Rules for the Classification of Self-Elevating Units - Jack-ups and Liftboats

December 2016

Rule Note
NR 534 DT R01 E

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MARINE & OFFSHORE DIVISION
GENERAL CONDITIONS

ARTICLE 1

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

The Society:

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

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

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

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

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

ARTICLE 2

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

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

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

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

ARTICLE 3

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

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

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

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

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

ARTICLE 4

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

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

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

ARTICLE 5

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

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

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

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

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

ARTICLE 6

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

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

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

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

ARTICLE 7

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

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

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

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

ARTICLE 8

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

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

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

ARTICLE 9

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

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

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

ARTICLE 10

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

ARTICLE 11

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

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

ARTICLE 12

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

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

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

ARTICLE 13

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

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

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

RULE NOTE NR 534

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Section 1 General

Section 2 Structure Design Principles

Section 3 Design Conditions

Section 4 Environmental Conditions

Section 5 Analysis in Elevated Position

Section 6 Analysis in Transit and Installation Conditions

Section 8 Equipment, Appurtenances and Outfittings

Section 9 Construction Survey - Welding - Tests and Trials

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Appendix 1 Hydrodynamic Analysis of Self-Elevating Units in Floating Condition

Symbols

E : Young modulus, in N/mm^2, to be taken equal to 2,06 10^5 N/mm^2 for steel

R_f : Reference stress of the material, in N/mm^2, as defined in Sec 2, [1.1.1]

ℓ : Span of the leg, in m, defined as follows:

- hull in elevated position: length of the leg between the bottom of the spudcan / footing mat and either the lower guide or the center of the locking mechanism if any
- transit condition: length of the leg between the upper guide and the top of the leg
- installation condition (leg impact): length of the leg from the bottom of the spudcan / footing mat to the lower guide

A : Cross-sectional area of the leg, in cm^2. Formulae given in Sec 2, Tab 2 may be applied if relevant

I : Minimum moment of inertia of the leg, in cm^4, about its principal axis. Formulae given in Sec 2, Tab 2 may be applied if relevant

s : Spacing of ordinary stiffeners or length of the shorter side of the plate panel, in m

ℓ_s : Span, in m, of ordinary stiffeners, measured between the primary supporting members

H_{max} : Maximum wave height, in m

T_{ass} : Associated period to H_{max} , in s

g : Gravity acceleration taken equal to 9,81 m/s^2.

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 The present Rule Note provides requirements for the classification of the self-elevating units, such as jack-up units or liftboats, as defined in [4.2].

1.1.2 The requirements of the present Rule Note apply to units intended to be granted the structural type notation specified in [1.3.1].

1.2 Scope

1.2.1 The present Rule Note applies to both small structures operating in shallow water and large structures operating in deep water.

1.2.2 The present Rule Note provides requirements for the design, construction and testing of self-elevating units.

1.3 Class notations

1.3.1 Structural type notation

The present Rule Note applies to floating units intended to be granted the structural type notation **self-elevating unit**, as defined in Pt A, Ch 1, Sec 2 of the Offshore Rules (see [4.1.1]).

This structural type notation lays down that the jacking mechanism for the self-elevating units are to be approved by the Society as detailed in Sec 10.

1.3.2 Service notations

The units covered by the present Rule Note may be granted the relevant service notation(s) defined in Pt A, Ch 1, Sec 2 of the Offshore Rules (see [4.1.1]). The usual service notations for a self-elevating unit are described in Tab 1.

1.3.3 Site notation

A site notation, specifying the name of the field and/or the geographical area where the unit is to operate, is to be assigned. When the self-elevating unit is not intended to operate in a specific geographical area, the site notation is to be characterized by the most unfavourable sea conditions for the unit.

Whatever the site notation, the Party applying for classification is to provide the most unfavourable environmental conditions for which the self-elevating unit is designed, as stipulated in Sec 3. These conditions are to be reported in the Design Criteria Statement defined in [2.5].

All changes of the geographical area or the stipulated environmental conditions are to be submitted to the examination of the Society and the site notation may be modified accordingly after approval of the design for the new conditions and, if applicable, execution of the necessary reinforcements.

1.3.4 Transit notation

The transit notation is to be completed as follows:

- The navigation notation **unrestricted navigation** is, by default, to complete the **transit** notation and to be considered for the design of the hull (such as hull scantlings, etc.) of the unit. This navigation notation is to be stated in the Design Criteria Statement (see [2.5])
- In case specified environmental conditions for transit are provided by the Party applying for classification, the transit notation **transit - specific criteria** may be assigned to the unit for which the transit is restricted to these specified environmental conditions. These conditions are to be stated in the Design Criteria Statement (see [2.5]).

1.3.5 Additional class notations

Additional class notations, optional or mandatory, are defined in Pt A, Ch 1, Sec 2 of the Offshore Rules (see [4.1.1]).

Table 1 : Usual service notations for self-elevating units

Service notation	Description
production	For units intended to oil production and fitted with production plant
gas production	For units intended to gas production and fitted with gas production plant
drilling (geotechnical) **drilling (workover)** **drilling assistance**	For units intended to drilling activities and fitted with drilling equipment
accommodation	For units intended to accommodate offshore personnel
lifting	For units intended to perform lifting operations at sea
Wind Turbine IMR Vessel	For units designed for installation and maintenance of offshore wind turbines

2 Classification principles

2.1 General provision

2.1.1 Unless otherwise stated, the general provisions of Part A, Chapter 1 of the Rules for the Classification of Offshore Units (NR445), where the principal conditions and other aspects of the classification process are defined, are applicable.

2.2 Scope of classification

2.2.1 The scope of classification is based on an appraisal of the integrated unit, covering in general:

a) Hull, hull attachments and appurtenances including:
   - foundations for the support of topside equipment and the hull mounted equipment
   - support structure for life saving appliances
   - passive fire protection
   - cathodic protection

b) Intact and damage stability

c) Accommodation quarters

d) Equipment and systems installed in the hull, the failure of which may jeopardise the safety of the floating unit

e) Fire and gas detection system for the hull as well as the definition of the hazardous areas of the hull

f) Fire-fighting systems for the protection of the hull

g) Drilling equipment and installations (in case of additional class notation **DRILL**)

h) Process plant and components (in case of additional class notation **PROC**)

i) Helideck (in case of additional class notation **HEL**)

j) Lifting appliances (in case of additional class notation **ALM**).

2.3 Classification limits

2.3.1 Site conditions

It is incumbent to the owners/operators:

- to perform the necessary investigations, including environmental and geotechnical surveys, prior to operating the unit at a given site
- to ascertain that the actual conditions met at the contemplated operating site remain on the safety side when compared to the design data and assumptions (particularly those listed in the Design Criteria Statement, as defined in [2.5]). Such site assessment is not part of the classification.

Classification does not cover the following items:

- assessment of sea bottom conditions and geotechnical investigations
- prediction of footing penetration during preloading
- self-elevating unit foundation stability after preloading
- assessment of the possible sea floor movement.

2.3.2 Operating procedures

Classification does not cover the procedures to be used for the unit positioning, leg jacking (lowering or elevating), preloading, jetting and other procedures related to operations.

It is the responsibility of the Owner, or the Operator if distinct from the Owner, to ascertain that the said procedures and their implementation satisfy the design criteria of the unit and the design of the related equipment.

For other classification limits applicable to operating procedures, refer to Part B, Chapter 2 of the Offshore Rules (see [4.1.1]).

2.3.3 Hull attachments and appurtenances

The class limit for the review of the supports of appurtenances is defined as follows:

- for classed equipment, the whole structure supporting the equipment is included in the scope of the classification and subject to the requirements in Sec 8, [1]
- for non-classed equipment, the scope of the review is limited, in principle, to the review of the hull attachment and the affected supporting structure to any non-welded connection of the equipment (pinned, bolted connection, sliding support, etc.). For appurtenances welded on the hull, the scope of the classification is defined on a case-by-case basis but is limited to the connection with the hull only.

2.4 Classification restrictions

2.4.1 When the design data and assumptions specified by the Party applying for classification do not comply with the requirements of the applicable Rules, restrictions may be placed upon the unit class.

2.4.2 When deemed necessary, restrictions may be placed on the duration of the service life of the unit.

2.4.3 Class restrictions, if any, are to be entered as a Memorandum on the unit Certificates of Classification and are to be incorporated in the Operating Manual prescribed in [2.7].

2.5 Design Criteria Statement

2.5.1 General

Classification is based upon the design data or assumptions specified by the Party applying for classification.

A Design Criteria Statement is to list the service(s) performed by the unit and the design conditions and other assumptions on the basis of which class is assigned to the unit.

The Design Criteria Statement is issued by the Society, based on the information provided by the Party applying for classification.

The Design Criteria Statement is to be referred to on the Classification Certificates of the unit.

The Design Criteria Statement is to be incorporated in the Operating Manual as prescribed in Pt A, Ch 1, Sec 1, [3.4] of the Offshore Rules (see [4.1.1]).

2.5.2 Unit services

The Design Criteria Statement is to list the main services for which the unit is designed, as well as the service notation and other notations assigned to the unit.

The nature of the unit activity is to be duly accounted for in the application of the Offshore Rules (see [4.1.1]), as far as classification is concerned.

2.5.3 Structural design criteria

The Design Criteria Statement is to list the necessary data pertaining to the structural design of the unit for its different conditions of operation, according to the provisions of Part B, Chapter 2 of the Offshore Rules (see [4.1.1]).

2.5.4 Machinery, electrical and other system design conditions

The Party applying for classification is to submit the necessary description, diagrammatic plans and design data of all the systems, including those used solely for the service (drilling, lifting, etc.) performed by the unit and, where applicable, their cross connections with the other systems. The submitted data are to incorporate all information necessary to the assessment of the unit for the purpose of the assignment of class or for the assignment of additional class notations.

In accordance with Pt A, Ch 1, Sec 1, [4.8.1] of the Offshore Rules (see [4.1.1]), the Party applying for classification is to give an electric balance estimation for the different conditions of operation of the unit. The specifications are to list all the important equipment and apparatus, their rating and the power factors, as applicable.

2.6 Design life

2.6.1 The requirements about design life, unit modification and unit re-assessment are given in Pt A, Ch 1, Sec 1, [1.7] of the Offshore Rules (see [4.1.1]).

2.7 Operating Manual

2.7.1 An Operating Manual, including instructions regarding the safe operation of the unit and of the systems and equipment fitted on the unit, is to be placed on board the unit.

The Operating Manual is to be, at all times, made available to all concerned. A copy of the Operating Manual is to be retained ashore by the Owner of the unit or by his representatives.

The Operating Manual is to incorporate a dedicated section containing all the information relating to classification, particularly the environmental, loading and other design criteria, as well as the classification restrictions. The Operating Manual of a self-elevating unit is also to stipulate the instructions related to the transit conditions, the preloading and the emergency procedures in case of punch through.

It is the responsibility of the Party applying for classification to prepare the contents of the Operating Manual.

2.7.2 The Operating Manual is to be submitted to the Society for review, this review being limited to check that the classification related material as mentioned above is consistent with the data given in the Design Criteria Statement defined in [2.5].

The minimum requirements about the content in the Operating Manual are given in [5.1.3].

3 Statutory requirements

3.1 General

3.1.1 The classification of a unit does not relieve Owners, Designers, Builders and other Interested Parties from compliance with any requirements issued by the administration (international conventions, national laws and regulations, and other instruments).

3.1.2 When authorized by the administration concerned, the Society is to act on its behalf within the limits of such authorization. In this respect, the Society is to take into account the relevant national requirements, survey the unit, report and issue or contribute to the issue of the corresponding certificates (see Pt A, Ch 1, Sec 1, [3.1.3] of the Offshore Rules).

3.2 Project specification

3.2.1 Prior to the design of the unit, a complete list of the Rules, Codes and statutory requirements to be complied with is to be established and submitted, detailing the:

- International conventions
- Flag State requirements
- Coastal State requirements
- Owner standards and procedures
- Industry standards.

3.2.2 The project specification is also to specify the list of the Owner requested certificates.

3.3 Conflict of Rules

3.3.1 In case of conflict between the present Rule Note and any statutory requirement as given by the Flag State or the Coastal State, the latter ones are to take precedence over the requirement of the present Rule Note.

3.3.2 In case of conflict between the Owner or industry standards and the present Rule Note, the latter one is normally to take precedence.

4 Definitions

4.1 Referenced documents

4.1.1 Offshore Rules

When reference is made to the Offshore Rules, the latest version of NR445 "Rules for the Classification of Offshore Units" is applicable.

4.1.2 Ship Rules

When reference is made to the Ship Rules, the latest version of NR467 "Rules for the Classification of Steel Ships" is applicable.

4.1.3 NR216

When reference is made to NR216, the latest version of the "Rules on Materials and Welding for the Classification of Marine Units" is applicable.

4.1.4 NR426

When reference is made to NR426, the latest version of the "Construction Survey of Steel Structures of Offshore Units and Installations" is applicable.

4.2 Self-elevating unit

4.2.1 A self-elevating unit is a unit with a floating hull fitted with legs capable of being lowered to the sea bed and of raising the hull above the sea level (see Fig 1).

The legs may be:

- of a shell or truss type
- equipped with a lower mat, a spudcan, a gravity-based structure or with footings designed to penetrate the sea bed
- vertical or slanted.

4.3 Modes of operation

4.3.1 A self-elevating unit is to be designed to resist to the loads occurring during all stages of the life-cycle of the unit such as working, survival, transit, installation and retrieval modes:

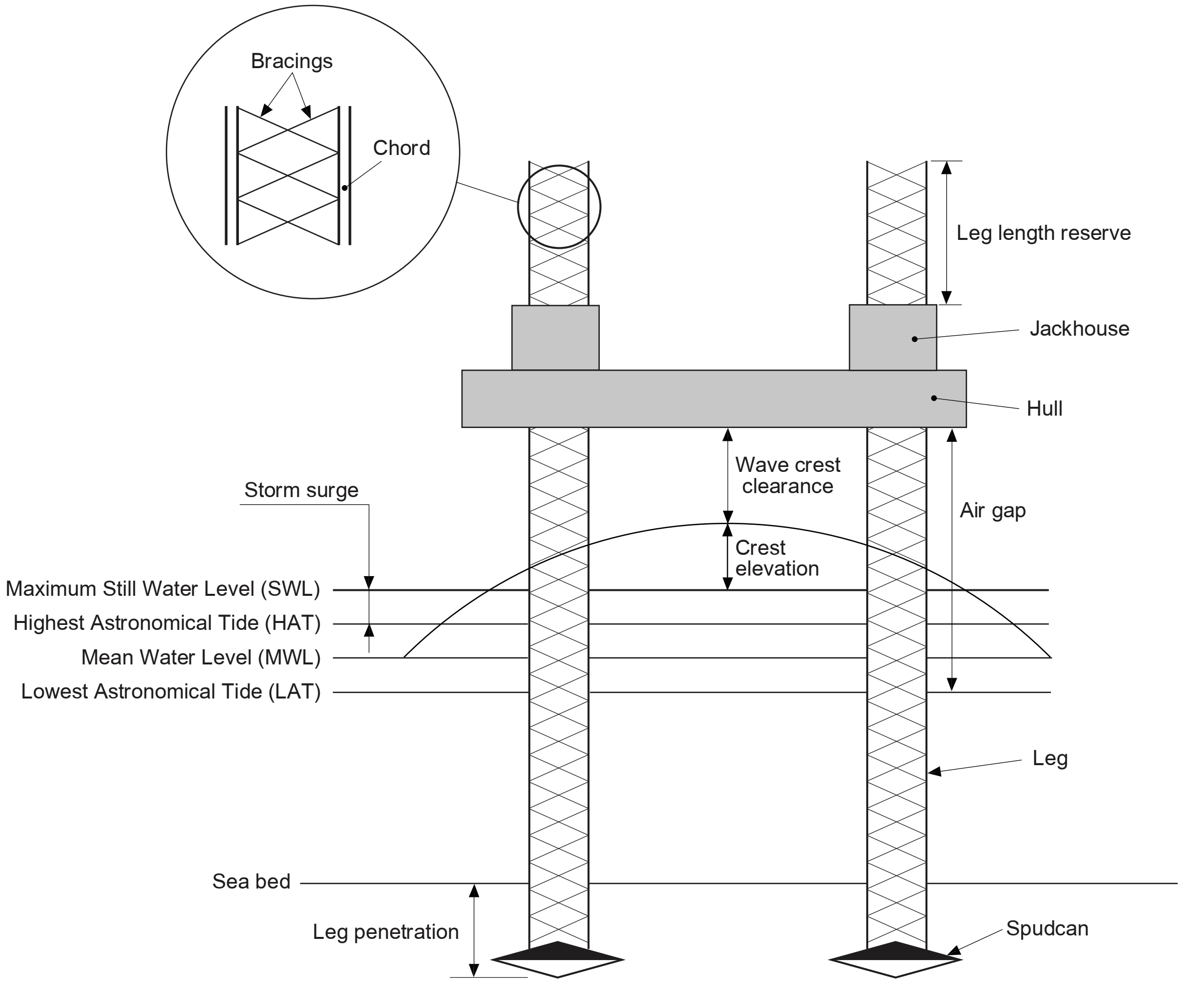
a) Working mode

The unit is on location, supported on the sea bed to operate, and combined environmental and operational loading are within the appropriate design limits established for such operations.

b) Survival mode

The unit is on location, supported on the sea bed and may be subjected to the most severe environmental loading for which the unit is designed. The operations for which the unit has been designed, such as drilling, well servicing, installation, may have been interrupted due to the severity of the environmental loadings.

