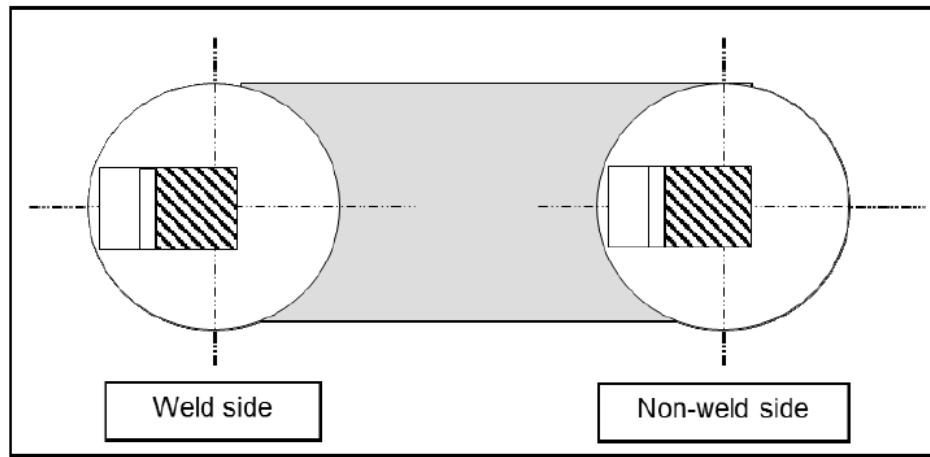


Figure 10.1.3.5. Location of CTOD test specimens for chain

10.1.4 Approval of quality system at chain and accessory manufacturers

10.1.4.1 Chain and accessory manufacturers are to have a documented and effective quality system approved by PRS. The provision of such a quality system is required in addition to, and not in lieu of, the witnessing of tests by a Surveyor as specified in Subchapters 10.2 to 10.5.

10.1.5 Approval of steel mills; rolled bar

10.1.5.1 Bar materials intended for chain and accessories are to be manufactured only by works approved by PRS.

The approval is limited to a nominated supplier of bar material. If a chain manufacturer wishes to use material from a number of suppliers, separate approval tests must be carried out for each supplier.

10.1.5.2 Approval will be given only after successful testing of the completed chain. Each grade is to be individually approved. Approval of a higher grade does not constitute approval of a lower grade. If it is demonstrated to the satisfaction of PRS that the higher and lower grades are produced to the same manufacturing procedure using the same chemistry and heat treatment, consideration will be given to qualification of a lower grade by a higher. The parameters applied during qualification are not to be modified during production. The approval will normally be limited up to the maximum diameter equal to that of the chain diameter tested. The rolling reduction ratio is to be recorded and is to be at least 5:1 for R3, R3S, R4, R4S i R5. The rolling reduction ratio used in production can be higher, but should not be lower than that qualified.

10.1.5.3 The steelmaker is to submit a specification of the chemical composition of the bar material, which must be approved by PRS and by the chain manufacturer. The steelmaker is to confirm by analysis and testing that the specification is met. For grade R4, R4S and R5 chains, the steel shall contain a minimum of 0.20% molybdenum.

10.1.5.4 A heat treatment sensitivity study simulating chain production conditions shall be applied in order to verify mechanical properties and establish limits for temperature and time combinations. All test details and results are to be submitted to PRS.

10.1.5.5 The bar manufacturer is to provide evidence that the manufacturing process produces material that is resistant to strain ageing, temper embrittlement and for R3S, R4, R4S and R5, hydrogen embrittlement. All test details and results are to be submitted to PRS.

10.1.6 Approval of forges and foundries; accessories

10.1.6.1 Forges and foundries intending to supply finished or semi-finished accessories are to apply to PRS for approval. A description of manufacturing processes and process controls is to be submitted to PRS. The scope of approval is to be agreed with PRS. The approval is to be limited to a nominated

supplier of forged or cast material. If an accessory manufacturer wishes to use material from a number of suppliers, a separate approval must be granted for each supplier.

10.1.6.2 Approval will be given only after successful testing of the completed accessory. Approval for a higher grade does not constitute approval for a lower grade. If it is demonstrated to PRS that the higher and lower grades are produced to the same manufacturing procedure using the same steel specification, supplier and heat treatment, consideration will be given to qualification of a lower grade by a higher. The approval will normally be limited to the type of accessory and the mooring grade of material up to the maximum diameter or thickness equal to that of the completed accessory used for qualification unless otherwise agreed by PRS. However for different accessories that have the same geometry, the tests for initial approval are to be carried out on the one having the lowest reduction ratio. Qualification of accessory pins to maximum diameters is also required. Individual accessories of complex geometries will be subject to the requirements of PRS.

10.1.6.3 For forgings – forgings are to have wrought microstructure and the minimum reduction ratio is to be 3 to 1. The forging reduction ratio, used in the qualification tests, from cast ingot/slab to forged component is to be recorded. The forging reduction ratio used in production can be higher, but should not be lower than that qualified. The degree of upsetting during qualification is to be recorded and maintained during production. Heat cycling during forging and reheating is to be monitored by the manufacturer and recorded in the forging documentation. The manufacturer is to have maintenance procedure and schedule for dies and tooling which shall be submitted to PRS.

10.1.6.4 The forge or foundry is to submit a specification of the chemical composition of the forged or cast material, which must be approved by PRS. For Grade R4, R4S and R5 chains, the steel should contain a minimum of 0.20 per cent molybdenum.

10.1.6.5 Forges and foundries are to provide evidence that the manufacturing process produces material that is resistant to strain ageing, temper embrittlement and for R4S and R5 grades, hydrogen embrittlement. A heat treatment sensitivity study simulating accessory production conditions shall be applied in order to verify mechanical properties and establish limits for temperature and time combinations. (Cooling after tempering shall be appropriate to avoid temper embrittlement). All test details and results are to be submitted to PRS.

10.1.6.6 For initial approval CTOD tests are to be carried out on the particular mooring grade of material. Three CTOD tests are to be tested in accordance with a recognized standard such as EN ISO 15653. For rectangular accessories, the CTOD test pieces is to be standard 2x1 single edge notched bend specimen of thickness equal to full thickness of material to be tested. Subsize specimen can be used subject to approval by PRS. For circular geometries the minimum cross section test piece size shall be 50 × 25 mm for accessory diameters less than 120 mm, and 80 × 40 mm for diameters 120 mm and above. The notch of the CTOD specimen is to be located as close to the surface as practicable. The tests are to be taken at minus 20°C and the results submitted for review. The minimum values of each set of three specimens are to at least meet the requirements as indicated in Table 10.1.6.6:

Table 10.1.6.6
Minimum CTOD test values for accessories

Grade of accessory	R3 [mm]	R3S [mm]	R4 [mm]	R4S & R5 [mm]
CTOD	0.20	0.22	0.24	0.26

The geometry of accessories can vary. Figure 10.1.6.6 shows the CTOD location for circular and rectangular cross sections such as those of the D-shackle and accessories fabricated from rectangular sections. The orientation of the specimen shall consider the direction of the grain flow. Figure b) shows two possible sampling positions for CTOD test specimens with notch orientation for rectangular type accessories.

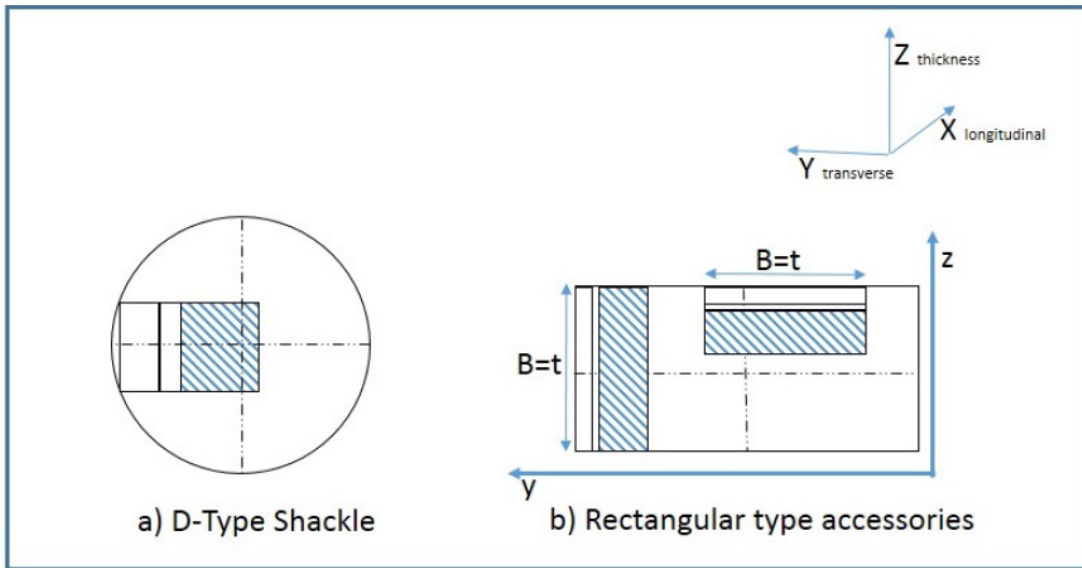


Figure 10.1.6.6. Location of CTOD test specimens: a) Circular type accessory and b) rectangular type accessory, B corresponds to the thickness of material, the grain flow is considered in the longitudinal direction X

10.1.6.7 Calibration of furnaces shall be verified by measurement and recording of a calibration test piece with dimensions equivalent to the maximum size of link manufactured.

Thermocouples are to be placed both on the surface and in a drilled hole located to the mid thickness position of the calibration block.

The furnace dimensions shall be such as to allow the whole furnace charge to be uniformly heated to the necessary temperature. Temperature uniformity surveys of heat treatment furnaces for forged and cast components shall be carried out according to API Spec 6A/ISO 10423 Annex M or ASTM A991. The initial survey shall be carried out with maximum charge (load) in the furnace. Subsequent surveys shall be carried out annually and may be carried out with no furnace charge.

The quench bath maximum temperature and the maximum heat treatment transfer times from furnace to quench are to be established and documented. During production the established quenching parameters are to be followed and records are to be maintained of bath temperatures and transfer times.

10.1.6.8 For R4S and R5 chains, refer to additional requirements in 10.1.3.5.

10.2 Materials

10.2.1 Scope

The requirements of subchapter 10.2 apply to rolled steels, forgings and castings used for the manufacture of offshore mooring chain and accessories.

10.2.2 Rolled steel bars

10.2.2.1 Steel manufacture

10.2.2.1.1 The steels are to be manufactured by basic oxygen, electric furnace or such other process as may be specially approved. All steels are to be killed and fine grain treated. The austenitic grain size for R3, R3S and R4 is to be 6 or finer in accordance with ASTM E112 or equivalent grain size index in accordance to ISO 643. Measurements for circular sections are to be taken at 1/3 radius.

10.2.2.1.2 Steel for bars intended for R4S and R5 chains is to be vacuum degassed.

10.2.2.1.3 For R4S and R5 chains, the following information is to be supplied by the bar manufacturer to the mooring chain manufacturer and the results included in the chain documentation:

- a) each heat is to be examined for non-metallic inclusions. The level of micro inclusions is to be quantified and assessed in accordance to the national/international standards; to be sure that inclusion levels are acceptable for the final product;

- b) a sample from each heat is to be macro etched according to ASTM E381 or equivalent, to be sure there is no injurious segregation or porosity;
- c) ~~Forming~~ hardenability data, according to ASTM A255, or equivalent, is to be supplied with each heat.

10.2.2.2 Chemical composition

For acceptance tests, the chemical composition of ladle samples of each heat is to be determined by the steel maker and is to comply with the approved specification.

10.2.2.3 Mechanical tests

10.2.2.3.1 Bars of the same nominal diameter are to be presented for test in batches of 50 tonnes or fraction thereof from the same heat. Test specimens are to be taken from material which is heat treated in the same manner as intended for the finished chain.

10.2.2.3.2 Each heat of Grade R3S, R4, R4S and R5 steel bars is to be tested for hydrogen embrittlement. In case of continuous casting, test samples representing both the beginning and the end of the charge shall be taken. In case of ingot casting, test samples representing two different ingots shall be taken.

10.2.2.3.2.1 Two (2) tensile test specimens shall be taken from the central region of bar material which have been simulated heat treated. A specimen with a diameter of 20 mm is preferred (consideration will be given to a diameter of 14 mm).

10.2.2.3.2.2 One of the specimens is to be tested within max. 3 hours after machining. For a 14 mm \varnothing specimen, the time limit is 1.5 hours. Where this is not possible, the specimen is to be immediately cooled to -60°C immediately after machining and kept at that temperature for a maximum period of 5 days.

10.2.2.3.2.3 The second specimen is to be tested after baking at 250°C for 4 hours, alternatively 2 hours for 14 mm diameter specimen.

10.2.2.3.2.4 A slow strain rate $< 0.0003 \text{ s}^{-1}$ must be used during the entire test, until fracture occurs (this means approx. 10 minutes for a 20 mm diameter specimen). Tensile strength, elongation and reduction of area are to be reported.

10.2.2.3.2.5 The acceptance requirement for the test is:

$$Z_1/Z_2 \geq 0.85$$

where:

Z_1 – reduction of area without baking,

Z_2 – reduction of area after baking.

If the requirement $Z_1/Z_2 \geq 0.85$ is not met, the bar material may be subjected to a hydrogen degassing treatment after agreement with PRS. New tests shall be performed after degassing.

10.2.2.3.3 For all grades, one tensile and three Charpy V-notch specimens are to be taken from each sample selected. The test specimens are to be taken at approx. one-third radius below the surface, as shown in Fig.10.2.2.3.3 and prepared in accordance with requirements of Chapter 2 of the *Rules for the Classification and Construction of Sea-going Ships, Part IX – Materials and Welding*. The results of all tests are to be in accordance with the appropriate requirements of Table 10.2.2.3.3.

Table 10.2.2.3.3
Mechanical properties of offshore mooring chain and accessories

Grade	Yield stress [MPa] minimum ⁽¹⁾	Tensile strength [N/mm ²] minimum ⁽¹⁾	Elongation [%] minimum	Reduction ⁽³⁾ of area [%] minimum	Charpy V-notch impact tests		
					Test temperature [$^{\circ}\text{C}$] ⁽²⁾	Average energy [J] minimum	Avg. energy flash weld [J] minimum
R3 R3S	410	690	17	50	0	60	50
					-20	40	30
	490	770	15	50	0	65	53
					-20	45	33

R4	580	860	12	50	0	50	36
R4S ⁽⁴⁾	700	960	12	50	-20	56	40
R5 ⁽⁴⁾	760	1000	12	50	-20	58	42

Notes:

1. Aim value of yield to tensile ratio: 0.92 max.
2. At the option of PRS, the impact test of Grades R3 and R3S may be carried out at either 0 °C or minus 20 °C.
3. Reduction of area of cast steel is to be for Grades R3 and R3S: min. 40%, for R4, R4S and R5: min. 35%, cf. item 10.2.4.4.
4. Aim maximum hardness for R4S is HB330 and R5 HB340.