Figure 1 : Definition of sea levels, air gap and clearance



c) Transit mode

The unit moves from one location to another within the appropriate design limits established for such operations.

The transit mode includes short-duration field moves between locations in close proximity and ocean transit for which a specific preparation of the unit is generally needed.

The unit may be self-floating or supported by a transportation unit during the ocean tow.

d) Installation mode

Period when the unit is firstly lowering legs to the sea bed, secondly elevating hull at the required elevation above the sea level, and then preloading the legs to the extreme loading.

e) Retrieval mode

Period when the unit is lowering the hull and then elevating legs to be ready for transit mode.

4.4 Water levels, crest elevation and water depth

4.4.1 The reference water levels and crest elevation are defined as follows in the present Rule Note (see Fig 1):

- mean water level (MWL): mean level between the highest astronomical tide (HAT) and the lowest astronomical tide (LAT)
- astronomical tidal range: range between the highest astronomical tide (HAT) and the lowest astronomical tide (LAT)
- maximum still water level (SWL): level at the highest astronomical tide (HAT) including storm surge
- crest elevation: height of wave crest above the SWL.

4.4.2 Except otherwise specified, the reference water depth to be considered is the distance between the sea bed and the SWL.

4.5 Configuration of a self-elevating unit in elevated position

4.5.1 The configuration of a self-elevating unit in elevated position is to be defined based on the site data associated with the unit service(s) (such as geotechnical drilling, production, workover, assistance, lifting, accommodation).

4.5.2 The configuration is defined with the following parameters (see Fig 1):

a) Leg penetration length

The leg penetration length is the maximum leg penetration into the sea bed, including the spudcan if any.

b) Leg length reserve

The leg length reserve is the reserve above the upper guide to avoid any soil settlement or punch through and to provide a contingency in case the penetration exceeds the predicted one.

c) Air gap

The air gap is defined as the distance between the underside of the hull and the LAT.

d) Wave crest clearance

The wave crest clearance is defined as the distance between the highest wave crest and the underside of the hull.

4.6 Configuration of a self-elevating unit in floating position

4.6.1 In floating position, the legs are usually elevated and supported by the hull.

The draught of the unit is defined as the distance from the lowest point of the hull to the waterline.

5 Documents to be submitted

5.1 General

5.1.1 The required documentation is listed in Part A, Chapter 1 of the Offshore Rules.

5.1.2 The required documentation is to clearly show all the essential features, arrangements and scantlings of the structure, machinery, boilers, auxiliaries and other equipment covered by the classification.

5.1.3 In addition to [5.1.1], the documentation is to include the information listed in [5.2] for plan review purposes.

5.2 Additional information for plan review purposes

5.2.1 Design criteria and data

The design criteria and data, as stipulated in Sec 3, include environmental data (see Sec 4).

The data are to be as comprehensive as possible and to clearly give evidence of all the applicable environmental restrictions:

- maximum loading for all deck areas
- results of model basin tests, when performed
- results of wind tunnel tests, when performed
- for equipment liable to induce, when in use, significant loads within the structure of the unit, all information on these loads, such as:
  - drilling loads
  - crane loads on pedestal and on boom and hook rests (lifting)
  - other loads from lifting and handling equipment.

5.2.2 Structural, stability and hydrodynamic calculations

- calculations of the environmental loadings including forces and moments from wind, waves, currents, ice, snow, earthquakes, as applicable
- calculations of loads induced by equipment
- stability calculations for the intact and damaged conditions including detailed computation of wind exposed areas and, if applicable, ice formation effects
- global analysis of the unit in elevated position
- calculations of the unit resistance against overturning while resting on the sea bed in elevated position
- hydrodynamic calculations in floating condition, if relevant
- hull calculations in floating condition
- leg strength calculation in floating condition
- local strength calculations of:
  - legs
  - leg/hull connection
  - spudcans or bottom mat, if relevant
  - leg/spudcan or leg/mat connection, if relevant
  - cantilever/hull connection, if relevant
  - other hull attachments and appurtenances, if any
- fatigue calculations of structural details
- calculations of jacking systems and, if any, fixation systems
- calculations of segregation of loads between jacking and fixation systems, if relevant
- calculations of cathodic protection system.

5.2.3 General and structural drawings

a) general arrangement plan (in elevating and transit conditions)

b) capacity plan indicating the volumes, overflows and positions of the centres of gravity of the various compartments, together with their locations

c) deck loading plans

d) main structural drawings showing structural arrangements, scantlings, grades of steel, welded connections and structural details. These drawings are to include, as applicable:

- transverse and longitudinal sections of the hull
- decks, including the helicopter deck and its support frame
- shell plating and framing
- bulkheads and flats
- legs including:
  - for lattice legs: racks, chords, bracings and their connections
  - for shell type legs: shell plating, stiffeners, stringers, struts, connections of racks with shell plating and supporting leg rack members, potential openings, where relevant
- detailed drawings of the racks, if any, including their arrangement in transit and elevating conditions
- footings (spudcans) or mats
- leghouses
- superstructures and deckhouses.

e) detailed structural drawings in the areas of connections between main structural members in way of:

- foundations of elevating systems
- leghouse guides
- drilling derrick
- cantilever
- anchoring equipment
- crane foundations, and
- all the other parts liable to be subjected to high local loadings or stress concentrations.

5.2.4 Operating Manual

In addition to Pt A, Ch 1, Sec 4 of the Offshore Rules, the Operating Manual is to include the following information, where applicable:

- design limitations:
  - during transit (leg arrangement, rig and other equipment sea fastening)
  - during installation (leg lowering, preloading)
  - on site
  - during retrieval (hull lowering, leg retrieval)
- emergency procedures in case of punch through
- preload procedure
- for normal operation, information regarding the preparation of the unit to avoid structural damage during the setting or retraction of legs on or from the seabed, or during extreme weather conditions while in transit, including the positioning and securing of legs, cantilever drill floor structures and drilling equipment or materials which might shift position
- jacking gear main loading capacity in operating conditions
- maximum loading capacity in case of engaged fixation system
- Design Criteria Statement issued by the Society, including the classification restrictions, if any
- classification certificates, continuous survey lists and other certificates issued by the Society.

5.2.5 Jacking systems

The documents to be submitted for the jacking systems are given in Sec 10.

6 Applicable rules

6.1 General

6.1.1 The rules applicable for the classification of self-elevating units are summarized in Tab 2.

Table 2 : Applicable requirements

Item	Rules, Section, Article or Table
General arrangement	Sec 2 and Offshore Rules, Part B
Stability and subdivision	Sec 6, [2] and Offshore Rules, Part B
Structural assessment	See Tab 3
Machinery and systems	Sec 10 and Offshore Rules, Part C
Electrical installations and automation	Offshore Rules, Part C
Safety features	Offshore Rules, Part C
Materials and welding	NR216
Construction survey	Sec 9 and NR426
In-service surveys	Offshore Rules, Part A, Chapter 2

Table 3 : Applicable Sections and Articles for the scantling of unit items

Item	Section / Article
Hull and legs structure	Sec 2 Sec 5 Sec 6 Sec 7
Hull attachment and appurtenances	Sec 2 Sec 8, [1]
Superstructures and deckhouses	Sec 8, [3]
Crane	Sec 8, [2]
Helicopter decks	Sec 8, [4]
Hull outfitting	Sec 8, [5]
Launching appliances	Sec 8, [6]
Jacking system	Sec 10

7 Reference co-ordinate system

7.1 Hull

7.1.1 Except otherwise specified, the unit geometry and loads are defined with respect to the following right-hand co-ordinate system:

- Origin: at the intersection between the longitudinal plane of symmetry of unit, the aft end and the baseline
- X axis: longitudinal axis, positive forwards
- Y axis: transverse axis, positive towards portside
- Z axis: vertical axis, positive upwards.

7.1.2 Positive rotations are oriented in anti-clockwise direction about the X, Y and Z axes.

SECTION 2 STRUCTURE DESIGN PRINCIPLES

1 Steel grade and structural categories

1.1 Material strength

1.1.1 According to the Offshore Rules, the reference stress of material R_f, in N/mm², to be considered for strength calculation is defined by:

$$R_f = \text{Min}\left(R_{eH} ; \frac{R}{1,2}\right)$$

where:

R_{eH} : Specified minimum yield stress of the material, in N/mm²

R : Tensile strength of the material, in N/mm².

1.1.2 For steel having a yield stress above 690 N/mm², special consideration is to be given by the Society.

1.2 Steel grade selection

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

1.2.2 The steel grade for a structural element is to be selected in accordance with Pt B, Ch 3, Sec 2 of the Offshore Rules, on the basis of:

- the design service temperature defined in Sec 4, [6]
- the structural category set out in [1.3]
- the reference thickness of the element defined in Pt B, Ch 3, Sec 2 of the Offshore Rules.

The design air temperature is to be considered for the structural elements located above the minimum water depth (i.e. LAT).

The design water temperature is to be considered for the structural elements located below the minimum water depth (refer to Sec 4, [6] for additional information).

1.3 Structural categories

1.3.1 Categories to be considered

Structural elements in welded steel constructions are classed into three categories, as listed hereafter:

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

1.3.2 Categories of the structural members

The structural members of self-elevating units are to be categorized as indicated in Tab 1.

The structural categories are to be indicated on the drawings submitted to the Society for approval.

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

1.4 Steels with specified through-thickness properties

1.4.1 The designer is to evaluate the risk of any lamellar tearing.

1.4.2 The steels with specified through-thickness properties are to comply with the requirements in Pt B, Ch 3, Sec 2, [4] of the Offshore Rules.

1.5 Corrosion allowances

1.5.1 The scantlings obtained by applying the criteria specified in the present Rule Note are gross scantlings, i.e. those providing the strength characteristics required to sustain the loads including corrosion margin. The strength criteria take into account a moderate and progressive corrosion up to an amount of 4% in 20 years.

1.5.2 For the particular case of legs without cathodic protection, a corrosion rate of 0,4 mm per year is to be considered in the splash zone (i.e. in the area limited by the LAT minus the trough of wave, and the SWL plus the crest of wave). This value is to be deduced from the as-built thickness minus the Owner margin, as specified in [1.5.3]. The corrosion rate applies on both the external shell and the internal one, if relevant.

1.5.3 Any additional thickness increment, as may be provided in accordance with the provisions of Pt B, Ch 3, Sec 5 of the Offshore Rules, is to be deduced from the actual nominal thicknesses prior to application of strength criteria.

1.5.4 When the unit is converted from an existing unit, the assessment of strength is to be based on the actual measured thicknesses reduced by any specified corrosion prediction or corrosion allowance.

Table 1 : Application of structural categories

Structural member category
SECOND CATEGORY: • Second category elements are structural elements which are classed neither in the special nor in the first categories
FIRST CATEGORY: a) Hull and other appurtenances: • bottom plating • strength deck plating, excluding that belonging to the special category • side shell plating • bulkhead plating belonging to main structure of the hull • legwell recess • heavily loaded elements forming main truss or frames of integrated decks, support frames or heavy modules • structure supporting crane pedestals, large flare towers or long span bridges • helideck frames • cantilever beams and substructure of drill floor (legs and main beams) • appurtenances connections to hull when used for essential operations, excluding those belonging to the special category b) Leghouses: • shell plates of boxed jackhouses and main girders of truss jackhouses • tubular intersections in the truss of jackhouses c) Legs: • vertical members of cylindrical and rectangular hollow section legs (external shell plating including vertical stiffeners if any, racks if any, etc.) • chords, racks and main bracings of lattice legs d) Spudcans and mat: • top plating, bottom plating, side shell plating and bulkheads in spudcans • spudcan round bar • spudcan tip • deck plating, shell plating and bulkheads in mat structure
SPECIAL CATEGORY: a) General: • cast steel structural members b) Hull and other appurtenances: • sheer strake at strength deck **(1)** • stringer plate in strength deck **(1)** • deck strakes in way of bulkheads participating to overall bending moment **(1)** • strength deck and bottom plating at outboard corners of large hatch openings (moonpool) • bilge strake **(1)** • highly stressed area of appurtenance connections to the hull (including padeyes if any), when used for essential operations c) Leghouses: • structure in way of jacking or other elevating arrangements including padeyes or bearing members • structure in way of leg fixation systems including padeyes or bearing members • leghouse guides for load transferring from legs to the hull • connections of leghouses to the hull d) Legs, spudcans and mat: • tubular intersections for lattice legs • connection of legs to spudcans or mat structure
(1) Single strakes are required to be of special category or of grade E/EH and are to have breadths not less than (800 + 5 L) mm, where L is the rule length of the hull, as defined in Sec 6. **Note 1:** Any welded attachment of loaded equipment on hull plating is not to have a grade lower than the grade used for the hull plating.

2 Structural principles

2.1 Accessibility for inspection during service

2.1.1 Principle

Accessibility for inspection, and also for maintenance, is required with respect to the durability and integrity of the structure.

2.1.2 Means of access

The means of access in a self-elevating unit are to allow inspection of the critical structure connections identified during the drawing review by the Society and/or the designer.

The number of inaccessible areas is to be limited and clearly identified on the structure drawings. The Society reserves the right to require additional corrosion allowances for these areas. Special attention is to be paid to fatigue strength.

Web frame numbers are to be attached to the structure or the walkway inside the tanks, to the satisfaction of the attending Surveyor.

Equipment on deck is to be arranged to allow inspections of the deck plating and to avoid permanent concentration of dust and remaining water.

For permanent means of access, refer to Pt B, Ch 3, Sec 1 of the Offshore Rules.

2.2 General construction

2.2.1 Structural continuity

Attention is to be paid to the structural continuity:

- of the leg structure
- in way of the connections of the leghouse ends (jackhouse ends, spudhouse ends) with the hull
- of the leg connections with the spudcans or the mat structure
- in way of the changes in the framing system
- at the connections of the primary or ordinary stiffeners
- in way of the deck equipment connections.

The framing system of the hull is to consider the global stress flow in both elevated and floating positions. In principle, several framing types are adopted for triangular hulls, to ensure a better hull strength continuity between leghouses. Rectangular hulls are, usually, longitudinally framed.

Where stress concentrations may occur in way of structural discontinuities, adequate compensations and/or reinforcements are to be provided.

Openings are to be avoided, as far as practicable, in way of highly stressed areas.

Where necessary, the shape of openings is to be specially designed to reduce the stress concentration factors. Particular attention is to be paid to the passage of secondary stiffeners through web plating in the stress vicinity of heavy loads.

Openings are generally to be well rounded, with smooth edges.

Primary supporting members are to be arranged in such a way that they ensure adequate continuity of strength. Abrupt changes in height or in cross-section are to be avoided.

2.2.2 Sniped ends

In principle, sniped ends of primary and secondary stiffeners are not to be greater than 30 degrees.

2.3 Plating

2.3.1 A local increase in plating thickness is generally to be achieved through insert plates.

Insert plates are to be made of materials of a quality at least equal to that of the plates on which they are welded.

Plating under heavy concentrated loads may be reinforced with doublers (allowed under compression loads only) and/or stiffeners, where necessary. Doublers in way of equipment are to be limited in size and avoided in the deck areas with high stresses.

Doublers having a width, in mm, greater than:

- 20 times their thickness, for thicknesses ≤ 15 mm
- 25 times their thickness, for thicknesses > 15 mm,

are to be fitted with slot welds, according to Pt B, Ch 11, Sec 1 of the Ship Rules.

2.4 Ordinary stiffeners

2.4.1 The strength principle requirements for the ordinary stiffeners are those given in Pt B, Ch 4, Sec 3, [3] of the Ship Rules.

2.5 Primary supporting members

2.5.1 The strength principle requirements for the primary supporting members are those given in Pt B, Ch 4, Sec 3, [4] of the Ship Rules.

Additional strength principle requirements for bottom, side, deck and bulkhead structures are given respectively in the Sections from Pt B, Ch 4, Sec 4 to Pt B, Ch 4, Sec 7 of the Ship Rules.