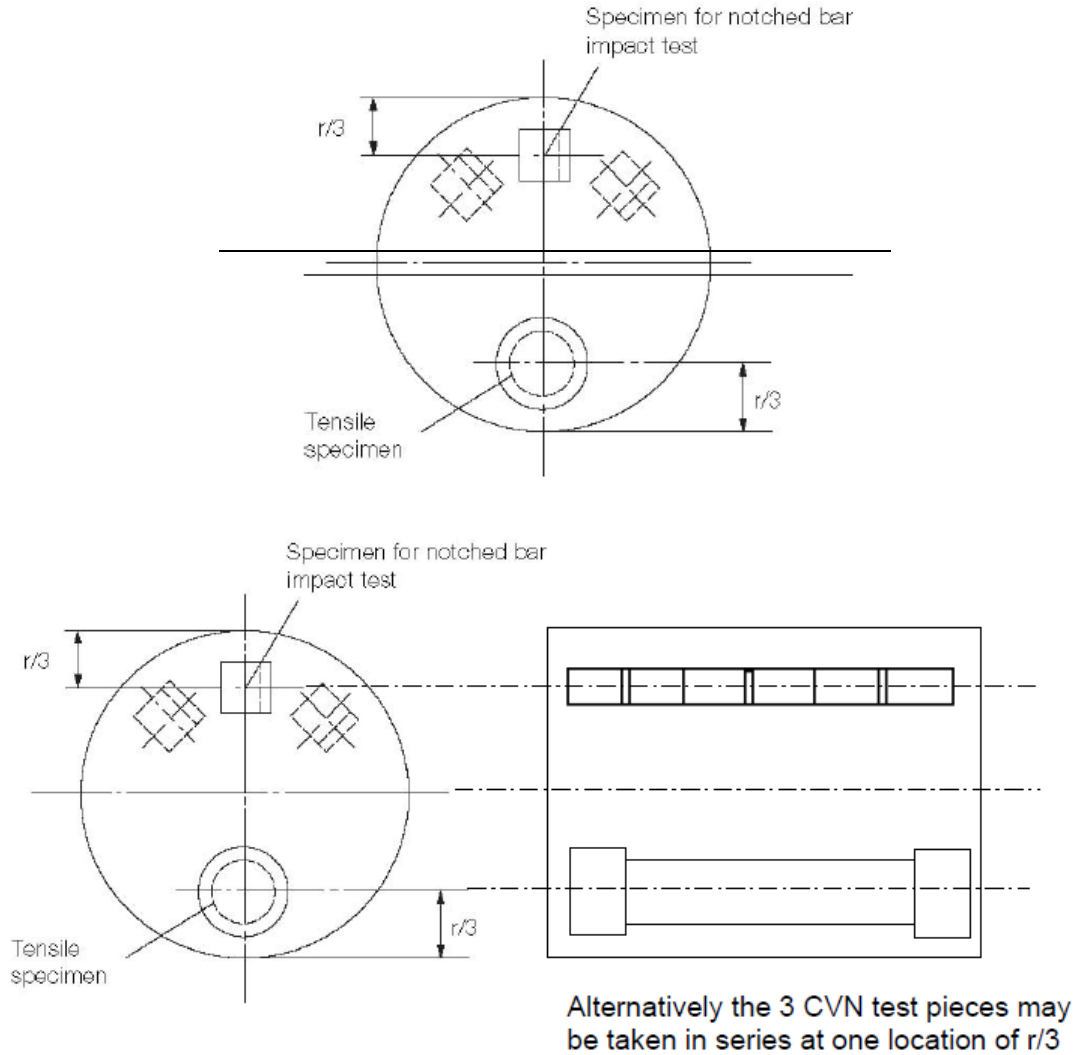


Fig.10.2.2.3.3. Sampling of steel bars, forgings and castings

10.2.2.3.4 Re-test requirements for tensile and Charpy impact tests are detailed in Chapter 2 of *the Rules for the Classification and Construction of Sea-going Ships, Part IX – Materials and Welding*.

10.2.2.3.5 Failure to meet the requirements will result in rejection of the batch represented unless it can be clearly attributable to improper simulated heat treatment.

10.2.2.4 Dimensional tolerances

The diameter and roundness shall be within the tolerances specified in Table 10.2.2.4, unless otherwise agreed.

Table 10.2.2.4
Dimensional tolerance of bar stock

Nominal diameter [mm]	Tolerance on diameter [mm]	Tolerance on roundness
-----------------------	----------------------------	------------------------

		$(d_{\max} - d_{\min})$ [mm]
less than 25	-0 + 1.0	0.6
25 – 35	-0 + 1.2	0.8
36 – 50	-0 + 1.6	1.1
51 – 80	-0 + 2.0	1.5
81 – 100	-0 + 2.6	1.95
101 – 120	-0 + 3.0	2.25
121 – 160	-0 + 4.0	3.00
161 – 222	-0 + 5.0	4.00

10.2.2.5 Non destructive testing and repair

10.2.2.5.1 NDT (Non-destructive testing) shall be performed by a laboratory approved by PRS according to *Publication No. 56/P – Procedural Requirements for Laboratories*. Rejection/acceptance criteria are to be submitted to PRS for approval.

10.2.2.5.2 The manufacturer shall ensure that 100% of the bar material intended for either chain or fittings is to be subjected to ultrasonic examination at an appropriate stage of the manufacture to producers approved by PRS and to acceptance criteria required. The bars shall be free of pipe, cracks and flakes. If the end length of the delivered bars is not subjected to UT then it must be agreed between the bar supplier and the chain manufacturer of what length of the bar is to be removed from the ends. The details are to be documented in the approval of each supplier. Phased array UT procedures may be applied, subject to approval of PRS.

10.2.2.5.3 100% of the bar material is to be examined by magnetic particle (MT) or eddy current (ET) or magnetic leakage flux testing (MLFT) methods. The bars shall be free of injurious surface imperfections such as seams, laps and rolled-in mill scale. Provided that their depth is not greater than 1% of the bar diameter, longitudinal discontinuities may be removed by grinding and blending to a smooth contour.

All bars supplied in a machined (peeled) condition shall be 100% visually inspected. PRS may also require: 10% inspected with magnetic particle testing (MT) or eddy current testing (ET) or Magnetic Leakage Flux Testing (MLFT), for longitudinal imperfections. The maximum depth of peeling is to be agreed and documented in the approval of each supplier.

10.2.2.5.4 The frequency of NDT may be reduced at the discretion of PRS provided it is verified by statistical means that the required quality is consistently achieved.

10.2.2.5.5 Weld repair of bar is not permitted.

10.2.2.6 Marking

Each bar is to be stamped with the steel grade designation and the charge number (or a code indicating the charge number) on one of the end surfaces. Other marking methods may be accepted subject to agreement.

10.2.3 Forged steel

10.2.3.1 Forged steel manufacture

10.2.3.1.1 Forged steels used for the manufacture of accessories shall be in compliance with approved specifications and the submitted test reports approved by PRS Surveyor. Steel is to be manufactured by basic oxygen, electric furnace or such other process as may be specially approved. All steel is to be killed and fine grain treated. The austenitic grain size for R3, R3S and R4 is to be 6 or finer in accordance with ASTM E112, or equivalent grain size index in accordance to ISO 643. Measurements for circular sections are to be taken at 1/3 radius. Measurements for non-circular sections are to be taken at 1/4 t.

10.2.3.1.2 Steel for forgings intended for R4S and R5 chains is to be vacuum degassed. The austenitic grain size is to be 6 or finer in accordance with ASTM E112, or equivalent grain size index in accordance to ISO 643. Measurements for circular sections are to be taken at 1/3 radius. Measurements for non-circular sections are to be taken at ¼ t.

10.2.3.1.3 For steel intended for R4S and R5 accessories, the following information is to be supplied by the steel manufacturer to the mooring accessory manufacturer and the results included in the accessory documentation:

- a) each heat is to be examined for non-metallic inclusions. The level of micro inclusions is to be quantified and assessed in accordance with the national/international standards to be sure that inclusion levels are acceptable for the final product;
- b) a sample from each heat is to be macroetched according to ASTM E381 or equivalent, to be sure there is no injurious segregation or porosity;
- c) ~~Joining~~ hardenability data, according to ASTM A255, or equivalent, is to be supplied with each heat.

10.2.3.2 Chemical composition

See 10.2.2.2.

10.2.3.3 Heat treatment

Finished forgings are to be properly heat treated in compliance with specifications submitted and approved.

10.2.3.4 Mechanical properties

The forgings must comply with the mechanical properties given in Table 10.2.2.3.3, when properly heat treated.

10.2.3.5 Mechanical tests

10.2.3.5.1 For test sampling, forgings of similar dimensions (diameters do not differ by more than 25mm) originating from the same heat treatment charge and the same heat of steel are to be combined into one test unit. From each test unit one tensile and three impact test specimens are to be taken and tested in accordance with the requirements of Chapter 2 of the *Rules for the Classification and Construction of Sea – going Ships, Part IX – Materials and Welding*. For the location of the test specimens see Fig.10.2.2.3.3.

10.2.3.5.2 Each heat of Grade R3S, R4, R4S and R5 is to be tested for hydrogen embrittlement. In case of continuous casting, test samples representing both the beginning and the end of the charge shall be taken. In case of ingot casting, test samples representing two different ingots shall be taken.

10.2.3.5.2.1 Two (2) tensile test specimens shall be taken from the central region of forged material which has been subjected to the heat treatment cycle intended to be used in production. A specimen with a diameter of 20 mm is preferred (consideration will be given to a diameter of 14 mm).

10.2.3.5.2.2 One of the specimens is to be tested within a maximum of 3 hours after machining (for a 14 mm diameter specimen, the time limit is 1½ hours). Where this is not possible, the specimen is to be immediately cooled to -60° C after machining and kept at that temperature for a maximum period of 5 days.

10.2.3.5.2.3 The second specimen is to be tested after baking at 250° C for 4 hours, alternatively 2 hours for 14 mm diameter specimen.

10.2.3.5.2.4 A slow strain rate < 0,0003 s⁻¹ must be used during the entire test, until fracture occurs (This is approximately 10 minutes for the 20 mm diameter specimen). Tensile strength, elongation and reduction of area are to be reported.

10.2.3.5.2.5 The acceptance requirement for the test is:

$$Z1/Z2 \geq 0.85$$

where:

Z1 = Reduction of area without baking

Z2 = Reduction of area after baking

If the requirement $Z1/Z2 \geq 0.85$ is not achieved, the bar material may be subjected to a hydrogen degassing treatment after agreement with PRS. New tests shall be performed after degassing.

10.2.3.6 Non-destructive testing and repair

10.2.3.6.1 Non-destructive testing (NDT) shall be performed by a laboratory approved by PRS according to *Publication No. 56/P – Procedural Requirements for Laboratories*. Rejection/acceptance criteria are to be submitted to PRS for approval.

10.2.3.6.2 The forgings are to be subjected to 100% ultrasonic examination at an appropriate stage of manufacture and in compliance with the standard submitted and approved.