2.6 Leghouse

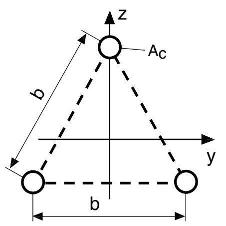
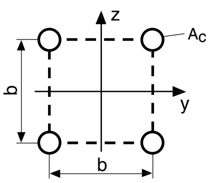
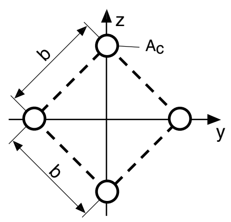
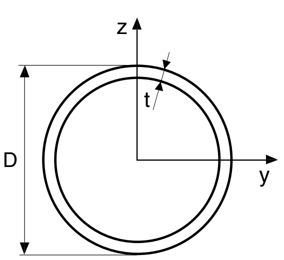
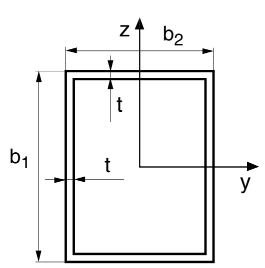
2.6.1 The leghouse includes all the structural elements of the hull allowing the load transfer between legs and hull. The horizontal guides (hull structural members in contact with the legs), the elevating and locking systems with their supporting structure are also part of the leghouse.

The leghouse is usually formed by spudhouse and jackhouse.

2.6.2 Load carrying members of the leghouses are to be:

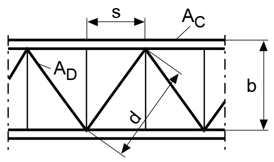
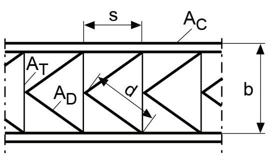
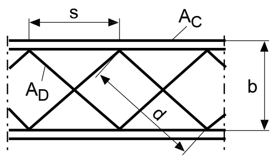
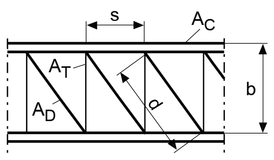
- designed for the maximum design loads, and
- so arranged that loads transmitted from the legs are properly diffused into the hull structure.

Table 2 : Equivalent strength properties for shell type legs

Leg type		Equivalent properties	
1		$A = 3\ A_C$ $A_{Shy} = A_{Shz} = \frac{3}{2} A_{Sh}$	$I_y = I_z = \frac{1}{2} A_C b^2 10^{-4}$ $I_T = \frac{1}{4} A_{Sh} b^2 10^{-4}$
2		$A = 4\ A_C$ $A_{Shy} = A_{Shz} = 2\ A_{Sh}$	$I_y = I_z = A_C\ b^2\ 10^{-4}$ $I_T = A_{Sh}\ b^2\ 10^{-4}$
3		$A = 4\ A_C$ $A_{Shy} = A_{Shz} = 2\ A_{Sh}$	$I_y = I_z = A_C\ b^2\ 10^{-4}$ $I_T = A_{Sh}\ b^2\ 10^{-4}$
4		$A = \pi\ (D - t)\ t\ 10^{-2}$ $A_{Shy} = A_{Shz} = \frac{A}{2}$	$I_y = I_z = \frac{\pi t (D - t)^3}{8} 10^{-4}$ $I_T = \frac{\pi t (D - t)^3}{4} 10^{-4}$
5		$A = 2\ t\ (b_1 + b_2)\ 10^{-2}$ $A_{Shy} = 2\ t\ b_2\ 10^{-2}$ $A_{Shz} = 2\ t\ b_1\ 10^{-2}$	$I_y = \frac{1}{12}[b_2 b_1^3 - (b_2 - 2t)(b_1 - 2t)^3] 10^{-4}$ $I_z = \frac{1}{12}[b_1 b_2^3 - (b_1 - 2t)(b_2 - 2t)^3] 10^{-4}$

A : Cross-sectional area of the leg, in cm²
A_C : Cross-sectional area of the chords, in cm², including racks as stipulated in Sec 5, [2.3.1]
A_{Shy} : Shear area with respect to y-axis of the leg, in cm²
A_{Shz} : Shear area with respect to z-axis of the leg, in cm²
A_{Sh} : Shear area of one leg side, in cm², as defined in Tab 3
I_y : Moment of inertia about the y-axis of the leg, in cm⁴
I_z : Moment of inertia about the z-axis of the leg, in cm⁴
I_T : Torsional moment of inertia of the leg, in cm⁴
b : Distance between the chords, in m
D : Outer diameter of the cylindrical shell type leg, in mm
b_1, b_2 : Depth and breadth of the rectangular hollow section leg, in mm
t : Thickness of the leg shell, in mm.

Table 3 : Equivalent shear area of one leg side for lattice type legs

	Structure	Equivalent shear area A_{Sh} of one leg side, in cm²
1		$A_{Sh} = \dfrac{(1+\nu)sb^2}{\dfrac{d^3}{2A_D} + \dfrac{s^3}{6A_C}}$
2		$A_{Sh} = \dfrac{(1+\nu)sb^2}{\dfrac{d^3}{A_D} + \dfrac{b^3}{8A_T}}$
3		$A_{Sh} = \dfrac{(1+\nu)sb^2}{\dfrac{d^3}{4A_D}}$
4		$A_{Sh} = \dfrac{(1+\nu)sb^2}{\dfrac{d^3}{2A_D} + \dfrac{b^3}{2A_T} + \dfrac{s^3}{6A_C}}$

A_C : Cross-sectional area of the chords, in cm², including racks as stipulated in Sec 5, [2.3.1]
A_D : Cross-sectional area of the diagonal bracings, in cm²
A_T : Cross-sectional area of the transverse bracings, in cm²
b : Distance between the chords, in m
d : Length of the diagonal bracings, in m
s : Spacing of the bays, in m
ν : Poisson's ratio. Unless otherwise specified, a value of 0,3 is to be taken into account.

2.6.3 For the purposes of better contact and gap reduction between the legs and guides, doubling plates may be fitted. The contact area is to be as large as possible and the extent of doublers is to cover the whole contact area.

In case several doubling plates are fitted for shell to shell contact, the contact area is not to be interrupted because of the presence of doublers. The welded connections of the doublers between them are to be as flush as possible.

In addition to the normal loads due to leg-guide contact (analysed according to Sec 5 and Sec 6), the welds between the doublers and the guide structure are also to withstand the tangential friction forces provided by the leg displacements against the guide ones.

2.7 Legs

2.7.1 Legs may be either of shell type or of lattice type (truss leg type). Individual footings (spudcans) may be fitted or legs may be permanently attached to a bottom mat.

2.7.2 Shell type legs (with cylindrical or rectangular hollow section) may be designed as either stiffened or unstiffened shells.

All structural elements participating to the global strength of the legs (shell, ordinary stiffeners if any) are to be continuous when crossing primary members.

2.7.3 Lattice type legs are usually made of tubular members. Particular attention is to be paid to the tubular connections which are highly stressed areas subject to fatigue. Eccentricities are generally to be minimized.

The bracing system of lattice type legs is to be so arranged as to ensure structural redundancy.

2.7.4 The cross-sectional properties of shell type legs and lattice type legs may be obtained from the formulae given in Tab 2 and Tab 3.

2.8 Spudcans and bottom mat

2.8.1 When spudcans are fitted, particular attention is to be paid to the connection with the legs which may be subject to fatigue. Suitable reinforcements are normally to be provided inside the spudcans. Suitable overlapping of the legs is to be fitted so as to properly transfer the loads from the legs to the spudcans.

When internal vertical plating is fitted inside the spudcan, its upper end is to be smoothly connected (with rounded edge) to the leg outer shell or leg chord. For shell type legs, the upper end is also to be connected to the ring stiffeners of the leg shell (or other ring structural members), in order to avoid hard point on the leg shell.

2.8.2 When the bottoms of the legs are attached to a mat, particular attention is to be given to the attachment, the framing and bracing of the mat, in order that the loads resulting from the legs are properly distributed.

2.9 Superstructures and deckhouses

2.9.1 The superstructures and deckhouses are to have sufficient strength for their sizes, functions and locations, with due consideration given to the environmental conditions the unit may be exposed to. Their scantlings are to be designed in transit conditions for sustaining green water pressure on unprotected front bulkheads, as defined in Sec 8, [3].

2.10 Reinforcements in way of supporting structures for hull attachments

2.10.1 Generally, the supports for attachments and appurtenances are to be fitted in way of longitudinal and transverse bulkheads or in way of deck beams. The other supports are to be fitted in way of large primary supporting members.

The main structure may be locally reinforced by means of insert plates.

Cut-outs in local structures in way of hull attachments are to be closed by full collar plates.

Particular attention is to be paid to the buckling effect below the supports.

SECTION 3 DESIGN CONDITIONS

1 General

1.1 Definition

1.1.1 The design conditions are the data on which the structural design is based. The data are to include a description of:

- the general configuration of the unit (air gap, leg penetration length, leg length reserve, etc.)
- the distribution of fixed and operational loads (see Sec 5, [4.1])
- the environmental conditions (see Sec 4)
- the wind screen areas
- any other relevant data.

1.2 Modes of operation and accidental conditions

1.2.1 The design conditions are to be specified by the Party applying for classification for all modes of operation (see also Sec 1, [4.3]) and for accidental conditions:

a) Operating design conditions

The operating design conditions are defined as the most stringent conditions for the strength and the stability of the self-elevating unit during working mode.

The environmental data to be specified for these conditions are to constitute the limits for the condition of operation of the unit or for the operation of a particular equipment or system.

b) Severe storm design conditions

The severe storm design conditions are defined as the most stringent conditions for the strength and the stability of the self-elevating unit during survival mode. They are considered as extreme conditions.

The environmental data for these conditions, as specified in Sec 4, are to be provided for a return period not less than:

- 50 years, in general
- 100 years, for self-elevating units permanently installed on site.

c) Transit design conditions

The transit design conditions are defined as the most stringent conditions for the strength and the stability of the self-elevating unit during field or ocean transit mode (see definitions in Sec 1, [4.3.1]).

If ocean transit is not allowed, it is to be stipulated in the Design Criteria Statement.

In principle, the legs are elevated in transit operations.

The initial transportation to site of a permanent installation is also considered as a transit condition.

Motions and accelerations for transit conditions are to be determined based on significant metocean data with a return period of at least:

- 50 years for mobile units
- 10 years for permanent units, except when otherwise specified by the Party applying for classification.

d) Installation/retrieval design conditions

Installation/retrieval design conditions are defined as the most stringent conditions for the strength and the stability of the self-elevating unit during installation or retrieval mode.

Installation/retrieval design conditions cover leg impact conditions while lowering the legs and preloading condition.

Preloading condition is a condition where the legs are statically loaded at the maximum vertical loading, associated with severe storm conditions.

e) Accidental conditions, if relevant

The design of the unit may consider the possibility of accidental loads resulting from collisions, dropped objects, fire or explosions.

For units with lattice legs, an accidental condition with one broken bracing in the most loaded area of the leg structure is to be studied, in order to evaluate the redundancy of the bracing system.

Other accidental conditions such as broken bracings, broken joints, leg deformation, punch through and ship impact may be studied.

In principle, the environmental data for the accidental conditions, as specified in Sec 4, are to be taken for a return period of one year.

1.2.2 All the above loading conditions are to be described in details in the Operating Manual.

2 Self-elevating unit in elevated position

2.1 Calculation methodology

2.1.1 A global analysis of the self-elevating unit in elevated position is to be carried out for the checking of the unit overall behaviour.

2.1.2 The self-elevating unit response is generally non-linear for the following reasons:

- the non-linear wave loadings, due to:
  - the hydrodynamic drag loads
  - the wave kinematic
  - the variation of the submerged portion of the legs
  - the interaction between wave and current
- the non-linear amplification of the large deflections of the legs
- the resonance of the structure at wave period
- the non-linear interactions such as:
  - leg/hull interaction
  - leg/sea bottom interaction
- the static inclination of the legs, due to:
  - fabrication tolerance
  - fixation system
  - hull inclination.

These non-linearities are to be properly taken into account for the resistance assessment.

2.1.3 In general, a deterministic analysis (design wave methodology) is accurate enough for resistance assessment. Calculation methodology for deterministic analysis, modelling, loads and load effects are described in Sec 5. The procedures for wave load calculation is defined in Sec 5, [4.4].

Stochastic analysis (irregular sea state described by wave energy spectrum) is required for the structures with significant dynamic response (see Sec 5, [4.5.4]) and fatigue assessment. Further information of stochastic analysis, in both frequency and time domains, are mentioned in Technical and Research Bulletin 5-5A, Guidelines for Site Specific Assessment of Mobile Jack-up Units published by the Society of Naval Architects and Marine Engineers (SNAME).

2.2 Loading conditions

2.2.1 The structural strength assessment of a self-elevating unit in elevated position, is to be based on the following design conditions:

- operating design conditions
- severe storm design conditions
- preloading conditions
- inspection, maintenance and repair conditions, if relevant
- accidental conditions.

The corresponding load cases are specified in Sec 5, [5.2].

3 Self-elevating unit in transit conditions

3.1 Design considerations for hull structure

3.1.1 The hull of the self-elevating unit is to be designed to withstand sea pressure, internal tank pressure, inertia loads and hull girder loads.

The hull strength is to comply with the requirements given in Sec 6.

3.2 Design considerations for legs and leg/hull connection

3.2.1 General

The structural elements of the unit (legs, leg/hull connection) are to be designed for the static and inertia forces induced by the motions and accelerations of the self-elevating unit in the most severe environmental conditions for the two following conditions:

- field transit conditions
- ocean transit conditions.

Legs and leg/hull connection structure are to be assessed, using the simplified approach defined in Sec 6. Alternative methodology may be accepted by the Society, on a case-by-case basis.

3.2.2 Leg arrangement

The legs and leg/hull connection structure are to be assessed for any proposed leg arrangement with respect to the vertical position during field and ocean transit modes, and the approved positions are to be specified in the Operating Manual (see Sec 1, [2.7]). Such leg arrangements are also to be considered for stability assessment.

3.2.3 Motions and accelerations

Legs and leg/hull connection structure are to be designed for bending moments and forces caused by motions, taking into account:

- a minimum value of single amplitude of roll or pitch equal to 6° at the natural period of the unit (see Sec 6, [4.1.3]) plus 120% of the gravity caused by the inclination angle of the legs for the field transit conditions
- the values given by the hydrodynamic calculations as specified in [3.2.4] or, as an alternative, a value of single amplitude of roll or pitch equal to 15° at a 10 s period plus 120% of the gravity caused by the inclination angle of the legs for the ocean transit conditions.

3.2.4 Hydrodynamic calculations and model tests

The motions and accelerations to be taken into account for both field and ocean transit conditions may be derived from the hydrodynamic calculations (see App 1 for the methodology) and/or obtained from model tests on the basis of the unit characteristics and intended environmental transit conditions.

Hydrodynamic calculations may be required by the Society when deemed necessary.

3.2.5 Wind loads

The effect of wind forces resulting from the maximum wind velocity, as defined in Sec 5, [4.3], is to be taken into account in addition to [3.2.3].

3.3 Dry tow transit

3.3.1 Dry tow transit (transit mode where the unit is carried as cargo on another ship or barge) is not covered within the scope of classification. However, should loads during towing be considered, refer to Sec 6, [3.4.2].

4 Installation / retrieval design conditions

4.1 Leg impact

4.1.1 Legs are to be designed to withstand:

- the dynamic loads which may be encountered by their unsupported length just prior to touching the bottom, and
- the shock of touching the bottom while the unit is afloat and subject to wave motions.

In principle, leg strength due to the leg impact on the sea bottom is to be examined in accordance with Sec 6, [5.2.1], except when a more detailed analysis is provided.

4.2 Preloading condition

4.2.1 The maximum preloading force per leg is to be specified by the Party applying for classification. This preloading force is not to be less than the maximum vertical reaction force obtained in the global analysis.

4.2.2 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 preloading procedure is to be included in the Operating Manual as required in Sec 1, [5.2.4].

SECTION 4 ENVIRONMENTAL CONDITIONS

Symbols

H_s : Significant wave height, in m, corresponding to the mean wave height of the one third highest waves

T_p : Peak period of the wave spectrum, in s

T_z : Zero up-crossing wave period, in s.

1 General

1.1 Application

1.1.1 The purpose of this Section is to provide requirements regarding the necessary environmental information, to be specified by the Party applying for classification, for the structural design assessment of a self-elevating unit.

1.2 References

1.2.1 Industry Standards

a) ISO 19901-1: "Petroleum and natural gas industries - Specific requirements for offshore structures - Part 1: Metocean design and operating conditions"

b) Technical and Research Bulletin 5-5A: "Guidelines for Site Specific Assessment of Mobile Jack-up Units published" by the Society of Naval Architects and Marine Engineers (SNAME)

c) API RP 2A-WSD: "Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design"

d) ISO 19905-1: "Petroleum and natural gas industries - Site-specific assessment of mobile offshore units - Part 1: Jack-ups".