10.2.3.6.3 Defects on non-machined surfaces may be removed by grinding to a depth of 5% of the nominal diameter. Grinding is not permitted on machined surfaces, except for slight inspection grinding on plane surfaces to a maximum depth of 0.8 mm in order to investigate spurious indications. Welding repairs are not permitted.

10.2.3.7 Marking

Marking is to be similar to that specified in 10.2.2.6.

10.2.4 Cast steel

10.2.4.1 Cast steel manufacture

10.2.4.1.1 Cast steel used for the manufacture of accessories shall be in compliance with approved specifications and the submitted test reports approved by PRS surveyor. Steel is to be manufactured by basic oxygen, electric furnace or such other process as may be specially approved. All steel is to be killed and fine grain treated. The austenitic grain size for R3, R3S and R4 is to be 6 or finer in accordance with ASTM E112 or equivalent grain size index in accordance to ISO 643. Measurements for circular sections are to be taken at 1/3 radius. Measurements for non-circular sections are to be taken at ¼ t.

10.2.4.1.2 Steel for castings intended for R4S and R5 accessories is to be vacuum degassed. The austenitic grain size is to be 6 or finer in accordance with ASTM E112. or equivalent grain size index in accordance to ISO 643. Measurements for circular sections are to be taken at 1/3 radius. Measurements for non-circular sections are to be taken at ¼ t.

10.2.4.1.3 For steel intended for R4S and R5 accessories, the following information is to be obtained and the results included in the accessory documentation:

- a) each heat is to be examined for non-metallic inclusions. The level of micro inclusions is to be quantified and assessed in accordance with the national/international standards to be sure that inclusion levels are acceptable for the final product;
- b) a sample from each heat is to be macro etched according to ASTM E381 or equivalent, to be sure there is no injurious segregation or porosity;
- c) Jominy hardenability data, according to ASTM A255, or equivalent, is to be supplied with each heat.

10.2.4.2 Chemical composition

See 10.2.2.2.

10.2.4.3 Heat treatment

All castings are to be properly heat treated in compliance with specifications submitted and approved.

10.2.4.4 Mechanical properties

The castings must comply with the mechanical properties given in Table 10.2.2.3.3. The requirement for reduction of area is, however, reduced to 40% for grades R3 and R3S and 35% for grades R4, R4S and R5.

10.2.4.5 Mechanical tests

For test sampling, castings of similar dimensions originating from the same heat treatment charge and the same heat of steel are to be combined into one test unit. From each test unit one tensile and three impact test specimens are to be taken and tested. For the location of the test specimens see Fig.10.2.2.3.3.

10.2.4.6 Non-destructive testing and repair

10.2.4.6.1 Non-destructive testing (NDT) shall be performed by a laboratory approved by PRS according to *Publication No. 56/P – Procedural Requirements for Laboratories*. Rejection/acceptance criteria are to be submitted to PRS for approval.

10.2.4.6.2 The castings are to be subjected to 100% ultrasonic examination in compliance with the standard submitted and approved.

10.2.4.6.3 Defects on non-machined surfaces may be removed by grinding to a depth of 5% of the nominal diameter. Grinding is not permitted on machined surfaces, except for slight inspection grinding on plane surfaces to a maximum depth of 0.8 mm in order to investigate spurious indications.

10.2.4.6.4 Where the repair entails removal of more than 5% of the diameter or thickness, the defective area shall be repaired by welding. The excavations shall be suitably shaped to allow good access for welding. The resulting grooves shall be subsequently ground smooth and complete elimination of the defective material shall be verified by NDT.

10.2.4.6.5 Weld repairs are classified as major or minor. A weld repair is considered major when the depth of the groove prepared for welding exceeds 25% of the diameter/thickness or 25 mm, whichever is smaller. All other weld repairs are considered minor.

10.2.4.6.6 Major weld repairs require approval before the repair is commenced. Proposals for major repairs shall be accompanied by sketches or photographs showing the extent and positions of the repairs. A grain refining heat treatment shall be given to the whole casting prior to major repairs. A post weld heat treatment or repeat of original heat treatment of castings shall be carried out.

10.2.4.6.7 Minor and major weld repairs must be recorded on sketches or photographs showing the extent and positions of the repairs.

10.2.4.6.8 All weld repairs shall be done by qualified welders using qualified procedures. Welders shall be qualified according to ISO 9606, ASME IX, ASTM A488 or equivalent. Procedures shall be qualified according to ISO 15614, ASME IX, ASTM A488 or equivalent with the following additional requirements: Charpy V notch impact tests with notch locations in weld metal, fusion line and heat affected zone + 2 mm and + 5 mm from fusion line, respectively. Test results shall meet the requirements specified for the parent metal.

10.2.4.6.9 Marking

See 10.2.2.6.

10.2.5 Materials for studs

The studs are to be made of steel corresponding to that of the chain or in compliance with specifications submitted and approved. In general, the carbon content should not exceed 0.25 per cent if the studs are to be welded in place.

10.2.5.1 Studs intended for stud link chain cable are to be made of steel corresponding to that of the chain in compliance with specifications submitted and approved.

10.3 Design and chain manufacture

10.3.1 Design

10.3.1.1 Drawings accompanied by design calculations, giving detailed design of chain and accessories made by, or supplied through, the chain manufacturer are to be submitted for approval. Typical designs are given in ISO 1704. For studless chain the shape and proportions are to comply with the requirements of this Chapter 10. Other studless proportions are to be specially approved. It should be considered that new or non-standard designs of chain, shackles or fittings, may require a fatigue analysis and possible performance, fatigue or corrosion fatigue testing.

10.3.1.2 In addition, for stud link chain, drawings showing the detailed design of the stud shall be submitted for information. The stud shall give an impression in the chain link which is sufficiently deep to secure the position of the stud, but the combined effect of shape and depth of the impression shall not cause any harmful notch effect or stress concentration in the chain link.

10.3.1.3 Machining of Kenter shackles shall result in fillet radius min. 3% of nominal diameter.

10.3.2 Manufacturing process

Offshore mooring chains shall be manufactured in continuous lengths by flash butt welding and are to be heat treated in a continuous furnace; batch heat treatment is not permitted **except in special circumstances where short lengths of chain are delivered, such as chafing chain. See 10.6 Annex to Chapter 10.**

The use of joining shackles to replace defective links is subject to the written approval of the end purchaser in terms of the number and type permitted. The use of connecting common links is restricted to 3 links in each 100 m of chain.

10.3.3 Manufacturing Process Records

Records of bar heating, flash welding and heat treatment shall be made available for inspection by the PRS surveyor.

10.3.3.1 Bar heating

Bars for links shall be heated by electric resistance, induction or in a furnace.

For electric resistance heating **or induction heating**, the heating phase shall be controlled by an optical heat sensor.

The controller shall be checked at least once every 8 hours and records made.

For furnace heating, the heat shall be controlled and the temperature continuously recorded using thermocouples in close proximity to the bars. The controls shall be checked at least once every 8 hours and records made.

10.3.3.2 Flash welding

The following welding parameters shall be controlled during welding of each link:

- .1** platen motion;
- .2** current as a function of time;
- .3** hydraulic pressure.

The controls shall be checked at least every 4 hours and records made.

10.3.3.3 Heat treatment

Chain shall be austenitized, above the upper transformation temperature, at a combination of temperature and time within the limits established.

When applicable, chain shall be tempered at a combination of temperature and time within the limits established.

Temperature and time or temperature and chain speed shall be controlled and continuously recorded.

Grain determination shall be made for the final product. The austenitic grain size for R3, R3S, R4, R4S and R5 is to be 6 or finer in accordance with ASTM E112 or equivalent grain size index in accordance to ISO 643. Measurements for circular sections are to be taken at surface, 1/3 radius and centre for the base material, HAZ and weld.

10.3.4 Mechanical properties

The mechanical properties of finished chain and accessories are to be in accordance with Table 10.2.2.3.3. For the location of test specimens see Figs. 10.2.2.3.3 and 10.3.4.

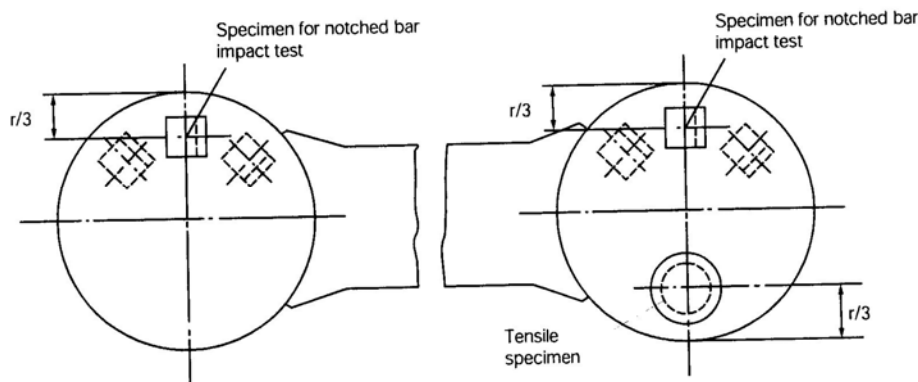


Fig. 10.3.4. Sampling of chain links

10.3.5 Proof and breaking test loads

Chains and accessories are to withstand the proof and break test loads given in Table 10.3.5.