1.3 Environmental data

1.3.1 The environmental data are to be specified by the Party applying for classification. They are to include:

- data for the severe storm design condition (extreme, survival), in accordance with requirements of Sec 3, [1.2.1]
- data for the limiting environmental (threshold) conditions considered for operating, transit, installation and preloading design conditions of the unit
- the long-term distribution of the environmental data on which the design of the structure for fatigue is based
- data for any other particular design condition of the unit under consideration.

1.3.2 It is the responsibility of the Party applying for classification to ascertain that the environmental parameters are correct, complete and compatible with the use of the unit, in accordance with the provisions of the present Section.

1.4 Environmental load

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

- wave
- wind
- current
- ice and snow, where relevant
- earthquake, where relevant.

The dynamic loads induced by the unit motions (inertia forces) or by the dynamic response to the environment actions are to be considered as environmental loads.

The reactions to the environmental loads (foundations) are to be considered as environmental loads.

1.4.2 Specific environmental loadings such as loadings due to ice, snow or earthquake are not dealt with in the present Rule Note. In case such loadings are to be considered, the Offshore Rules are to be referred to.

1.5 Documentation to be submitted

1.5.1 The data defining the environmental conditions are to be specified in terms of:

- wave data
- wind data
- current data
- water depth and tide data
- atmospheric and sea temperature data,

and, where applicable:

- marine growth
- any other relevant conditions.

2 Waves

2.1 General

2.1.1 Waves data are to be specified, for the purpose of resistance assessment, for each condition of the unit.

2.1.2 For a given condition of operation of the unit, the wave height is to be specified for a sufficient range of periods, such that the maximum response of the unit is properly covered for all the sea states liable to be met in such a condition. Directional data may be considered, where applicable.

2.1.3 The wave conditions to be considered for design purposes of the unit in elevated position (see Sec 3, [2.1]) may be described by design wave methods or by a stochastic method using the wave energy spectrum. The stochastic method is to be used for the fatigue analyses.

2.2 Design wave approach

2.2.1 In design wave approach (deterministic or quasi-static method), the sea states are represented by regular waves.

2.2.2 The design waves are to be those producing the most unfavorable loads on the structure, taking into account the size and shape of the structure.

2.2.3 Where the design wave approach is used, the wave data are to be specified, for each design condition, in terms of:

- maximum wave height H_{max}
- associated wave period T_{ass}
- wave direction.

2.2.4 For a 3-hour sea state, the following relationship between the significant wave height H_s and the maximum wave height H_{max} is to be considered:

$H_{max} = 1,86\ H_s$

This relationship is to be applied for the air gap calculation, to obtain the wave crest elevation.

2.2.5 If T_{ass} , the associated period to H_{max} , is not specified, it is to be taken equal to, in s:

$$T_{ass} = 2,5\sqrt{H_{max}}$$

2.2.6 For wave force calculation, a reduced wave height H_{det} , determined as follows, may be applied:

$H_{det} = 1,60\ H_s$

This reduced wave height is to be used with a wave kinematic factor of 1,0 as hydrodynamic properties.

2.2.7 In addition to [2.2.3], wave data are to be specified for wave periods equal or close to the natural period of the unit (see Sec 5, [4.5]).

2.3 Random/stochastic wave approach

2.3.1 In random/stochastic wave approach, the irregular sea states are described by wave energy spectrum.

2.3.2 For structure with significant dynamic response (see Sec 5, [4.5.4]) and for fatigue assessment, the sea state is to be described by a random wave mode.

2.3.3 Short-term irregular sea state

A short-term irregular sea state is described by means of wave energy characterized by:

- the significant wave height H_s
- the peak period T_p or the zero up-crossing period T_z
- a wave spectrum
- the mean wave direction
- a directional spreading function, where applicable.

Irregular sea states are actually divided into two broad types: wind seas and swells. Wind seas are generated by local wind whereas swells are waves which have no connection to the local wind but have travelled out the area where they were generated. Spectra for swells and wind seas are to be clearly distinguished.

In general, the Pierson-Moskowitz spectrum is to be applied. Narrower spectrum, such as JONSWAP or swell spectrum, should be considered for location with limited fetch or shallow water (see [1.2], item a).

2.3.4 Long-term distribution of the irregular sea state

A long-term distribution of the sea state is described by a family of wave spectra with their associated probability of occurrence.

The sea state statistic data are generally provided under the form of a "scatter diagram" with the joint distribution of significant wave height and wave period:

- H_s intervals of 1 meter
- T_p (or T_z) intervals of 1 second
- number of occurrences, with a reference duration of 3 hours.

The scatter diagram summarizes the directions, together with the number / percentage of occurrences for each heading sector.

Extreme environmental conditions, either directional or seasonal extremes (typhoons, etc.) given by a metocean specialist, are to be separately described and documented in specification, and are to be submitted to the Society for information.

3 Wind

3.1 Wind specification

3.1.1 Wind data are to be specified for the purpose of resistance assessment in elevated position and for stability assessment in floating position.

3.1.2 As the wind velocity changes with both time and height above sea level, the wind design data are to be specified as the wind speed at a reference height above the water level (usually 10 m above the mean water level) and averaged over 1 minute, or another suitable reference time interval.

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

3.1.3 Wind is to be considered from any direction relative to the unit. Directional data may be considered, where applicable.

4 Current

4.1 Current specification

4.1.1 Current data are to be primarily specified for the purposes of resistance assessment of the self-elevating unit in elevated position.

4.1.2 The current velocity profiles are to be specified from the sea bed to the sea surface level (SWL), taking into account the contribution of all the relevant components such as tidal current, wind generated current, circulation current, etc.

Where no particular data are specified:

- the wind generated surface current may be taken as 2,6% of the reference wind speed as defined in [3.1.2]
- the current profiles suggested in standards given in [1.2.1], item b) or item c) may be applied.

Unusual bottom or stratified effects are to be clearly stated, when relevant.

Directional profiles may be considered, where applicable.

5 Water depth and tides

5.1 Water depth and tide specification

5.1.1 The maximum still water level (SWL), as defined in Sec 1, [4.4], is to be specified for the purposes of resistance assessment of the self-elevating unit in elevated position.

5.1.2 For the purpose of strength analysis at a given site, consideration is also to be given to the minimum water depth associated with extreme waves.

6 Design temperatures

6.1 Air temperature

6.1.1 For the emerged part of the structure (splash zone and above), the design temperature is defined as the mean air temperature of the coldest day (24 h) of the year for any anticipated area of operation.

6.1.2 Where no particular value is specified, the following design air temperature may be considered:

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

6.2 Water temperature

6.2.1 For the immersed part of the structure, the design temperature is the water temperature of the coldest day (24 h) of the year for any anticipated area of operation.

6.2.2 Where no particular value is specified, a design water temperature of 0°C may be considered.

7 Marine growth

7.1 Marine growth specification

7.1.1 The marine growth data, if relevant, are to be specified for the purpose of global analysis of the self-elevating unit since they tend to modify the drag and the inertia forces and to increase the leg mass.

7.1.2 Thickness t_{MG} of marine growth and the application height on the legs of the self-elevating unit, if relevant, are to be specified.

8 Soil

8.1 General

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

8.1.2 As a rule, the minimum and maximum design penetrations of the leg tip (legs with spudcan or legs with mat) below mud line are to be specified.

8.1.3 The effects of scouring on the bottom bearing surface may be considered.

SECTION 5 ANALYSIS IN ELEVATED POSITION

Symbols

λ : Wave length to be taken equal to:

$$\lambda = \frac{g}{2\pi} T_{ass}^2$$

The actual value in shallow water is to be considered if necessary

ρ : Sea water density, to be taken equal to 1,025 ton/m^3

P_a : Average vertical loads, in kN, in the leg in way of the fixation system, if any, or at mid-distance between upper and lower guides otherwise

P_{Euler} : Euler critical loads, in kN, defined by:

$$P_{Euler} = \frac{\pi^2 EI}{(k\ell)^2} 10^{-5}$$

where k is the effective leg length factor, to be taken equal to 2,0 for legs with independent footings and 1,2 for legs with mat, except otherwise duly justified

T_{ass} , E, I and ℓ are defined at the beginning of the present Rule Note.

1 General

1.1 Application

1.1.1 The purpose of this Section is to provide requirements related to the global analysis of the self-elevating unit in elevated position:

- Articles [2] and [3] apply to the structural and hydrodynamic modelling of the self-elevating unit
- Articles [4] and [5] apply to the determination, application and combination of the loads
- Article [6] deals with the resistance assessment. It includes air gap, leg length reserve, stability and structure checks. Additional local analyses are specified for the critical structural members.

1.2 Reference

1.2.1 Industry standards

a) Technical and Research Bulletin 5-5A: “Guidelines for Site Specific Assessment of Mobile Jack-up Units published” by the Society of Naval Architects and Marine Engineers (SNAME)

b) API RP 2A-WSD: “Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design”

c) ISO 19905-1: “Petroleum and natural gas industries - Site-specific assessment of mobile offshore units - Part 1: Jack-ups”.

1.3 Calculation procedures

1.3.1 A global analysis of the self-elevating unit in elevated position is to be performed in order to:

- check the overall behaviour
- assess the air gap and the overturning stability, and
- determine the maximum strength capacity of the legs, the elevating and fixation system(s) and the leghouses.

The analysis is to be based on environmental data submitted by the Party applying for classification, in compliance with Sec 4.

1.3.2 The non-linear characteristics of the self-elevating unit may be modelled either accurately or with equivalent simplified assumptions. In most cases, the latter ones are sufficient for the representation of a realistic global response.

1.3.3 The critical structural areas may be identified during the global analysis. They are to be locally analysed through a finite element analysis.

1.4 Definitions

1.4.1 A self-elevating unit is to sustain the global loads due to the application of external environmental loads. For the purpose of the present Rule Note, the following definitions are reminded:

- the overturning moment is defined as the total moment generated by the environmental loads and which tends to capsize the unit
- the base shear force is defined as the total horizontal resulting force transferred to the soil by the footings.

2 Structural modelling

2.1 General

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

The simplified and detailed levels of modelling described from [2.2] to [2.5] may be combined. In principle, a simplified model performed in accordance with [2.2.1], [2.3.2] and [2.4.2] is accurate enough for the assessment of the overall behaviour of the self-elevating unit in elevated position.

2.2 Hull modelling

2.2.1 Beam model

In case a beam model is used for the modelling of the hull, the stiffness and inertia of the model are to represent those of the hull. The model is to be based on a grillage of equivalent beams modelling side shell, longitudinal and transverse bulkheads. These equivalent beams are positioned at their neutral axis. Their span, spacing, attached plating and mechanical properties are to be determined according to Sec 2, [2.5].

The hull has usually a closed box shape and, so, is not made of several open section beams. Therefore, particular attention is to be paid to the assessment of the torsional inertia of the equivalent beams. The overall torsional inertia of the hull may be estimated, considering the hull girder as a box-type section beam and distributed between the beams.

The formula of torsional inertia for box-type section beam given in the Ship Rules, Pt B, Ch 7, App 1, [3.5.2] may be applied as a guidance.

2.2.2 Finite element models

The structural model is to represent the primary supporting members with the plating to which they are connected.

The ordinary stiffeners are also to be represented in order to reproduce the stiffness and inertia of the actual hull structure. In principle, they are to be represented by beam elements.

Meshing is to be carried out following the uniformity criteria for the different elements, i.e.:

- most of the quadrilateral elements are to be such that the ratio between the longer side length and the shorter side length does not exceed 2. Some of them may have a ratio up to 4. Their angles are to be greater than 60° and less than 120°. The triangular element angles are to be greater than 30° and less than 120°
- in principle, the size of the elements is not to exceed the spacing of the secondary stiffeners. A finer mesh (typically 100 mm x 100 mm) is to be used for local strength assessment.

2.3 Leg modelling

2.3.1 General

The leg stiffness used in the global analysis may account for a contribution from a portion of the rack tooth material. The assumed effective area of the rack teeth is not to exceed 10% of their maximum cross-sectional area. When the capacity of the chords is checked, the chord properties are to be determined discounting the rack teeth.

2.3.2 Equivalent leg model

Lattice legs may be represented as equivalent beam models. In that case, special care is to be paid on the representation of the actual cross-sectional and shear areas, as well as of the bending and torsional moments of inertia.

The formulae given in Sec 2, Tab 2 and Sec 2, Tab 3 may be used as a guidance.

2.3.3 Detailed leg model

The legs are to be modelled using either shell or beam elements. The model geometry of the leg is to be fully in accordance with the design. For lattice legs modelled with beam elements, the chords and bracings are to be represented at their neutral axis. Brackets, if any, need not, normally, be taken into account for the global analysis, but they are to be considered for the local analysis.

2.4 Leg/hull connection modelling

2.4.1 General

Particular attention is to be paid to the modelling of the leg/hull connection since it influences the force and moment distribution over the whole structure.

2.4.2 Simplified modelling

For simplified modelling, the connection between the leg and the hull is to be assumed fixed in way of the fixation system, if any. Otherwise, it is to be assumed fixed at mid-distance between the upper and lower guides.

2.4.3 Detailed modelling

The connections between guides and legs, as well as between elevating/fixation systems and legs, are to be accurately modelled at their actual positions, with proper stiffnesses and acting directions to reflect the actual connections.

a) Guides

   The upper and lower guides are to be modelled to sustain the horizontal loads (from the legs) only in the directions where the actual contacts can happen. The local guide structures are relatively rigid, compared to their adjacent structures in the leghouses.

   The nominal position of the lower guide is to be determined based on the sum of leg penetration, water depth and air gap in each elevated condition. For lattice type legs, additional positions in way of the leg nodes and at mid-span between two nodes (around the nominal position) are to be studied, in order to have a proper strength assessment of the leg chords and bracings.

   A series of spring/gap elements are generally to be applied for the modelling of the connections between guides and legs. These elements are to be properly oriented in the horizontal plane to reflect the actual contact directions. In case spring elements are applied, tensile loads in these elements are to be avoided by manual release.

   Initial gap and/or fabrication tolerance between legs may be considered in the modelling.

b) Elevating systems

   In case a rack-and-pinion elevating system is fitted, the jacking pinions are to be modelled using the pinion stiffness specified by the manufacturer. The pinions are to sustain the vertical load and the corresponding horizontal load. The initial gap representing total clearance due to backlash, wear and tolerances should be considered in the modelling.

In case a pin-and-hole elevating system is fitted, the elevating device is to be modelled using the stiffness values obtained from the manufacturer. The device is to sustain the vertical loads. A spring element is generally to be applied for the modelling of the connection between the elevating device and the leg.

Any other elevating system is to be modelled to reflect the actual interaction mechanism, on a case-by-case basis.

c) Fixation system

The fixation system is to be modelled to sustain both vertical and horizontal loads, based on the stiffness specified by the manufacturer.

The local moment strength of the fixation system should be considered either:

- by modelling two sets of connections, respectively at top and bottom of the fixation system, or
- by including a rotational stiffness.

Guidance on the modelling of other elements such as shock pads can be found in [1.2.1], item a).

2.5 Boundary conditions

2.5.1 The following boundary conditions are to be considered:

- for the design of the leg upper part as well as the leg/hull connection, the spudcans are assumed to be simply supported
- for the design of the leg lower part, the spudcans are assumed to be fixed.

2.5.2 For legs with mat, the boundary conditions are to be applied on the mat with a proper stiffness. Contact element/surface may be applied.

2.5.3 For the natural period assessment of the self-elevating unit (see [4.5]), the spudcans are assumed to be simply supported.

In case of self-elevating units having a natural period equal to or greater than the wave period, special considerations may be given by the Society to the boundary conditions.

2.5.4 In lieu of [2.5.1] and [2.5.3], the leg bottom stiffness, based on a relevant foundation analysis, may be taken into account on a case-by-case basis, in particular for permanent units.

2.5.5 The boundary conditions are to be applied either:

- at the maximum predicted penetration if the spudcan is partially penetrated, or
- at mid-height of the spudcan (including tip when relevant) if the spudcan is fully penetrated (spudcan upper surface covered by soil).

3 Hydrodynamic modelling

3.1 Marine growth

3.1.1 When applicable, a marine growth is to be included in the hydrodynamic model, adding the appropriate marine growth thickness on the outside boundary of each individual member below the mean water level (MWL) + 2 m.

Thus, for a tubular member, the outer diameter D becomes:

$D = D_{initial} + 2\ t_{MG}$

where:

$D_{initial}$: Initial outer diameter without marine growth

t_{MG} : Marine growth thickness, as specified in Sec 4, [7].

3.2 Drag and inertia coefficients

3.2.1 Drag and inertia coefficients are to be taken from recognized industry standards (see [1.2.1]).

The values of drag coefficient C_D and inertia coefficient C_M given in Tab 1 may be considered for the calculation, except otherwise mentioned.

Table 1 : Drag and inertia coefficients

Shape of beam cross-section	Surface condition	C_D	C_M
Cylindrical (outer diameter less than 1,5 m)	smooth	0,65	2,00
	rough	1,00	1,80
Rectangular	rough	2,00	$1 + \frac{\pi}{4}\left(\frac{D}{B} + \frac{1}{2}\sqrt{\frac{D}{B}}\right)$
B : Sectional dimension parallel to the flow D : Sectional dimension normal to the flow.			

3.2.2 The smooth values are to be applied above (MWL + 2 m) and the rough values below (MWL + 2 m), where MWL is as defined in Sec 1, [4.4.1].

3.2.3 In case an equivalent truss leg modelling is used, the hydrodynamic properties are to be calculated according to the standards quoted in [1.2.1], items a) and c).

4 Loads and load effects

4.1 Fixed and operational loads

4.1.1 Fixed loads

The fixed loads correspond to the light weight, i.e. the weight of the complete unit with all the permanently attached machineries, equipment and other items of outfit, such as:

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

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

4.1.2 Operational loads

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

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

The dynamic loads induced by the equipment in operation are to be considered as operational loads.

4.1.3 Mass distribution

The mass distribution resulting from the fixed and operational loads is to be accurately represented for each loading condition, in order to correspond to the actual total weight and the position of the centre of gravity.

4.1.4 Hull sagging

During installation on site, the hull usually switches from hogging condition, generated by the buoyancy, to sagging condition, due to hull self-weight and functional loads when the unit starts to jack up. The leg bending moment induced by hull sagging is widely dependent on the hull/guide clearances, the design of the jacking system and the operating parameters. This leg bending moment may be reduced on a case-by-case basis, according to the standards quoted in [1.2.1], items a) and c).

4.2 Leg inclination

4.2.1 The effect of static leg inclination is to be considered as it induces an additional bending moment at the leg guide connection.

The total offset e_0 of the leg spudcan, from the theoretical initial position, in m, is given by (see Fig 1):

$e_0 = e_1 + e_2 + e_3$

where:

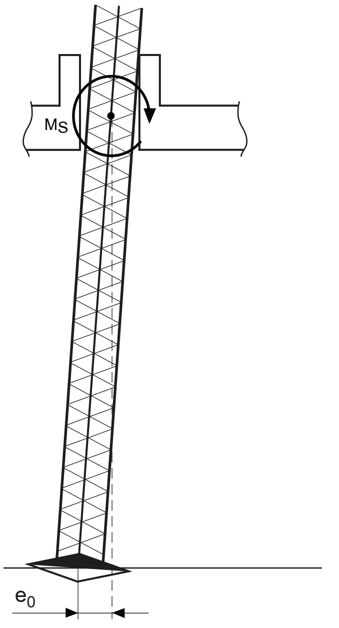
e_1 : Eccentricity due to leg/guide clearances, in m

e_2 : Offset due to the maximum hull inclination (heel and trim) permitted by the operating manual, in m

e_3 : Offset due to leg fabrication tolerances, in m.

The total offset e_0 is to be submitted by the designer.

Figure 1 : Total initial offset at spudcan



4.2.2 The additional bending moment M_S, in kN·m, at the leg hull connection, due to the static leg inclination, is to be calculated according to the following formula:

$$M_S = \frac{P_a e_0}{1 - \dfrac{P_a}{P_{Euler}}}$$

where:

e_0 : As defined in [4.2.1].

4.3 Wind loads

4.3.1 The wind loads are to be determined using the wind velocity and the wind profile as specified in Sec 4, [3].

4.3.2 When wind tunnel data are available, these data are to be considered for the calculation of the pressure and resulting forces.

4.3.3 When no particular data are specified, the wind force F_{Wind}, in kN, is to be calculated as follows:

$$F_{Wind} = \frac{1}{2} C_S C_H \rho_{Air} A_{Wind} V_{Wind}^2 10^{-3}$$

where:

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

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

ρ_{Air} : Air specific mass, equal to 1,222 kg/m^3

A_{Wind} : Projected area of the exposed surface of the structural member in the direction of the wind flow, in m^2

V_{Wind} : 1 minute wind velocity at 10 m above the mean water level (MWL), in m/s. See Sec 4, [3].

Table 2 : Shape coefficient C_S

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

Table 3 : Height coefficient C_H

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

4.3.4 The wind forces are usually evaluated in head and beam sea conditions (respectively F_0 and F_{90}).

They may be extrapolated to other wind headings, using the following formulae:

$F_x(\theta) = K_{Dc}\, F_0$

$F_y(\theta) = K_{Ds}\, F_{90}$

where:

- θ : Direction of the wind flow with x-axis, in degrees. The x-axis is defined as the longitudinal axis
- $F_x(\theta)$: Value of the wind force, in kN, along x-axis for the direction θ, with $F_x(0) = F_0$
- $F_y(\theta)$: Value of the wind force, in kN, along y-axis for the direction θ, with $F_y(90) = F_{90}$
- F_0 , F_{90} : Values of the wind force, in kN, corresponding to the head wind force and the beam wind force, respectively, and calculated according to [4.3.1]
- $K_{Dc}(\theta)$, $K_{Ds}(\theta)$: Coefficients defined by:

$$K_{Dc}(\theta) = \frac{2\cos(\theta)}{1 + [\cos(\theta)]^2}$$

$$K_{Ds}(\theta) = \frac{2\sin(\theta)}{1 + [\sin(\theta)]^2}$$

4.3.5 The wind forces are to be applied at the centre of the areas exposed to the wind.

4.4 Hydrodynamic loads

4.4.1 The reference dimensions of the submerged members of a self-elevating unit in a plane normal to the fluid velocity are normally less than five times the wavelength, and Morison forces are to be considered:

$F_{Hydro} = F_{Drag} + F_{Inertia}$

where:

- F_{Hydro} : Total hydrodynamic force (Morison force) per unit length, in kN·m^{-1}, to be applied on the submerged elements
- F_{Drag} : Morison drag force per unit length, in kN·m^{-1}, normal to the axis of the considered member and in the direction of the relative fluid velocity, defined by:

$$F_{Drag} = \frac{1}{2}\rho C_D D v_n |v_n|$$

- $F_{Inertia}$: Morison inertia force per unit length, in kN·m^{-1}, normal to the member axis and in the direction of the fluid particle acceleration normal to the member, defined by:

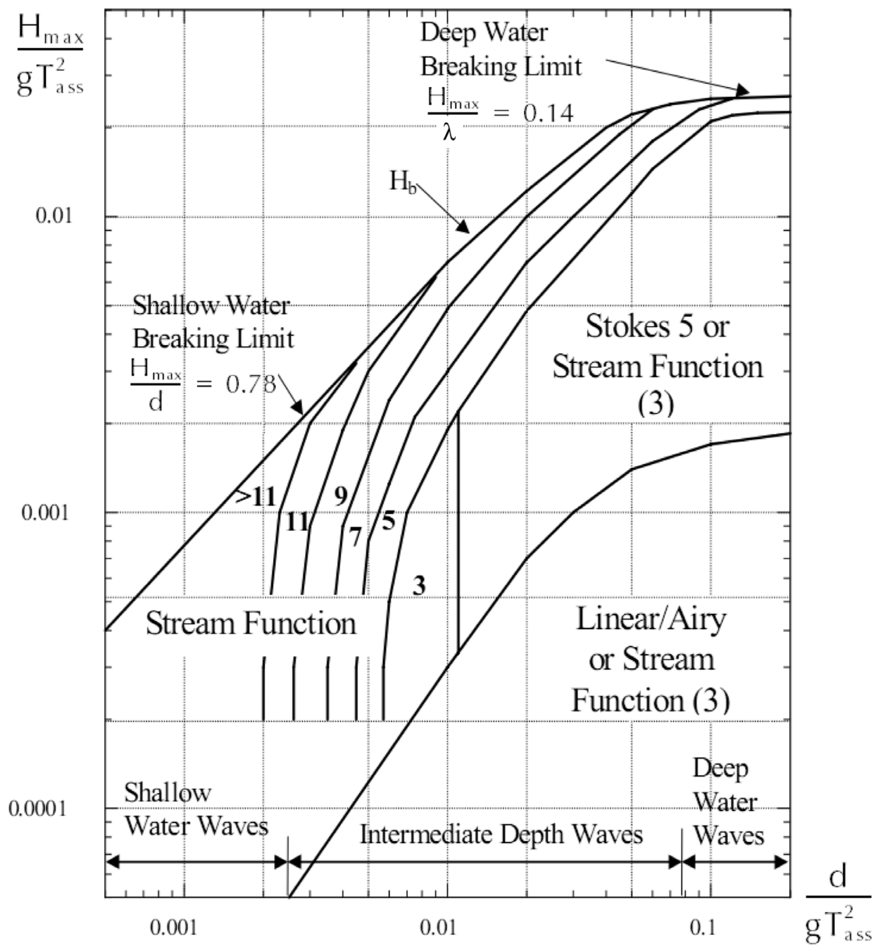
$$F_{Inertia} = \rho\, C_M\, S\, a_n$$

- C_D , C_M : Drag and inertia coefficients defined in [3.2]
- D : Reference dimension, in m, in a plane normal to the fluid velocity v_n
- v_n : Relative fluid particle velocity normal to the member axis, in m/s, taking into account the wave particle velocity u_n , the current velocity v_{Cn} , and the lateral velocity of the considered member if not negligible
- S : Cross-sectional area of the member, in m^2
- a_n : Fluid particle acceleration normal to the member, in m/s^2.

4.4.2 The evaluation of the wave particle velocity u_n and the fluid particle acceleration a_n is to be based on an appropriate wave theory (Airy, Stokes and Stream theory) according to the water depth, the maximum wave height and the associated wave period, as given in Fig 2.

For stochastic wave, by superposition of Airy waves, the wave kinematics between the wave crest and the still water level (SWL) should be estimated by stretching or extrapolation methods.

Figure 2 : Wave theory



d	:	Mean water depth, i.e. distance between the sea bed and the mean water level (MWL), in m, as specified in Sec 4, [5]
H_b	:	Breaking wave height, in m.

4.4.3 The current velocity v_{Cn} is to be computed from the current data specified in Sec 4, [4]. It is to be added vectorially to the wave particle velocity u_n.

4.4.4 The current profile is modified by the presence of the wave crest and trough. An appropriate current profile stretching or compressing method, according to the standard quoted in [1.2.1], item b), is to be applied for the determination of the drag force.

4.4.5 The phase difference of the wave between legs is to be considered for the assessment of the hydrodynamic loads.

4.5 Dynamic amplification loads

4.5.1 The natural periods of the self-elevating unit may fall within the range of the wave periods. Therefore, the wave loads, because of their time-varying nature, may excite the unit structure and amplify the static responses. To take into account this phenomenon, additional dynamic amplification loads are to be considered during the analysis.

4.5.2 The natural period T_0 of the unit is to be assessed, and its determination is to be performed using a finite element analysis.

As an alternative, T_0 may be obtained from the following formula:

$$T_0 = 2\pi\sqrt{\frac{M}{K}}$$

where:

M	:	Mass of the unit, in tons, defined by: $M = M_p + 0{,}5\ (M_{LL} + M_{WB} + M_{AW}) + M_{LU}$
M_p	:	Weight of the hull, in tons, including lightship and payload
M_{LL}	:	Total weight, in tons, of all the legs below either the lower guide or the centre of the locking mechanism if any
M_{LU}	:	Total weight, in tons, of all the legs above either the lower guide or the centre of the locking mechanism if any
M_{WB}	:	Total weight, in tons, of water ballast inside the legs if any

M_{AW} : Added water mass, in tons. M_{AW} is to be evaluated according to the following formula:

$M_{AW} = 1,025\ (C_M - 1)\ V$

with:

C_M : Inertia coefficient defined in [3.2.1]

V : Volume of the submerged part of the legs, in m^3

K : Transverse stiffness of the unit, in $kN{\cdot}m^{-1}$ defined by:

$$K = n\frac{3EI}{\ell^3}10^{-5}$$

with:

n : Number of legs.

4.5.3 The increase of the natural period due to Euler effect is to be taken into account either by a direct analysis or by the simplified methodology explained hereafter.

In case a direct analysis is used, the methodology is to be duly justified (see references in [1.2.1], items a) and c)).

Otherwise, the increase of the natural period is obtained from the following formula:

$$T_n = \frac{T_0}{\sqrt{1 - \frac{P_a}{P_{Euler}}}}$$

where:

T_n : Natural period of the self-elevating unit, in s, taking into account Euler effect

T_0 : Natural period of the self-elevating unit, in s, as defined in [4.5.2].

4.5.4 In principle, the dynamic amplification loads for the deterministic analyses are to be obtained using the classical Single Degree of Freedom (SDOF) methodology. More sophisticated methodologies (negative stiffness), as defined in the standards quoted in [1.2.1], items a) and c), are to be considered for stochastic analyses.

The dynamic amplification loads act in the same direction as the hydrodynamic loads defined in [4.4.1].

According to the SDOF method, the dynamic amplification loads F_{Dyn} are to be applied as nodal forces at the centre of gravity of the hull and calculated, in kN, with the following formula:

$F_{Dyn} = (DAF - 1)\ BS$

where:

BS : Amplitude of the quasi-static base shear force, in kN, due to the wave and current loads over one cycle:

$$BS = \frac{BS_{max} - BS_{min}}{2}$$

with:

BS_{max} : Maximum quasi-static base shear force, in kN

BS_{min} : Minimum quasi-static base shear force, in kN

DAF : Dynamic amplification factor, defined by:

$$DAF = \frac{1}{\sqrt{[(1-\Omega^2)^2 + (2\xi\Omega)^2]}}$$

with $DAF \geq 1,0$

Ω : Ratio defined by the following formula:

$$\Omega = \frac{T_n}{T_{ass}}$$

with:

T_n : Natural period of the self-elevating unit, in s, as defined in [4.5.3]

T_{ass} : Wave excitation period, i.e. associated period to H_{max}, in s, as specified in Sec 4, [2]

ξ : Percentage of the critical damping determined from Tab 4 and corresponding to the sum of the structural, foundation and hydrodynamic dampings.

In principle, ξ is to be taken as follows:

- $\xi = 0,04$ for the cylindrical and rectangular section legs
- $\xi = 0,07$ for the lattice legs.

Table 4 : Damping according to the source

Damping source	Critical damping
Structure holding system, etc...	0,02
Foundation	between 0 and 0,02
Hydrodynamic	between 0 and 0,03

4.5.5 When DAF is greater than 2, a stochastic wave approach (as defined in the standards quoted in [1.2.1], items a) and c)) is generally to be preferred to a design wave approach.

In any case, at the resonance and to account for irregular waves effect, DAF is to be taken such that:

$$DAF \leq \frac{1}{1,5\xi^{0,65}}$$

4.6 P – Δ and Euler effect

4.6.1 Due to high leg axial loads, the lateral or bending stiffness of the leg beam is reduced. As a result, the horizontal hull displacement under environmental loads is increased.

4.6.2 In principle, non-linear large displacement methods or simplified geometric negative stiffness methods, as defined in the standards quoted in [1.2.1], items a) and c), are recommended for the modelling of this phenomenon.

4.6.3 As an alternative, the linear first order hull displacement is to be increased using the following simplified geometric stiffness approach:

$$\Delta = \frac{\Delta_0}{1 - \frac{P_a}{P_{Euler}}}$$

where:

Δ : Amplified linear-elastic displacement, in m

Δ_0 : Linear first order hull displacement, in m, due to the environmental loads.

The displacement is usually measured at the centre of gravity of the hull.

The amplified linear-elastic displacement Δ may be obtained by applying additional nodal forces/moments at the centre of gravity of the hull.

5 Loading conditions and load combinations

5.1 Loading conditions

5.1.1 The structure of the unit in elevated position is to be designed for the following loading conditions:

- operating design conditions
- severe storm design conditions
- preloading condition
- retrieval condition
- accidental conditions, if relevant.

These loading conditions are to be based on data specified for the design conditions defined in Sec 3, [1.2.1], items a), b), d) and e).

5.2 Load cases

5.2.1 For each loading condition, load cases are to be established. The load cases refer to the most unfavourable combinations of the environmental loads with the fixed and associated operational loads.

5.2.2 For operating, severe storm and accidental loading conditions, the loads defined in [4.1] to [4.6] are to be considered.

5.2.3 For preloading condition, loads defined in [4.1] and [4.2] are to be considered. Environmental loads are usually not considered.

5.2.4 In addition to [5.2.1], static load cases are to be analysed for hull strength assessment. The static load cases refer to the most unfavourable combinations of the fixed and operational loads on the hull.