10.3.6 Freedom from defects

All chains are to have a workmanlike finish consistent with the method of manufacture and be free from defects. Each link is to be examined in accordance with subchapter 10.4.5 using approved procedures.

Table 10.3.5
Formulas for proof and break test loads, weight and length over 5 links

Test Load [kN]	Grade R3 Stud Link	Grade R3S Stud Link	Grade R4 Stud Link	Grade R4S Stud Link	Grade R5 Stud Link
1	2	3	4	5	6
Proof	$0.0148d^2$ ($44 - 0.08d$)	$0.0180d^2$ ($44 - 0.08d$)	$0.0216d^2$ ($44 - 0.08d$)	$0.0240d^2$ ($44 - 0.08d$)	$0.0251d^2$ ($44 - 0.08d$)
Break	$0.0223d^2$ ($44 - 0.08d$)	$0.0249d^2$ ($44 - 0.08d$)	$0.0274d^2$ ($44 - 0.08d$)	$0.0304d^2$ ($44 - 0.08d$)	$0.0320d^2$ ($44 - 0.08d$)
Test Load [kN]	Grade R3 Studless	Grade R3S Studless	Grade R4 Studless	Grade R4S Studless	Grade R5 Studless
Proof	$0.0148d^2$ ($44 - 0.08d$)	$0.0174d^2$ ($44 - 0.08d$)	$0.0192d^2$ ($44 - 0.08d$)	$0.0213d^2$ ($44 - 0.08d$)	$0.0223d^2$ ($44 - 0.08d$)
Break	$0.0223d^2$ ($44 - 0.08d$)	$0.0249d^2$ ($44 - 0.08d$)	$0.0274d^2$ ($44 - 0.08d$)	$0.0304d^2$ ($44 - 0.08d$)	$0.0320d^2$ ($44 - 0.08d$)
Chain Weight [kg/m]	Stud link = $0.0219d^2$				
Chain Weight [kg/m]	Studless chain Weight calculations for each design are to be submitted				
Pitch Length	Five Link Measure				

Minimum	$22d$
Minimum	$22.55d$

10.3.7 Dimensions and dimensional tolerances

10.3.7.1 The shape and proportion of links and accessories must conform to ISO 1704:1991 standard or the designs specially approved.

10.3.7.2 The following tolerances are applicable to links:

.1 negative tolerance on the nominal diameter measured at the crown:

- up to 40 mm nominal diameter: – 1 mm,
- over 40 up to 84 mm nominal diameter: – 2 mm,
- over 84 up to 122 mm nominal diameter: – 3 mm,
- over 122 mm nominal diameter: – 4 mm,
- over 152 up to 184 mm nominal diameter: – 6 mm,
- over 184 up to 210 mm nominal diameter: – 7.5 mm.

The cross sectional area at the crown must have no negative tolerance. For diameters of 20 mm or greater, the plus tolerance may be up to 5 % of the nominal diameter. For diameters less than 20 mm the plus tolerance is to be agreed with PRS at the time of approval.

The cross sectional area at the crown is to be calculated using the average of the diameters with negative tolerance and plus tolerance, measurements are to be taken from at least 2 locations approximately 90 degrees apart.

.2 diameter measured at locations other than the crown:

The diameter is to have no negative tolerance. The plus tolerance may be up to 5% of the nominal diameter – except at the butt weld where it is to be in accordance to manufacturer’s specification, which is to be agreed with PRS. For diameters less than 20 mm, the plus tolerance is to be agreed with PRS at the time of approval.

.3 the allowable manufacturing tolerance on a length of five links is +2.5%, but may not be negative;

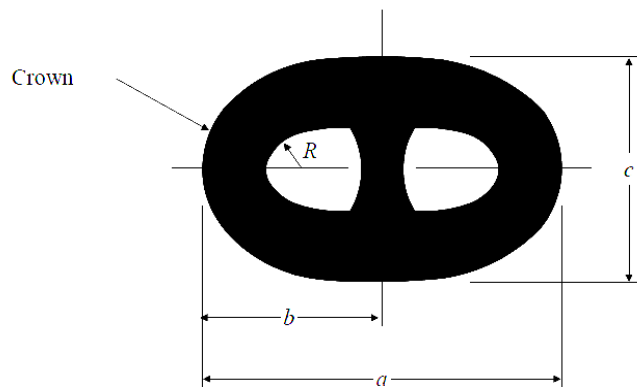
.4 all other dimensions are subject to a manufacturing tolerance of +/-2.5%, provided always that all parts fit together properly.

.5 the tolerances for stud links and studless common links are to be measured in accordance with Fig. 10.3.7.2.6;

.6 for stud link chains studs shall be located in the links centrally and at right angles to the sides of the link. The following tolerances in Fig. 10.3.7.2.6 are acceptable provided that the stud fits snugly and its ends lie flush against the inside of the link:

a) Stud link

The internal link radii (R) and external radii should be uniform.



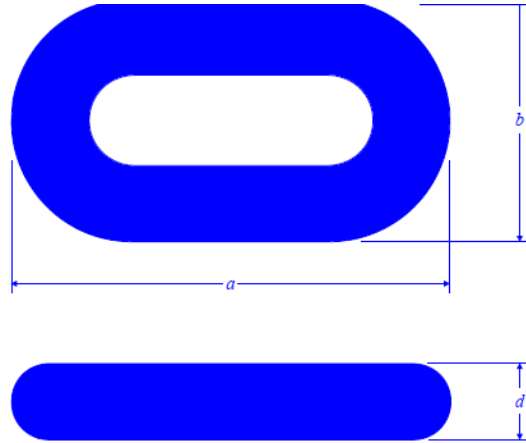
Designation ¹⁾	Description	Nominal dimension of the link	Minus tolerance	Plus tolerance
a	Link length	$6d$	$0.15d$	$0.15d$
b	Link half length	$a*2$	$0.1d$	$0.1d$

c	Link width	$3.6d$	$0.09d$	$0.09d$
e	Stud angular misalignment	0 degrees	4 degrees	4 degrees
R	Inner radius	$0.65d$	0	–

Notes: ⁽¹⁾ Dimension designation is shown in above figure.
 d = nominal diameter of chain, a^* = actual link length

b) Studless

The internal link radii (R) and external radii should be uniform.



Designation ¹⁾	Description	Nominal dimension of the link	Minus tolerance	Plus tolerance
a	Link Length	$6d$	$0.15d$	$0.15d$
b	Link Width	$3.35d$	$0.09d$	$0.09d$
R	Inner Radius	$0.60d$	0	–

Notes: ¹⁾ Dimension designation is shown in above figure.
²⁾ Other dimension ratios are subject to special approval.
 d = nominal diameter of chain

Figure 10.3.7.2.6

a) Stud link and b)studless common link, proportions dimensions and tolerances

10.3.7.3 The following tolerances are applicable to accessories:

- nominal diameter: +5 %, –0 %,
- other dimensions: ±2.5 %.

10.3.8 Welding of studs

A welded stud may be accepted for grade R3 and R3S chains. Welding of studs in grades R4 , R4S and R5 chain is not permitted unless specially approved.

10.3.8.1 Where studs are welded into the links this is to be completed before the chain is heat treated.

10.3.8.2 The stud ends must be a good fit inside the link and the weld is to be confined to the stud end opposite to the flash butt weld. The full periphery of the stud end is to be welded unless otherwise approved.

10.3.8.3 Welding of studs both ends is not permitted unless specially approved.

10.3.8.4 The welds are to be made by qualified welders using an approved procedure and approved low-hydrogen consumables.

10.3.8.5 The size of the fillet weld shall as a minimum be as per American Petroleum Institute (API) Specification 2F.

10.3.8.6 The welds are to be of good quality and free from defects such as cracks, lack of fusion, gross porosity and undercuts exceeding 1 mm.

10.3.8.7 All stud welds shall be visually examined. At least 10 per cent of all stud welds within each length of chain shall be examined by dye penetrant or magnetic particles after proof testing. If cracks or lack of fusion are found, all stud welds in that length are to be examined.

10.3.9 Connecting common links (splice links)

10.3.9.1 Single links to substitute for test links or defective links without the necessity for re-heat treatment of the whole length are to be made in accordance with an approved procedure. Separate approvals are required for each grade of chain and the tests are to be made on the maximum size of chain for which approval is sought.