For these static load cases, the loads defined in [4.1] and [4.2] are to be considered. No environmental load is taken into account.

5.2.5 If necessary, other load cases that might be more critical are also to be investigated.

5.3 Load combinations

5.3.1 For each load case, the environmental loads (current, wave, wind and dynamic amplification loads) are assumed to act simultaneously in the same direction.

5.3.2 At least the environmental load headings shown on Fig 3 and Fig 4 are to be considered.

The environmental load headings are to be considered with respect to the position of the centre of gravity of the unit to maximize the forces and bending moments in the legs.

Other environmental load headings may be required by the Society, on a case-by-case basis, in particular for hulls with more than four legs.

5.3.3 For each heading, the environmental elements (wind, waves and current) are to be combined with their design values.

For wave load assessment, the most unfavourable combination of wave height, wave period and water level is to be retained.

Wave loads are to be assessed considering the maximum wave height H_{max} and generally a range of wave periods. A range of ± 15% around the specified period is recommended. The wave loads are also to be evaluated at the natural period of the unit with the appropriate wave height (see Sec 4, [2.2]), if more severe.

Figure 3 : Environmental load headings for triangular hull

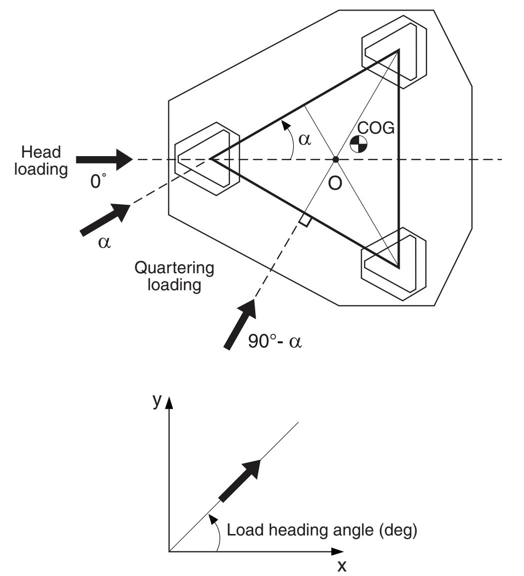
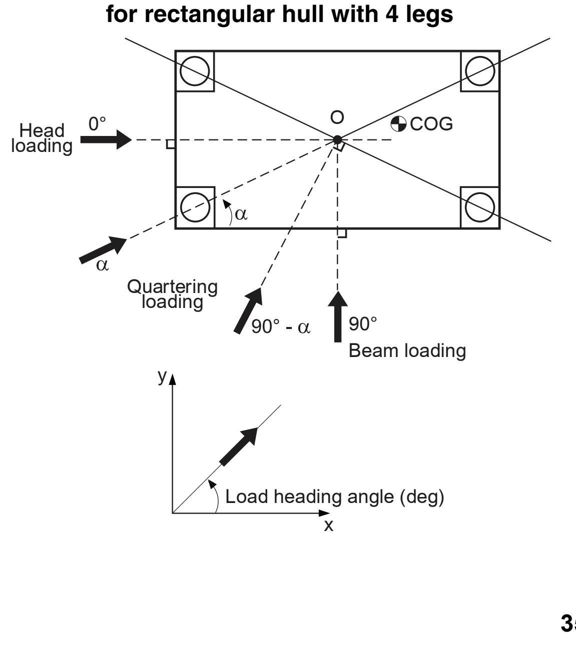


Figure 4 : Environmental loads headings for rectangular hull with 4 legs



6 Resistance assessment

6.1 Air gap

6.1.1 General

Self-elevating units are to be designed with sufficient air gap (see definition in Sec 1, [4.5]) to allow the passage of waves larger than the design waves under the hull.

The crest elevation, to be considered for air gap assessment, is to be measured above the maximum Still Water Level (see definition in Sec 1, [4.4]).

The crest clearance is to be measured between the underside of the unit in the elevated position and the crest of the design wave.

6.1.2 Mobile units

The unit is to be designed for a crest clearance of either:

- 1,2 m (4 feet), or
- 10% of the combined storm surge, astronomical tide and height of the maximum wave crest above the mean low water level (i.e. LAT),

whichever is less.

The air gap is to be calculated with the maximum wave height having a return period of 50 years.

6.1.3 Permanent units

The unit is to be designed for a crest clearance of at least 1,5 m (5 feet).

The air gap is to be calculated with the maximum wave height having a return period of 100 years.

The Society may require a higher air gap or a higher crest clearance, on a case-by-case basis.

6.2 Leg length reserve

6.2.1 A minimum leg length reserve of 1,5 m above upper guide, or one jack stroke on the hydraulic units, is to be fitted so as to provide a contingency in case the actual penetration exceeds that predicted.

6.2.2 A larger leg length reserve may be required, on a case-by-case basis.

6.3 Overturning stability

6.3.1 Definitions

The self-elevating unit is to have a sufficient reserve stability against the overturning moment generated by the metocean loads.

As defined in [1.4], the overturning moment tends to capsize the unit. It is to take into account the wave, wind, current effect, P-Δ effect and dynamic amplification loads.

Conversely, the stabilizing moment tends to stabilize the unit. It is generated by the fixed and operational loads corresponding to the loading condition.

As a rule, the minimum elevated weight is normally to be determined assuming 50% of the variable load permitted by the operating manual. The stabilizing moment is to be reduced considering buoyancy and leg inclination.

The stabilizing and overturning moments M_s and M_o are to be calculated around an horizontal axis of rotation passing by the centre of two spudcans (see Fig 5). Special consideration may be asked by the Society for self-elevating units with mast supports.

6.3.2 Criterion

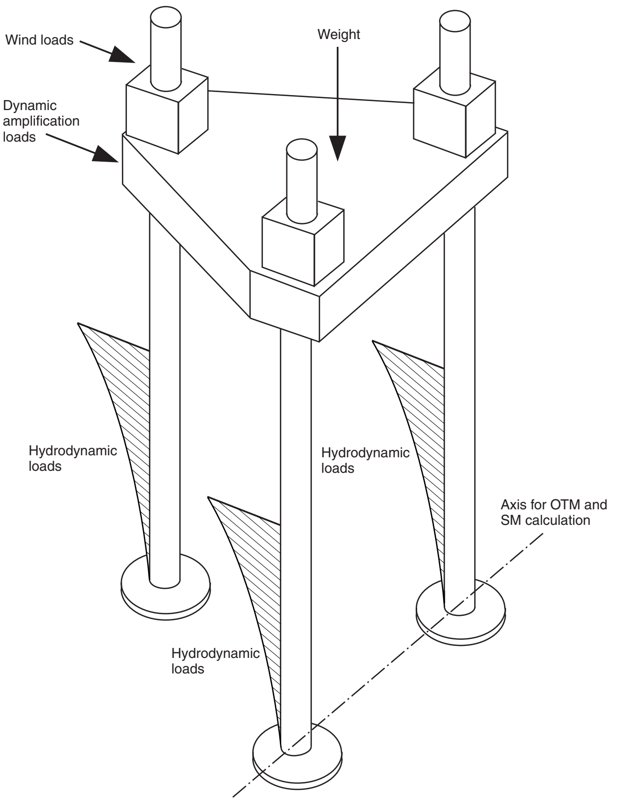
In operating and severe storm conditions, the stabilizing (M_s) and overturning (M_o) moments, in kN·m, are to fulfil the following criterion:

$M_s > 1,25\ M_o$

6.3.3 Permanent units

For permanent units, the overturning moment M_o is to be assessed considering the maximum wave height having a return period of 10 000 years.

Figure 5 : Axis of rotation for overturning and stabilizing moments



OTM means overturning moment; SM means stabilizing moment.

6.4 Structural strength in elevated position

6.4.1 General

The structural strength is to be checked in elevated position, as follows:

- leg scantlings
- elevating system included pinions and rack teeth, if any
- guide and leghouse connections
- spudcans and mat footing scantlings
- overall hull strength
- local structural details of the hull, if relevant.

For structural strength calculation of these elements, the basic allowable stress factor α, as defined in the Offshore Rules, Pt B, Ch 3, Sec 3, [5.4.2], is to be taken as follows, depending on the load cases:

- "Static" and "Preloading": $\alpha = 0,6$
- "Operating", "Severe storm" and "Retrieval": $\alpha = 0,8$
- "Accidental": $\alpha = 1,0$

Note 1: The load cases "Operating" and "Severe storm" refer to load case 2 in the Offshore Rules, Pt B, Ch 2, Sec 3.

Note 2: The basic allowable strength for load cases "Static" is increased by one-third for load cases 2 ("Operating" and "Severe storm") and by two-third for load cases 3 ("Accidental") defined in Pt B, Ch 2, Sec 3, [6.3] of the Offshore Rules. The same principle is to be applied when strength assessment is requested to be checked according to industry standards, such as quoted in [1.2.1], item b).

6.4.2 Legs

Legs are to be analysed through at least a beam model (integrated or separated from the global model), simply supported in way of the spudcan and satisfying the boundary conditions of the connections with the leghouses. Attention is drawn on lattice legs which are to be accurately modelled with all the chords and bracings, as specified in [2.3.3].

The global loads applying on legs, i.e.:

- the bending moment about the leg y-axis M_{by}
- the bending moment about the leg z-axis M_{bz}
- the shear force T, and
- the axial load distribution P along the legs,

are to be obtained from the global analysis. The application of the bending moments and shear force on the leg model may be performed by means of forces F_U (at upper guide) and F_L (at lower guide), calculated as per [6.4.3].

In case of units with lattice legs, the global or local analysis is to provide the following loads for each structural member i (bracings and chords):

- the bending moment about y-axis M_{by_i}
- the bending moment about z-axis M_{bz_i}
- the shear force $T_{\_i}$
- the axial force $P_{\_i}$, and
- the torsion moment M_{t_i}.

The local hydrostatic sea pressure p_h , in N/m², applying onto the leg members is determined as follows:

$$p_h = \rho g \left[z_d + \frac{1}{2} H_{max} \frac{\cosh\left(\frac{2\pi}{\lambda}(d - z_d)\right)}{\cosh\left(\frac{2\pi}{\lambda}d\right)} \right]$$

where:

d : Still water depth, in m, from the seabed to the SWL

z_d : Depth below the SWL, in m, counted positive downward.

The leg structure is to sustain the global and local loads. The scantlings of the legs are to comply with the requirements of Sec 7.

6.4.3 Guide and leghouse connections

The finite element analysis of the leghouses is to be performed. Particular attention is to be paid to the load transfer from the legs to the guides and leghouses.

In case of global analysis in which the leg/hull connections are simply modelled according to [2.4.2], the loads F_U and F_L , respectively at upper and lower guides, are obtained, in kN, from the following formulae (see also Fig 6):

$$F_U = \frac{M_{LG}}{h_G}(1 - \chi)$$

$$F_L = F_U + T_{LG}$$

where:

h_G : Distance between the lower and upper guides, in m

M_{LG} : Bending moment in the leg at the lower guide, in kN·m

T_{LG} : Shear force in the leg just below the lower guide, in kN

χ : Part of bending moment taken by jacking mechanisms (see Fig 6).

χ is to be considered as follows:

- for a jacking system without racks and pinions or fixation system: $\chi = 0$
- for a jacking system with racks and pinions (fixation system not fitted), χ may be calculated as follows:

$$\chi = \frac{1}{1 + \frac{G h_G A_{Shear}}{K_R} 10^3}$$

with:

G : Shear modulus, in N/mm², to be taken equal to $0,8 \cdot 10^5$ for steel

A_{Shear} : Shear area of the leg, in m², as defined in Sec 2, Tab 2, corresponding to A_{Shy} and A_{Shz} with respect to the leg axis

K_R : Rotational stiffness of the leg/hull connection due to racks and pinions, in kN·m rad^{-1}

K_R may be calculated by the following simplified two-dimensional model (see Fig 7):

$$K_R = \frac{1}{2} K_e d_e^2$$

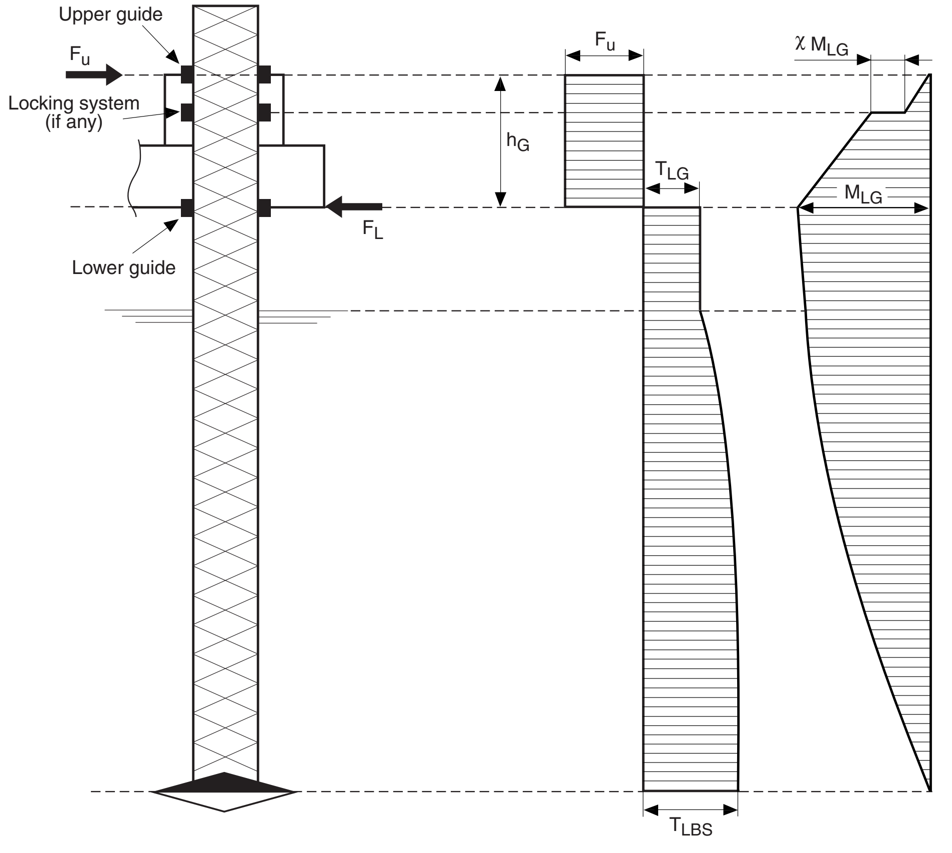
K_e : Vertical stiffness of the rack and pinion system (see Fig 7), in kN/m

d_e : Minimum distance between the teeth of the opposite leg racks in the considered direction (see Fig 7), in m.

For the design of legs and guides: $\chi \leq 0,5$

- for a jacking system with a fixation system:
  - for the design of the locking system: $\chi = 1,0$
  - for the design of the legs and guides: $\chi \leq 0,75$

Figure 6 : Bending moment and shear force at leg/hull connections

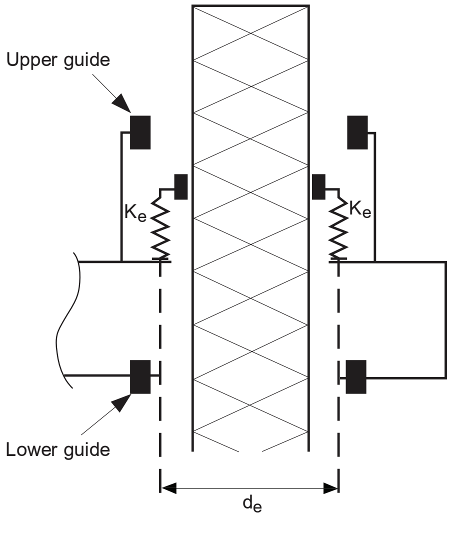


T_{LBS} : Leg base shear.

It is to be checked that the strength of the guides and leg-houses is in compliance with the following criteria:

- yielding criteria: refer to Pt B, Ch 3, Sec 3, [5] of the Offshore Rules
- buckling criteria: refer to Pt B, Ch 3, Sec 3, [6] of the Offshore Rules and Sec 7 of the present Rule Note, when relevant
- fatigue criteria, if relevant: refer to [6.5].

Figure 7 : Rotational stiffness of the elevating system



6.4.4 Elevating and locking systems

The elevating and locking systems are to be designed to withstand the loads (i.e. the vertical force and the part of bending moment not taken by guides as specified in [6.4.3]) coming from the global analysis.

Refer to Sec 10, [1].

The elevating and locking systems and their supporting structural members are to be in compliance with the following criteria:

- yielding criteria: refer to Pt B, Ch 3, Sec 3, [5] of the Offshore Rules
- buckling criteria: refer to Pt B, Ch 3, Sec 3, [6] of the Offshore Rules and Sec 7 of the present Rule Note, when relevant
- fatigue criteria, if relevant: refer to [6.5].

6.4.5 Spudcans and mat footing

A three-dimensional finite element analysis is to be performed to check the strength of spudcans/mat footing.

Uneven seabed condition may be required to be considered in the analysis.

The loading conditions in accordance with Sec 3 are to be agreed by the Society. As a minimum, the following conditions are to be considered for the resistance check of spudcans:

- the maximum preloading combined with a footing moment equal to one-third of the bending moment in the leg is to be considered, and
- the spudcan tip is to withstand half of the preload force. The remaining half is to be taken by small areas around the tip.

In case the spudcan/mat tanks are not vented freely to outside sea, the hydrostatic pressures under the maximum water depth (taking into account the astronomical and storm tides) are to be applied on the outer boundary of the spudcan/mat, in all the loading conditions.

It is to be checked that the spudcan and mat footing are in compliance with the following criteria:

- yielding criteria: refer to Pt B, Ch 3, Sec 3, [5] of the Offshore Rules
- buckling criteria: refer to Pt B, Ch 3, Sec 3, [6] of the Offshore Rules.

6.4.6 Overall hull strength

The hull is to be checked, in elevated position, in static loading condition. The overall hull strength is to be in compliance with the following criteria, using $\alpha = 0,6$:

- yielding criteria: refer to Pt B, Ch 3, Sec 3, [5] of the Offshore Rules
- buckling criteria: refer to Pt B, Ch 3, Sec 3, [6] of the Offshore Rules and Sec 7 of the present Rule Note, when relevant.

6.4.7 Local structural details of the hull

A relevant methodology is to be used for the assessment of the hull critical details. For appurtenances and their attachments, see Sec 8.

It is to be checked that these structural members are in compliance with the following criteria:

- yielding criteria: refer to Pt B, Ch 3, Sec 3, [5] of the Offshore Rules
- buckling criteria: refer to Pt B, Ch 3, Sec 3, [6] of the Offshore Rules and Sec 7 of the present Rule Note, when relevant
- fatigue criteria, if relevant: refer to [6.5].

6.5 Fatigue analysis

6.5.1 General

Fatigue calculation is to be provided to the Society for units with lattice legs or units operating in waterdepth greater than 40 m. The Society may request fatigue calculation for waterdepth less than 40 m, if deemed necessary.

The fatigue life of the unit is to be specified by the Party applying for classification. Otherwise, a fatigue life of 20 years on site is to be considered.

6.5.2 Fatigue analysis methodologies

Spectral analysis techniques are recommended. Other rational methods may be used, provided adequate representation of the forces and member responses can be demonstrated.

Both time and frequency domain methodologies may be applied (see [1.2.1], item b)).

6.5.3 Structural details

Fatigue assessment of the following details is to be performed:

a) Legs:
   - nodes for lattice legs
   - thickness tapering, if any, for cylindrical and rectangular section legs
   - leg connection with spudcan/bottom mat
   - leg connection piece for dismountable legs

b) Leghouses:
   - nodes for latticed jackhouses
   - end of bracket connections leading to hard points.

The Society may require other details to be checked, when deemed necessary, on the basis of the detailed geometry and stress level.

In addition to those details, the locations where the calculated hot spot stress is higher than the allowable yielding criteria are to be assessed for fatigue.

6.5.4 Loading

The spectral fatigue analysis is to take into account, at least, except duly justified:

- 12 headings (every 30 degrees)
- 25 frequencies for frequency domain calculations. Refinements are to be performed around peak and cancellation frequencies.

6.5.5 Load cases for fatigue evaluation

For fatigue evaluation, operating and storm conditions are to be considered proportionally to the duration of each condition on site over the total design life. Several sites may be considered, if necessary. Towing condition may be taken into account if relevant.

6.5.6 Stress concentration factors

The stress concentration factors are usually assessed through a Finite Element Model computation or parametric formulae (see Note 1).

Note 1: Efthymiou M., Development of SCF formulae and generalised influence functions for use in fatigue analysis, OTJ'88, Surrey 1988.

6.5.7 S-N curves

The S-N curves are to be taken from recognized standards.

6.5.8 Criterion

The damage ratio is to be not greater than the values given in Tab 5.

Table 5 : Damage ratio

Consequence of failure	Degree of accessibility for inspection, maintenance and repair		
	Not accessible **(2)**	Underwater inspection **(3)**	Dry inspection **(4)**
Critical **(1)**	0,10	0,33	0,50
Non-critical	0,20	0,50	1,00

(1) Critical damage includes loss of life, uncontrolled pollution, collision, sinking, other major damage to the installations and major production losses. All the structural elements are to be considered as critical, unless duly justified by an analysis of the consequences of failure.

(2) Includes areas that can be inspected in dry or underwater conditions but require heavy works such as dry-docking for repair.

(3) Includes areas that can be inspected in dry conditions but with extensive preparation and heavy impact on operation.

(4) Allowable damage ratio to be considered for mobile units (units inspected in dry dock as specified in the Offshore Rules, Part A). Legs and leghouses are to be considered as critical elements.

SECTION 6 ANALYSIS IN TRANSIT AND INSTALLATION CONDITIONS

Symbols

L : Rule length, in m, of the unit. L is to be not less than 96%, and need not exceed 97%, of the extreme length at the summer load waterline on transit

For non-rectangular hull, L is to be based on the extreme length of the unit, parallel to the towing direction at the summer draught

B : Moulded breath, in m, measured at the middle of the unit length

Δ : Total displacement of the unit, in tons

C : Wave parameter, to be taken equal to:

- for L < 90 m:

$$C = (118 - 0{,}36\ L)\frac{L}{1000}$$

- for L ≥ 90 m:

$$C = 10{,}75 - \left(\frac{300 - L}{100}\right)^{1,5}$$

D : Depth of the unit, in m

C_w : Waterplane coefficient, taken equal to:

$$C_w = \frac{A_w}{LB}$$

A_w : Waterplane area, in m²

T : Draught of the unit, in m, corresponding to the loading case for transit or installation condition

A_R : Roll single amplitude of the unit, in rad (see also the minimum values defined in Sec 3, [3.2.3])

A_P : Pitch single amplitude of the unit, in rad (see also the minimum values defined in Sec 3, [3.2.3])

KG : Vertical centre of gravity of the unit, in m, measured from the baseline and considered positive upwards

GM_t, GM_l : Distances, in m, from the unit centre of gravity to the transverse and longitudinal metacentres respectively, for the transit and the installation conditions. GM_t and GM_l are to be obtained from stability and/or hydrodynamic calculations

P_{Leg} : Total weight of one leg, in tons, including spudcan

P_h : Total weight of the hull, in tons

δ_t, δ_l : Roll and pitch radii of gyration, in m, for the transit condition, to be obtained from stability and/or hydrodynamic calculations (see also [4.1.4])

T_R, T_P : Roll and pitch periods, in s (see also [4.1.3])

x_i, y_i, z_i : Distances, in m, measured as shown on Fig 1

R_y : Minimum yield stress, in N/mm², of the material, to be taken equal to 235/k N/mm², unless otherwise specified

k : Material factor defined in [1.2.1]

σ_{VM} : Von Mises equivalent stress obtained from the following formula:

$$\sigma_{VM} = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2 + 3\tau_{12}^{\ 2}}$$

1 General

1.1 Application

1.1.1 The requirements of the present Section are complementary to the provisions of Sec 5.

1.1.2 The structural elements of the self-elevating units are to be adequately designed to withstand the load conditions induced by the unit motions when field and/or ocean transit are/is provided.

The main loads to be taken into account, resulting from the motions and accelerations of the unit induced during transit, are:

- the forces and moments induced by the legs, as defined in [4.2], for local reinforcement in way of the guides of the self-elevating units
- the sea pressure, for the scantling of the plates, the ordinary stiffeners and the primary supporting members.

  Depending on the type and size of the unit, the sea pressures to be considered are defined either in [4.4] or in Pt B, Ch 5, Sec 5 of the Ship Rules.

1.1.3 The structural elements of the self-elevating units are, in addition, to be adequately designed to withstand the loads during installation, as defined in [5.2].

1.1.4 Each main structural element of the unit (legs, hull and legs/hull interfaces) may be examined separately, taking into account the interaction forces and moments induced by the unit motions.

1.1.5 Hull structure

The hull structure of the unit is to be examined depending on the type and shape of the unit, as defined in Tab 1.

Finite element calculations, based on full length models and taking into account the global still water and wave loads to be used for the determination of the self-elevating unit girder strength, may be required by the Society when deemed necessary. In such a case, the wave loads are to be obtained by hydrodynamic calculations, as defined in Sec 3, [3.2.4].

1.1.6 In this Section, reference is made to the Rule Note NR600, Hull Structure and Arrangement for the Classification of Cargo Ships less than 65 m and Non Cargo Ships less than 90 m, as amended.

Table 1 : Hull scantling methodology depending on the type and shape of the unit

Type of unit	Loads to be applied	Scantlings
L ≤ 65m	Article [4]	Article [6]
L < 500 m, and L/B > 5, and B/D < 2,5, and C_B ≥ 0,6	Article [4], and Pt B, Ch 5, Sec 5 and Pt B, Ch 5, Sec 6 of the Ship Rules for pressures	Part B, Chapter 7 of the Ship Rules
Note 1: For the other self-elevating units, the global and local strength calculations are to be submitted for review, on a case-by-case basis. **Note 2:** As a Rule, three-dimensional finite element calculations are to be provided for non-rectangular units.		

1.2 Material

1.2.1 The selected steels and structural element categories are to be as defined in Sec 2, [1] and Sec 2, [2].

Unless otherwise specified, the material factor k, depending on the material reference stress R_f , has the values given in Tab 2.

For intermediate values of R_f , k may be obtained by linear interpolation.

Steels having a yield stress less than 235 N/mm² or greater than 390 N/mm² are considered by the Society on a case-by-case basis.

Table 2 : Material factor k

R_f , in N/mm²	k
235	1,00
315	0,78
355	0,72
390	0,68

2 Stability

2.1 General

2.1.1 Part B, Chapter 1 of the Offshore Rules is to be applied for the stability assessment.

In case of units unmanned during towing, the damage stability calculations may be not requested by the Society.

2.1.2 In case of non-rectangular hull, attention is drawn on the fact that the stability assessment is to be performed in fore/aft, athwartship and diagonal directions.

3 Structure elements to be checked

3.1 General

3.1.1 The three main structure elements to be checked in transit conditions are:

- the leg structure, according to [3.2]
- the connection between legs and hull structure, according to [3.3]
- the hull structure, according to [3.4].

Where the scantlings are obtained from direct calculation procedures different from those specified in the present Section, an adequate supporting documentation is to be submitted to the Society.

3.1.2 The spudcan and bottom mat structures are to be examined according to:

- the hydrostatic pressure given in [4.5]
- the scantling requirements provided in [7.2].

3.2 Leg structure

3.2.1 General

The leg structure is to be examined according to:

- the structure design principles defined in Sec 2
- the inertia and wind loads distributed along the legs during transit, as defined in [4.2], taking into account the design considerations defined in Sec 3, [3.2]
- the impact loads during installation, as defined in [5.2]
- the provisions given in [3.2.2] and [3.2.3]
- the strength requirements given in Sec 7.

3.2.2 Legs are to be analysed as cantilever beams, fixed in way of the unit leg support areas and loaded by distributed forces as stipulated in [4.2] and [5.2], respectively for transit and installation conditions.

3.2.3 Bending moments M_{by} and M_{bz} , respectively about y and z axes of the legs, shear force T and axial load distribution P along the legs are to be obtained from the analyses in transit and installation conditions, as defined in [3.2.2].

In case of units with lattice legs, the analyses are to provide the following loads for each member i (bracings and chords):

- bending moments M_{by_i} and M_{bz_i} , respectively about y and z axes
- shear force $T_{\_i}$
- axial force $P_{\_i}$
- torsion moment M_{t_i} .

3.3 Leg/hull connections

3.3.1 The leg/hull connections include all the local structures and systems used to transfer the leg moments and forces to the hull (i.e. the leghouse guides, and the elevating and locking systems including their supporting structure).

3.3.2 The leg/hull connections are to be examined by direct calculation according to:

- the structure design principles defined in Sec 2
- the forces and moments due to the inertia and wind loads on the legs in transit condition, as defined in [4.3]
- the forces and moments due to the impact loads on the legs during installation, as defined in [5.3]
- the strength requirements given in [3.3.3].

3.3.3 The structural strength of the leg/hull connections is to comply with the following criteria:

- yielding criteria: refer to Pt B, Ch 3, Sec 3, [5] of the Offshore Rules
- buckling criteria: refer to Pt B, Ch 3, Sec 3, [6] of the Offshore Rules and Sec 7 of the present Rule Note, when relevant.

For the structural strength calculation, the basic allowable stress factor α, as defined in the Offshore Rules Pt B, Ch 3, Sec 3, [5.4.2], is to be taken equal to 0,8 for the load cases "transit" and "leg impact".

3.4 Hull structure

3.4.1 The hull structure is to be examined according to [1.1.5].

3.4.2 The local forces and support reinforcements, in way of the structure intended to withstand the reactions induced by the transit where the unit is transported on a heavy lift unit, are to be submitted for examination.

4 Application of the loads in transit condition

4.1 General

4.1.1 The main hypotheses for the simplified approach calculation of the unit motions and accelerations during transit operations are as follows:

- the only calculations of the rolling and pitching accelerations are carried out. The effects of sway, heave and surge are taken into account in the force and moment effects by an increase of 20% in the gravity forces
- the roll and pitch accelerations are calculated at the natural period of roll and pitch of the unit (see [4.1.2])
- the single amplitude of roll and pitch is the one defined in Sec 3, [3.2.3].

The natural period values of roll and pitch may be requested by the Society for several loading cases and elevating positions of the legs during transit operations, according to the intended transit conditions provided in the operating manual.

4.1.2 Motions and accelerations (simplified approach)

The roll acceleration α_R and the pitch acceleration α_P , in rad/s², are obtained from the following formulae:

$$\alpha_R = A_R\left(\frac{2\pi}{T_R}\right)^2$$

$$\alpha_P = A_P\left(\frac{2\pi}{T_P}\right)^2$$

4.1.3 Natural periods of motions

The natural period T_R for the roll motion, in s, may be approached with the following formula:

$$T_R = 2\pi\frac{\delta_t}{\sqrt{gGM_t}}$$

The natural period T_P for the pitch motion, in s, may be approached with the following formula:

$$T_P = 2\pi\frac{\delta_l}{\sqrt{gGM_l}}$$

4.1.4 Natural radii of gyration

When the radii of gyration δ_t and δ_l are not known, the following values may be assumed for transit condition:

$$\delta_t = \sqrt{\frac{I_{mR}}{\Delta} - (KG - T)^2}$$

$$\delta_l = \sqrt{\frac{I_{mP}}{\Delta} - (KG - T)^2}$$

where:

I_{mR} : Total mass moment of inertia of the unit for roll motion, in tons·m², defined by:

$$I_{mR} = I_{lR} + I_{hR} + I_{aR}$$

I_{mP} : Total mass moment of inertia of the unit for pitch motion, in tons·m², defined by:

$$I_{mP} = I_{lP} + I_{hP} + I_{aP}$$

I_{lR} : Mass moment of inertia of the legs for roll motion, in tons·m², defined by:

$$I_{lR} = \sum_i P_{Leg}\left(\frac{\ell^2}{12} + z_{G,Leg}^2 + y_i^2\right)$$

I_{lP} : Mass moment of inertia of the legs for pitch motion, in tons·m², defined by:

$$I_{lP} = \sum_i P_{Leg}\left(\frac{\ell^2}{12} + z_{G,Leg}^2 + x_i^2\right)$$

I_{hR} : Mass moment of inertia of the hull for roll motion, in tons·m², defined by:

$$I_{hR} = P_h\left(C_w\frac{B}{3}\right)^2$$

I_{hP} : Mass moment of inertia of the hull for pitch motion, in tons·m², defined by:

- for non-rectangular units:

$$I_{hP} = P_h\left(C_w\frac{L}{3}\right)^2$$

- for rectangular units:

$$I_{hP} = P_h\left(C_w\frac{L}{4}\right)^2$$

I_{aR} : Mass moment of inertia of the water added mass for roll motion, in tons·m², defined by:

$$I_{aR} = (0,020C_w - 0,005)\Delta\frac{B^3}{T}$$

I_{aP} : Mass moment of inertia of the water added mass for pitch motion, in tons·m², defined by:

$$I_{aP} = 0,014C_w\Delta\frac{L^3}{T}$$

$z_{G, Leg}$: Distance, in m, between the still water level and the centre of gravity of the leg, including spudcan, as shown on Fig 1.