10.3.9.2 Manufacture and heat treatment of connecting common link is not to affect the properties of the adjoining links. The temperature reached by these links is nowhere to exceed 250°C.

10.3.9.3 Each link is to be subjected to the appropriate proof load and non-destructive testing as detailed in Table 10.3.5 and subchapter 10.4.5. A second link shall be made identical to the connecting common link; the link shall be tested and inspected per subchapter 10.4.4 and 10.4.5.

10.3.9.4 Each connecting common link is to be marked either: on the stud for stud link chain or, on the outer straight length on the side opposite the flash butt weld for studless chain. This marking is to be in accordance with subchapter 10.4.7 plus a unique number for the link. The adjoining links are also to be marked on the studs or straight lengths as above.

10.4 Testing and inspection of finished chain

10.4.1 General

10.4.1.1 This subchapter applies to but is not limited to finished chain cable such as common stud and studless links, end links, enlarged end links and connecting common links (splice links).

10.4.1.2 All chain is to be subjected to proof load tests, sample break load tests and sample mechanical tests after final heat treatment in the presence of a PRS surveyor. Where the manufacturer has a procedure to record proof loads and the PRS surveyor is satisfied with the adequacy of the recording system, he need not witness all proof load tests. The PRS surveyor is to satisfy himself that the testing machines are calibrated and maintained in a satisfactory condition. Prior to ~~testing and inspection~~, the chain is to be free from scale, paint or other coating **and is to have a suitably prepared surface as per the applied non-destructive testing standard**. The chain shall be sand or shot blasted to meet this requirement.

10.4.2 Proof and break load tests

10.4.2.1 The entire length of chain shall withstand the proof load specified in Table 10.3.5 without fracture and shall not crack in the flash weld. The load applied shall not exceed the proof load by more than 10% when stretching the chain. Where plastic straining is used to set studs, the applied load is not to be greater than that qualified in approval tests.

10.4.2.2 A break-test specimen consisting of at least 3 links is to be either taken from the chain or produced at the same time and in the same manner as the chain. The test frequency is to be based on tests at sampling intervals according to Table 10.4.2.4 provided that every cast is represented. Each specimen shall be capable of withstanding the break load specified without fracture and shall not crack in the flash weld. It shall be considered acceptable if the specimen is loaded to the specified value and maintained at that load for 30 seconds.

10.4.2.3 For chain diameters over 100 mm, alternative break-test proposals to the above break test will be considered whereby a one link specimen is used. Alternatives shall be subject to PRS approval, every heat is to be represented, the test frequency is to be in accordance with Table 10.4.2.4, and it is to be demonstrated and proven that the alternative test represents an equivalent load application to the three link test.

10.4.2.4 If the loading capacity of the testing machine is insufficient, an alternative load testing machine is to be used that does have sufficient capacity (eg. Two loading machines in parallel) provided the testing and calibration procedure are agreed with PRS.

Table 10.4.2.4
Frequency of break and mechanical tests

Nominal chain diameter [mm]	Maximum sampling interval [m]
min – 48	91
49 – 60	110
61 – 73	131
74 – 85	152
86 – 98	175
99 – 111	198
112 – 124	222
125 – 137	250
138 – 149	274
150 – 162	297
163 – 175	322
176 – 186	346
187 – 198	370
199-210	395
211-222	420

10.4.3 Dimensions and dimensional tolerances

10.4.3.1 After proof load testing measurements are to be taken on at least 5 per cent of the links in accordance with subchapter 10.3.7.

10.4.3.2 The entire chain is to be checked for the length, five links at a time. By the five link check the first five links shall be measured. From the next set of five links, at least two links from the previous five links set shall be included. This procedure is to be followed for the entire chain length. The measurements are to be taken preferably while the chain is loaded to 5 – 10 % of the minimum proof load. The tolerances for the 5 link measurements are indicated in Table 10.3.5, any deviations from the 5 link tolerance are to be agreed by the client and PRS. The links held in the end blocks may be excluded from this measurement.

10.4.3.3 Chain dimensions are to be recorded and the information retained on file.

10.4.4 Mechanical tests

10.4.4.1 Links of samples detached from finished, heat treated chain shall be sectioned for determination of mechanical properties. A test unit shall consist of one tensile and nine impact specimens. The tensile specimen shall be taken in the side opposite the flash weld. Three impact specimens shall be taken across the flash weld with the notch centered in the middle. Three impact specimens shall be taken across the unwelded side and three impact specimens shall be taken from the bend region.

10.4.4.2 The test frequency is to be based on tests at sampling intervals according to Table 10.4.2.4, provided that every cast is represented. Mechanical properties shall be as specified in Table 10.2.2.3.3.

10.4.4.3 The frequency of impact testing in the bend may be reduced at the discretion of PRS provided it is verified by statistical means that the required toughness is consistently achieved.

10.4.4.4 Hardness tests are to be carried out on finished chain. The frequency and locations are to be agreed with PRS. The recorded values are for information only and used as an additional check to verify that the heat treatment process has been stable during the chain production.

10.4.5 Non-destructive testing after proof load testing

All surfaces of every link shall be visually examined. Burrs, irregularities and rough edges shall be contour ground. Links shall be free from mill defects, surface cracks, dents and cuts, especially in the vicinity where gripped by clamping dies during flash welding. Studs shall be securely fastened. Chain is to be positioned in order to have good access to all surfaces. In order to allow optimal access to the surface area it is recommended that chain be hung in the vertical position, however access to inspect the interlink area may only be possible with the chain in the horizontal position.

10.4.5.1 Non-destructive testing is to be performed in accordance with a recognized standard and the procedures, together with acceptance/rejection criteria, are to be submitted to PRS for review. NDT is to be performed by a laboratory approved by PRS according to *Publication No.56/P – Procedural Requirements for Laboratories*.

Magnetic particles shall be employed to examine the flash welded area including the area gripped by the clamping dies. Procedures are to be submitted to PRS for approval. Procedures and equipment in accordance with those approved shall be used. Frequency of examination shall be every link. Additionally, 10% of links are to be tested on all accessible surfaces.

Link surface at the flash weld shall be free from cracks, lack of fusion and gross porosity. Testing shall be performed in accordance with ASTM E709 or another recognized standard (e.g. ISO 9934) using wet continuous fluorescent magnetization technique. Non fluorescent techniques can be accepted in special cases where the standard inspection procedures are impractical.

Links shall be free from:

- relevant linear indications exceeding 1.6 mm in transverse direction
- relevant linear indications exceeding 3.2 mm in longitudinal direction
- relevant non-linear indications exceeding 4.8 mm.

Ultrasonics shall be employed to examine the flash weld fusion. Procedures are to be submitted to PRS for approval. Procedures and equipment in accordance with those approved shall be used. On-site calibration standards for chain configurations shall be approved.

Frequency of examination shall be every link.

The flash weld shall be free from defects causing ultrasonic back reflections equal to or greater than the calibration standard. The flash butt welds shall be ultrasonic tested (UT) in accordance with ASTM E587 or another recognized standard using single probe, angle-beam shear waves in the range from 45 to 70°. Single probe technique has limitations as far as testing of the central region is concerned and the flash weld imperfections such as flat spots may have poor reflectivity. Where it is deemed necessary, detectability of imperfections may need to be carried out by using a tandem technique, TOFD or phased array.

Stud welds, if used, shall be visually inspected. The toes of the fillets shall have a smooth transition to the link with no undercuts exceeding 1.0 mm. Additionally, at least 10% of the stud welds distributed through the length shall be dye penetrant tested according to ASTM E1417 or magnetic particle tested according to ASTM E1444 or equivalent. Cracks, lack of fusion or gross porosity are not acceptable. If defects are found, testing shall be extended to all stud welds in that length.

10.4.6 Retest, rejection and repair criteria

10.4.6.1 If the length over 5 links is short, the chain may be stretched by loading above the proof test load specified provided that the applied load is not greater than that approved and that only random lengths of the chain need stretching.

If the length exceeds the specified tolerance, the overlength chain links shall be cut out and requirements of 10.4.6.2 shall apply.

10.4.6.2 If single links are found to be defective or to not meet other applicable requirements, defective links may be cut out and a connecting common link inserted in their place. The individual heat treatment and inspection procedure of connecting common links is subject to PRS approval. Other methods for repair is subject to the written approval of PRS and the end purchaser. Weld repair of chain is not permitted.

10.4.6.3 If a crack, cut or defect in the flash weld is found by visual or magnetic particle examination, it shall be ground down no more than 5 % of the link diameter in depth and streamlined to provide no sharp contours. The final dimensions must still conform to the agreed standard.

10.4.6.4 If indications of interior flash weld defects in reference to the accepted calibration standards are detected during ultrasonic examination, requirements of 10.4.6.2 shall apply.

10.4.6.5 If link diameter, length, width and stud alignment do not conform to the required dimensions, these shall be compared to the dimensions of 40 more links; 20 on each side of the affected link. If a single particular dimension fails to meet the required dimensional tolerance in more than 2 of the sample links, all links shall be examined. Requirements of subchapter 10.4.6.2 shall apply.

10.4.6.6 If a break load test fails, a thorough examination with the PRS surveyor informed in a timely manner is to be carried out to identify the cause of failure. Two additional break test specimens representing the same sampling length of chain are to be subjected to the break load test. Based upon satisfactory results of the additional tests and the results of the failure investigation, it will be decided what lengths of chain can be accepted. Failure of either or both additional tests will result in rejection of the sampling length of chain represented and requirements of 10.4.6.2 shall apply.

10.4.6.7 If a link fails during proof load testing, a thorough examination witnessed by the PRS surveyor informed in a timely manner is to be carried out to identify the probable cause of failure of the proof test. In the event that two or more links in the proof loaded length fail, that **section of proof loaded length** is to be rejected. The above failure investigation is to be carried out especially with regard to the presence in other lengths of factors or conditions thought to be causal to failure.

10.4.6.8 In addition to the above failure investigation, a break test specimen is to be taken from each side of the one failed link, and subjected to the breaking test. **Where multiple chains are produced simultaneously it is recognised that the preceding flash butt welded link and subsequent flash butt welded link will be on an alternative chain length or the other end of the chain length. In such cases PRS may require that two additional break tests are to be taken from the lengths of chain that include the preceding and subsequent welded links.** Based upon satisfactory results of both break tests and the results of the failure investigation, it will be decided what length of chain can be considered for acceptance. Failure of either or both breaking tests will result in rejection of the same proof loaded length.

Replacement of defective links is to be in accordance with 10.4.6.2

If the investigation identifies defects in the flash butt weld or a lower strength flash weld “a glue-weld” is found, additional NDT such as phased array UT is to be carried out to identify if other links are affected. A full assessment of the flash butt welding machine is to be carried out, together with assessment of the condition of the bar ends prior to welding.

10.4.6.9 Re-test requirements for tensile tests are to be in accordance with requirements of Chapter 2 of *Rules for the Classification and Construction of Sea-going Ships, Part IX – Materials and Welding*. Failure to meet the specified requirements of either or both additional tests will result in rejection of the sampling length of chain represented and requirements of 10.4.6.2 shall apply.

10.4.6.10 Re-test requirements for Charpy impact tests are to be in accordance with requirements of Chapter 2 of *Rules for the Classification and Construction of Sea – going Ships, Part IX – Materials and Welding*. Failure to meet the requirements will result in rejection of the sampling length represented and requirements of 10.4.6.2 shall apply.

10.4.7 Marking

10.4.7.1 The chain shall be marked at the following places:

- at each end,
- at intervals not exceeding 100 m,
- on connecting common links,
- on links next to shackles or connecting common links.

All marked links shall be stated on the certificate, and the marking shall make it possible to recognize leading and tail end of the chain. In addition to the above required marking, the first and last common link of each individual charge used in the continuous length shall be adequately and traceable marked.

The marking shall be permanent and legible throughout the expected lifetime of the chain.

10.4.7.2 The chain shall be marked on the studs as follows:

- chain grade,
- certificate No.,
- PRS stamp.

The certificate number may be exchanged against an abbreviation or equivalent. If so, this shall be stated in the certificate.

The chain certificate shall contain information on number and location of connecting common links. The certificate number and replacement link number may be exchanged against an abbreviation or equivalent. Other methods for repair are subject to the written approval of PRS and the end purchaser.

10.4.7.3 If indications of interior flash weld defects with reference to the accepted calibration standards are detected during ultrasonic examination, 10.4.6.2 shall apply.

10.4.8 Marking

10.4.8.1 The chain shall be marked at the following places:

- At each end,
- at intervals not exceeding 100 m,
- on connecting common links,
- on links next to shackles or connecting common links.

10.4.8.2 All marked links shall be stated on the certificate, and the marking shall make it possible to recognize leading and tail end of the chain. In addition to the above required marking, the first and last common link of each individual charge used in the continuous length shall be traceable and adequately marked.

The marking shall be permanent and legible throughout the expected lifetime of the chain.

10.4.8.3 The chain shall be marked on the studs as follows:

- chain grade,
- certificate No.,
- PRS stamp.

10.4.8.4 The certificate number may be exchanged against an abbreviation or equivalent. If so, this shall be stated in the certificate.

10.4.8.5 The chain certificate shall contain information on the number and location of connecting common links. The certificate number and replacement link number may be exchanged against an abbreviation or equivalent. If so, this shall be stated in the certificate.

10.5 Testing and inspection of accessories

10.5.1 General

10.5.1.1 This subchapter applies to but is not limited to mooring equipment accessories such as detachable connection links (shackles), detachable connecting plates (triplates), end shackles, swivels and swivel shackles **and subsea connectors**.

10.5.1.2 All accessories are to be subjected to proof load tests, sample break load tests and sample mechanical tests after final heat treatment in the presence of a PRS surveyor. Where the manufacturer has a procedure to record proof loads and the PRS surveyor is satisfied with the adequacy of the recording system, he need not witness all proof load tests. The PRS surveyor is to satisfy himself that the testing machines are calibrated and maintained in a satisfactory condition.

Prior to testing and inspection, the chain accessories are to be free from scale, paint or other coating.

10.5.1.3 For accessory production a Manufacturing Procedure Specification (MPS) is to be submitted to PRS that details all critical aspects of accessory production, casting, forging, heat treating (including arrangement and spacing of components in the heat treatment furnaces), quenching, mechanical testing, proof and break loading and NDT.

10.5.2 Proof and break load tests

10.5.2.1 All accessories are to be subjected to the proof load specified for the corresponding stud link chain.

10.5.2.2 Chain accessories are to be tested at the break load prescribed for the grade and size of chain for which they are intended. At least one accessory out of every batch or every 25 accessories, whichever is less, is to be tested. For individually produced, **individually heated treated** accessories, or accessories produced in small batches (less than 5), alternative testing will be subject to special consideration. Alternative testing shall be subject to PRS approval **and the following additional conditions may apply:**

(a) Alternative testing is described in a written procedure and manufacturing procedure specification (MPS).

(b) A finite element analysis is provided at the break load and demonstrates that the accessory has a safety margin over and above the break load of the chain.

(c) Strain age testing (as per approved procedure by PRS) is carried out on the material grade produced to the same parameters at the time of qualification.

(d) If an accessory is of a large size that will make heat treating in batches unfeasible or has a unique design, strain gauges are to be applied during the proof and break load tests during initial qualification and during production. The strain gauge results from production are to be comparable with the results from qualification.

10.5.2.3 A batch is defined as accessories that originate from the same heat treatment charge and the same heat of steel. Reference subchapters 10.2.3 and 10.2.4.

10.5.2.4 The accessories which have been subjected to the break load test are to be destroyed and not used as part of an outfit, with the exceptions given in 10.5.2.5.

10.5.2.5 Where the accessories are of increased dimension or alternatively a material with higher strength characteristics is used, they may be included in the outfit at the discretion of PRS, provided that:

- .1** The accessories are successfully tested at the prescribed breaking load appropriate to the chain for which they are intended, and
- .2** It is verified by procedure tests that such accessories are so designed that the breaking strength is not less than 1.4 times the prescribed breaking load of the chain for which they are intended;
- .3** **strain age properties have been carried out on the material grade produced to the same parameters;**
- .4** **strain gauges are to be applied during the break load test in the high stress locations to monitor that the strains stay within allowable limits.**

10.5.3 Dimensions and dimensional tolerances

10.5.3.1 At least one accessory (of the same type, size and nominal strength) out of 25 is to be checked for dimensions after proof load testing. The manufacturer is to provide a statement indicating compliance with the purchaser's requirements.

10.5.3.2 The following tolerances are applicable to accessories:

- a) nominal diameter: +5 percent, -0 percent;
- b) other dimensions: +/-2.5 percent.

These tolerances do not apply to machined surfaces.

10.5.4 Mechanical tests

10.5.4.1 Accessories are to be subjected to mechanical testing as described in subchapters 10.2.3 and 10.2.4. Mechanical tests are to be taken from proof loaded full size accessories that have been heat treated with the production accessories they represent. **At least one accessory out of every batch or every 25 accessories, whichever is less, is to be tested. Hardness tests are to be carried out on finished accessories. The frequency and locations are to be agreed with PRS. The recorded values are for information only and used as an additional check to verify that the heat treatment process has been stable during the accessory production.** The use of separate representative coupons is not permitted except as indicated in 10.5.4.4 below.

10.5.4.2 Test location of forged shackles. Forged shackle bodies and forged Kenter shackles are to have a set of three impact tests and a tensile test taken from the crown of the shackle.

Tensile tests on smaller diameter shackles can be taken from the straight part of the shackle, where the geometry does not permit a tensile specimen from the crown. The tensile properties and impact values are to meet the requirements of Table 10.2.2.3.3 in the locations specified in Figure 10.2.2.3.3, with the Charpy pieces on the outside radius.

10.5.4.3 The locations of mechanical tests of cast shackles and cast Kenter shackles can be taken from the straight part of the accessory. The tensile properties and impact values are to meet the requirements of Table 10.2.2.3.3 in the locations specified in Figure 10.2.2.3.3.

10.5.4.4 The locations of mechanical tests of other accessories with complex geometries are to be agreed with PRS.

For non-circular sections, 1/4t (thickness) from the surface is considered appropriate.

Rolled plates are to be tested to the Standard to which they are produced.

10.5.4.5 For individually produced (**heat treated**) accessories or accessories produced in small batches (less than 5), alternative testing can be proposed to PRS.

Each proposal for alternative testing is to be detailed by the manufacturer in a written procedure and submitted to PRS **and the following additional conditions may apply:**

(a) if separately forged or cast coupons are used, they are to have a cross-section and, for forged coupon, a reduction ratio similar to that of the accessories represented, and are to be heat treated in the same furnace and quenched in the same tank at the same time, as the actual forgings or castings. Thermocouples are to be attached to the coupon and to the accessories;

(b) if separately forged or cast coupons are agreed, it is to be verified by procedure test that coupon properties are representative of accessory properties.

10.5.4.6 A batch is defined as accessories that originate from the same heat treatment charge and the same heat of steel. Refer to subchapters 10.2.3 and 10.2.4.

10.5.4.7 Mechanical tests of pins are to be taken as per Figure 10.2.2.3.3 from the mid length of a sacrificial pin of the same diameter as the final pin. For oval pins the diameter taken is to represent the smaller dimension. Mechanical tests may be taken from an extended pin of the same diameter as the final pin that incorporates a test prolongation and a heat treatment buffer prolongation, where equivalence with mid length test values have been established.

The length of the buffer is to be at least equal to 1 pin diameter dimension which is removed after the heat treatment cycle is finished. The test coupon can then be removed from the pin.

The buffer and test are to come from the same end of the pin as per Figure 10.5.4.7.

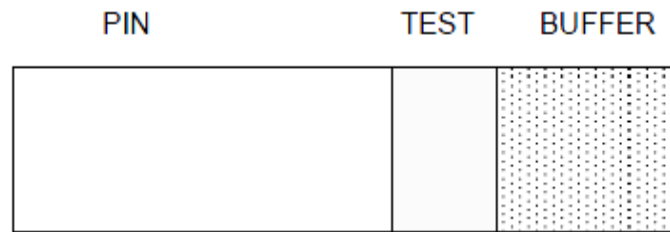


Figure 10.5.4.7. Buffer and test piece location

10.5.5 Non-destructive testing after proof load testing

All chain accessories are to be subjected to a close visual examination. Special attention is to be paid to machined surfaces and high stress regions. Prior to inspection, chain accessories are to have a suitably prepared surface as per the applied non-destructive testing standard. All non-machined surfaces are to be sand or shot blasted to permit a thorough examination. Where applicable, accessories shall be dismantled for inspection of internal surfaces. All accessories are to be checked by magnetic particles or dye penetrant. UT of accessories may be required by PRS. The acceptance/rejection criteria of UT established for the design is to be met.

10.5.5.1 Testing is to be performed in accordance with a recognized Standard and the procedures, together with acceptance/rejection criteria, are to be submitted to PRS for review. NDT is to be performed by a laboratory approved by PRS according to *Publication No. 56/P – Procedural Requirements for Laboratories*.

10.5.5.2 The manufacturer is to provide a statement that non destructive testing has been carried out with satisfactory results. This statement should include a brief reference to the techniques and to the operator's qualification.

10.5.5.3 Weld repairs of finished accessories are not permitted.

10.5.5.4 Test failures

In the event of a failure of any test the entire batch represented is to be rejected unless the cause of failure has been determined and it can be demonstrated to the PRS surveyor's satisfaction that the condition causing the failure is not present in any of the remaining accessories.

10.5.6 Marking

Each accessory is to be marked as follows:

- chain grade.

The certificate number may be exchanged against an abbreviation or equivalent. If so, this shall be stated in the certificate.

10.5.7 Documentation

A complete *Chain Inspection and Testing Report* in booklet form shall be provided by the manufacturer for each order. This booklet shall include all dimensional checks, test and inspection reports, NDT reports, process records and example photographs of components positioned in furnaces as well as any nonconformity, corrective action and repair work.

Each type of accessory shall be covered by separate certificates.

All accompanying documents, appendices and reports shall carry reference to the original certificate number.

The manufacturer will be responsible for storing, in a safe and retrievable manner, all documentation produced for a period of at least 10 years.

10.6 Annex to Chapter 10 related to Chafing Chain for Single Point Mooring Arrangements

10.6.1 Scope

These requirements apply to short lengths (approximately 8 m) of 76 mm diameter chain to be connected to hawsers for the tethering of oil carriers to single point moorings, FPSO's and similar uses.

10.6.2 Approval of Manufacturing

The chafing chain is to be manufactured by works approved by PRS, according to 10.1.3.

10.6.3 Materials

The materials used for the manufacture of the chafing chain are to satisfy the requirements of 10.2.

10.6.4 Design, manufacturing, testing and certification

10.6.4.1 The chafing chain is to be designed, manufactured, tested and certified in accordance with 10.3, 10.4 and 10.5, except that batch heat treatment is permitted.

10.6.4.2 The arrangement of the end connections is to be of an approved type.

10.6.4.3 The common link is to be of the stud link type – Grade R3 or R4.

10.6.4.4 The chafing chain is to be capable of withstanding the breaking test loads of 4884 kN (Grade R3) and 6001 kN (Grade R4). See Note 1.

10.6.4.5 The chain lengths shall be proof load tested in accordance with 10.4.2. The test load for Grade R3 is 3242 kN and for Grade R4 is 4731 kN.

Note 1:

Documented evidence of satisfactory testing of similar diameter mooring chain in the prior six month period may be used in lieu of break testing subject to agreement with PRS.

Note 2:

The requirements herein are also applicable to other diameter chafing chains, such as 84 mm and 96 mm, subject to compliance with the proof and break load requirements specified for the chain grade and diameters in Section 3 Table 5.

ANNEX 1: INCLINING TEST

1 An inclining test should be required for the first unit of a design, when the unit is as near to completion as possible, to determine accurately the light ship data (weight and position of centre of gravity).

2 For successive units which are identical by design, the light ship data of the first unit of the series may be accepted by PRS in lieu of an inclining test, provided the difference in light ship displacement or position of centre of gravity due to weight changes for minor differences in machinery, outfitting or equipment, confirmed by the results of a lightweight survey, is less than 1% of the values of the light ship displacement and principal horizontal dimensions as determined for the first of the series.

Extra care should be given to the detailed weight calculation and comparison with the original unit of a series of column-stabilized, semi-submersible types as these, even though identical by design, are recognized as being unlikely to attain an acceptable similarity of weight or centre of gravity to warrant a waiver of the inclining test.

3 The results of the inclining test, or those of the lightweight survey together with the inclining test results for the first unit should be indicated in *the Operating Booklet*.

4 A record of all changes to machinery, structure, outfitting and equipment that affect the light ship data should be maintained in a light ship data alterations log and be taken into account in daily operations.

5 For column-stabilized units:

.1 A lightweight survey or inclining test should be conducted at the first renewal survey. If a lightweight survey is conducted and it indicates a change from the calculated light ship displacement in excess of 1% of the operating displacement, an inclining test should be conducted, or the difference in weight should be placed in an indisputably conservative vertical centre of gravity and approved by PRS.

.2 If the survey or test at the first renewal survey demonstrated that the unit was maintaining an effective weight control programme, and at succeeding renewal surveys this is confirmed by the records under paragraph 4, 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 the operating displacement, a lightweight survey should be completed in accordance with paragraph 5.1.

6 The inclining test or lightweight survey should be carried out in the presence of PRS surveyor, or a duly authorized person or representative of an approved organization.

The results of the inclining test or lightweight survey adjusted for weight differences, will be reviewed by PRS prior to inclusion in the *Operating Booklet*.

List of amendments effective as of 1 January 2017

<i>Item</i>	<i>Title/Subject</i>	<i>Source</i>
2.7.1	Lightweight	IACS MODU 2

List of amendments effective as of 1 July 2017

<i>Item</i>	<i>Title/Subject</i>	<i>Source</i>
	a lot of places	IACS.UR W22 (Rev.6 June 16)