4.1.5 Unit relative motion

The relative motions h_1 and h_2 of the unit in upright and inclined conditions, at any hull transverse section, are obtained, in m, from the following formulae:

- in upright condition:

$h_1 = 0,7\ C$

- in inclined condition:

$$h_2 = 0,5\ h_1 + A_R\frac{B}{2}$$

Note 1: As an alternative, the value of h_2 directly calculated by hydrodynamic analysis may be considered by the Society.

with $h_1 \le \text{Min}\ (T\ ;\ D - 0,9\ T)$

4.2 Forces and moments for leg examination

4.2.1 The legs are to be designed for the forces and moments induced by their own weight, when subjected to the unit motions and accelerations defined in Sec 3, [3.2], combined with the wind velocity if necessary.

4.2.2 The legs are to be loaded with the following distributed forces, depending on the unit condition:

- unit in upright condition: only loads induced by pitch motion and wind loads, as defined in [4.2.4] and [4.2.5], are to be taken into account, roll motion effect being taken equal to zero
- unit in inclined condition: only loads induced by roll motion and wind loads, as defined in [4.2.3] and [4.2.5], are to be taken into account, pitch motion effect being taken equal to zero.

4.2.3 Load distribution under roll motion

The elementary horizontal force F_{iR}, in kN, induced by roll motion and applied to an elementary length of leg ℓ_i is obtained from the following formula:

$F_{iR} = p_i\ (1,2\ g \sin A_R + \alpha_R\ z_i)$

where:

p_i : Weight, in t, of an elementary length of leg ℓ_i.

The total vertical force F_{VR}, in kN, induced by the leg under roll motion is obtained from the following formula:

$F_{VR} = P_{Leg}\ (1,2\ g \cos A_R + \alpha_R\ y_i)$

4.2.4 Load distribution under pitch motion

The elementary horizontal force F_{iP}, in kN, induced by pitch motion and applied to an elementary length of leg ℓ_i is obtained from the following formula:

$F_{iP} = p_i\ (1,2\ g \sin A_P + \alpha_P\ z_i)$

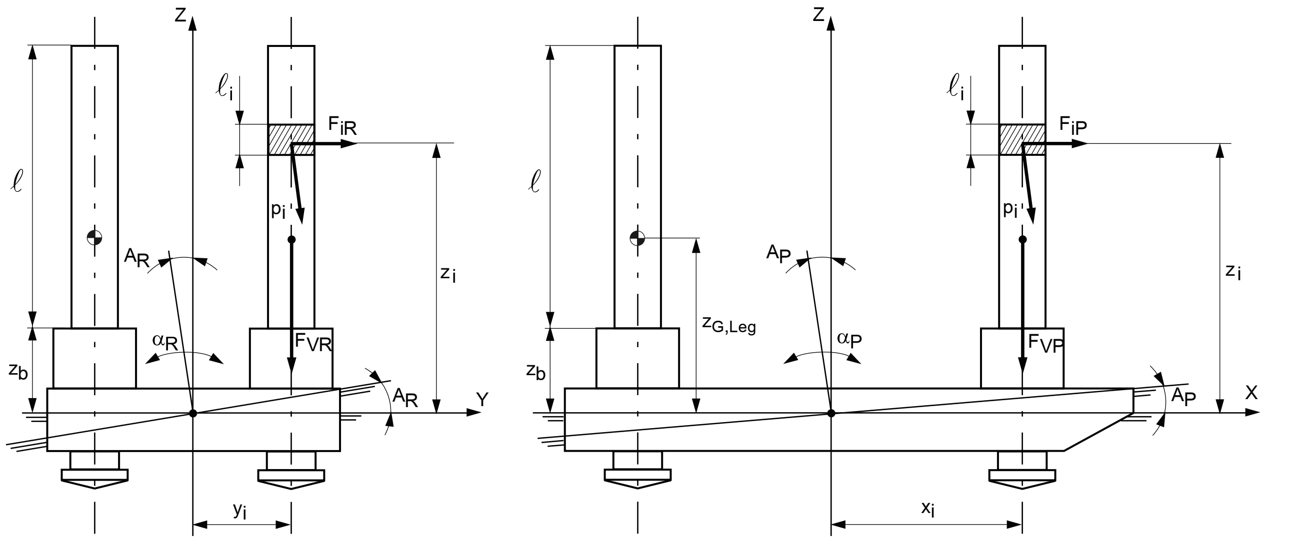
where:

p_i : Weight, in t, of an elementary length of leg ℓ_i.

The total vertical force F_{VP}, in kN, induced by the leg under pitch motion is obtained from the following formula:

$F_{VP} = P_{Leg}\ (1,2\ g \cos A_P + \alpha_P\ x_i)$

Figure 1 : Forces and moments induced by legs



4.2.5 Wind load distribution

The wind loads to be applied to the legs in transit condition are defined in Sec 5, [4.3.1].

4.3 Forces and moments for leg/hull connection examination

4.3.1 The global horizontal and vertical forces and moments applied to the leg guides and to the unit structure may be obtained by integration of the elementary loads defined in [4.2.3] and [4.2.4], combined with the wind effect defined in [4.2.5].

4.3.2 The following global forces and moments are to be considered, depending on the unit condition:

- unit in upright condition: only loads induced by pitch motion and wind loads, as defined in [4.2.4] and [4.2.5], are to be taken into account, roll motion effect being taken equal to zero
- unit in inclined condition: only loads induced by roll motion and wind loads, as defined in [4.2.3] and [4.2.5], are to be taken into account, pitch motion effect being taken equal to zero.

When the leg mass is uniformly distributed along the leg length, the values of the forces and moments induced by the legs to the unit structure at upper guide level may be calculated with the following simplified formulae:

- Forces and moment induced by roll motion:

$$F_{VR} = P_{Leg}(1{,}2\ g\cos A_R + \alpha_R y_i)$$

$$F_R = P_{Leg}\left[1{,}2\ g\sin A_R + \alpha_R\left(\frac{\ell}{2} + z_b\right)\right]$$

$$M_R = P_{Leg}\left(\frac{\ell}{2} + z_b\right)\left[1{,}2\ g\sin A_R + \alpha_R\left(\frac{2\ell^2 + 6\ell z_b + 6 z_b^2}{3\ell + 6 z_b}\right)\right]$$

- Forces and moment induced by pitch motion:

$$F_{VP} = P_{Leg}(1{,}2\ g\cos A_P + \alpha_P x_i)$$

$$F_P = P_{Leg}\left[1{,}2\ g\sin A_P + \alpha_P\left(\frac{\ell}{2} + z_b\right)\right]$$

$$M_P = P_{Leg}\left(\frac{\ell}{2} + z_b\right)\left[1{,}2\ g\sin A_P + \alpha_P\left(\frac{2\ell^2 + 6\ell z_b + 6 z_b^2}{3\ell + 6 z_b}\right)\right]$$

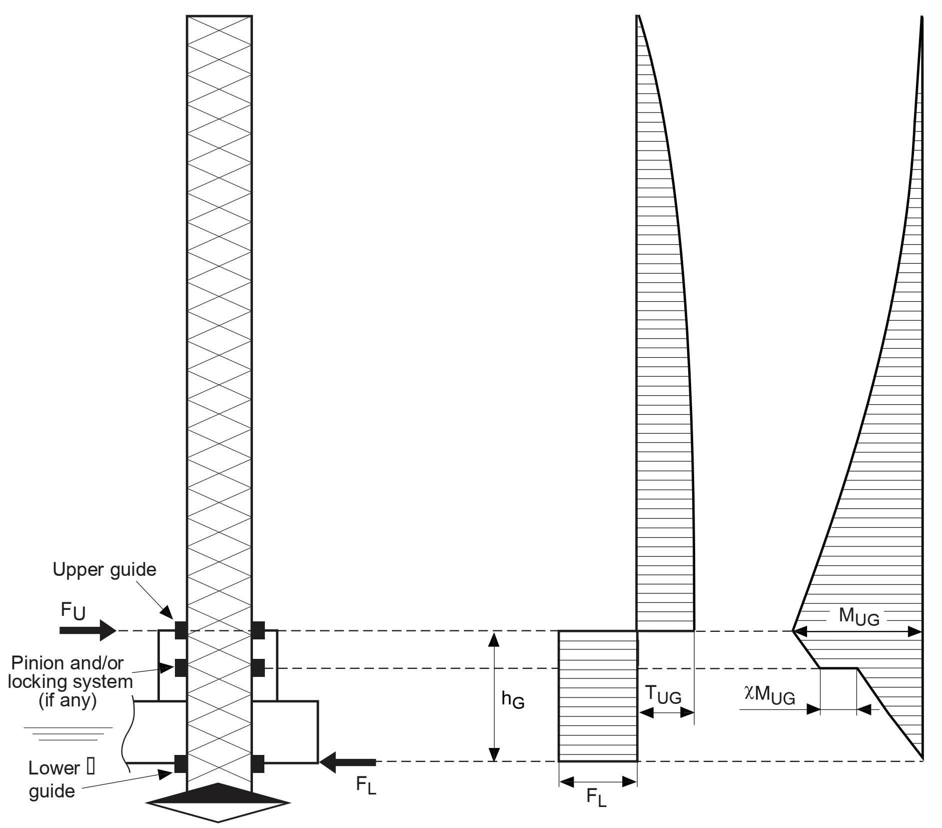
where:

F_{VR}, F_R, M_R : Respectively vertical and horizontal forces, in kN, and moment, in kN·m, induced by the leg to the unit structure under roll motion at the upper guide level

F_{VP}, F_P, M_P : Respectively vertical and horizontal forces, in kN, and moment, in kN·m, induced by the leg to the unit structure under pitch motion at the upper guide level

z_b : Distance, in m, between the still water level and the upper guide, as shown on Fig 1.

Figure 2 : Bending moments and shear forces at leg/hull connection



4.3.3 The horizontal loads F_U and F_L at, respectively, the upper and lower guides are given, in kN, by the following formulae (see Fig 2):

$$F_L = \frac{M_{UG}}{h_G}(1 - \chi)$$

$$F_U = F_L + T_{UG}$$

where (see Fig 2):

h_G : Distance between the lower and upper guides, in m

M_{UG} : Bending moment in the leg at the upper guide, in kN·m, to be taken as the combination of the bending moment resulting from the wind loads and the moment induced by the unit motion considered, M_R or M_P as defined in [4.3.2]

T_{UG} : Shear force in the leg just above the upper guide, in kN, to be taken as the combination of the shear force resulting from the wind loads and the shear force induced by the unit motion considered, F_R or F_P as defined in [4.3.2]

χ : Part of the bending moment taken by jacking mechanisms, as defined in Sec 5, [6.4.3].

4.4 Sea and internal pressure loads for small and non-rectangular units

4.4.1 Load point

Unless otherwise specified, the lateral pressures are to be calculated:

- at the lower edge of the elementary plate panel or of the strake, or, for horizontal plating, at the point having the minimum y-value among those of the elementary plate panel considered
- at mid-span of the longitudinal or transverse stiffeners, or at the lower and upper ends of the vertical stiffeners
- at mid-span of the longitudinal or transverse primary supporting members, or at the lower and upper ends of the vertical primary supporting members.

4.4.2 Sea pressure on bottom and side shell

The sea pressure p at any point of the hull bottom or side shell, in kN/m², are to be obtained according to NR600, Ch 3, Sec 3, assuming the relative motions and accelerations defined in [4.1].

4.4.3 Sea pressure on exposed deck

The sea pressure p at any point of the exposed deck, in kN/m², is to be:

- obtained from NR600, Ch 3, Sec 3, [2] for small units
- taken equal to 1,3 p_s for non-rectangular units,

  where:

  p_s : Cargo pressure on deck, in kN/m², to be taken as given in the loading plan.

4.4.4 Internal pressure

The internal pressure p to be considered for watertight bulkheads and decks located in liquid compartments is to be:

- obtained from NR600, Ch3, Sec 4, [3] for small units
- taken equal to 1,3 p_s for non-rectangular units,

  where:

  $p_s = \rho_L\, g\, (z_{TOP} - z)$

  ρ_L : Density, in t/m³, of the liquid cargo

  z_{TOP} : Vertical co-ordinate, in m, of the highest point of the tank, with respect to the reference system defined in Sec 1, [7]

  z : Vertical co-ordinate, in m, of the load point as defined in [4.4.1], with respect to the reference system defined in Sec 1, [7].

4.4.5 Flooding pressure

The internal pressures to be considered for watertight bulkheads and decks constituting flooding boundaries are to be obtained according to NR600, Ch 3, Sec 4, [6].

4.4.6 Testing pressure

The still water pressure p_T to be considered as acting on plates and stiffeners subject to tank testing is obtained from NR600, Ch 3, Sec 4, [5].

4.5 Sea pressure loads for spudcan and bottom mat in transit condition

4.5.1 The sea pressure, in kN/m², to be considered for the structural members of the spudcan and bottom mat, is given by:

$p_s = 10\, h$

where:

h : Vertical distance, in m, between the load point and:

- the maximum still water level (SWL), for the spudcan/ mat tanks not vented freely to the sea
- the deepest equilibrium waterline resulting from the damage stability calculations, for the spudcan/mat tanks vented to the sea.

In no case, p_s is to be taken less than 150 kN/m².

In very shallow waters, additional considerations may be requested, on a case-by-case basis.

5 Application of the loads in installation condition

5.1 General

5.1.1 Legs and elevating systems are to be designed to withstand the shock when touching the bottom while the unit is afloat and subjected to wave motions.

5.2 Forces and moments for leg examination

5.2.1 The maximum horizontal and vertical impact loads on legs, respectively P_y and P_z, are given, in kN, by the following formulae:

$$P_y = \theta_0 \sqrt{\frac{JK_y}{1 + \frac{b^2 K_z}{d^2 K_y}}}$$

$$P_z = \theta_0 \sqrt{\frac{JK_z}{1 + \frac{d^2 K_y}{b^2 K_z}}}$$

where:

θ_0 : Roll or pitch angle amplitude during installation, in rad, to be specified by the designer. θ_0 is to be specified by the Party applying for classification and usually computed by hydrodynamic calculations

K_y : Transverse stiffness of the leg, in kN·m^{-1}, defined by:

$$K_y = \frac{3EI}{\ell^3} 10^{-5}$$

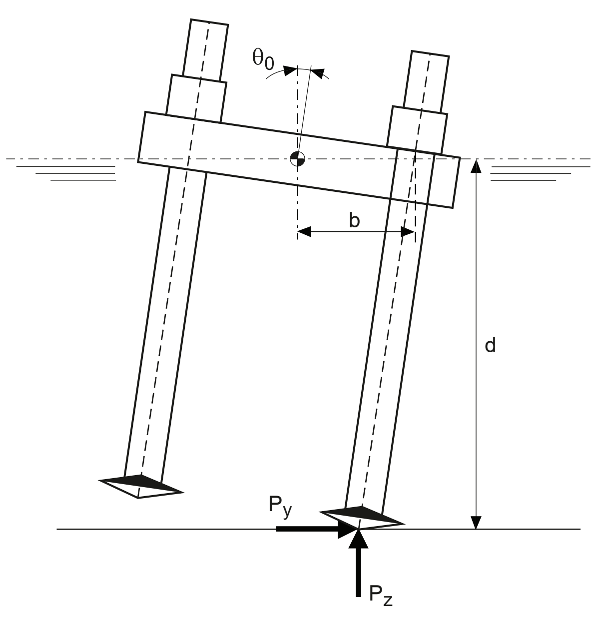
K_z : Vertical stiffness of the leg, in kN·m^{-1}, defined by:

$$K_z = \frac{EA}{\ell} 10^{-1}$$

d : Water depth, in m, to be considered during installation operation

b : Distance between the centre of flotation and the leg, in m, as shown on Fig 3

Figure 3 : Leg impact loads



J : Value defined as follows:

- for roll: $J = I_{mR} (2\pi / T_R)^2$
- for pitch: $J = I_{mP} (2\pi / T_P)^2$

T_R , T_P : As defined in [4.1.3]

I_{mR} , I_{mP} : As defined in [4.1.4].

5.2.2 The nodal forces P_y and P_z defined in [5.2.1] are to be applied at the lower end of the spudcan, as shown on Fig 3.

5.3 Forces and moments for leg/hull connection examination

5.3.1 Forces and moments at guides and elevating system are to be assessed according to the methodology described in Sec 5, [6.4.3] and based on the impact loads given in [5.2.1].

6 Hull scantlings for small units

6.1 General

6.1.1 The present Article deals with the yielding check of the structural elements of the main hull for small units having a rule length L less than 65 m, as per Tab 1.

6.2 Plating

6.2.1 Minimum gross thicknesses

The plating gross thicknesses t_g, in mm, are not to be less than the values given in Tab 3.

Table 3 : Plating minimum gross thicknesses

Plating	Minimum gross thickness, in mm
Bottom	$5,0 + 4,5\,s + 0,0026\,L\sqrt{k}$
Side shell and deck	$4,5 + 4,5\,s + 0,0026\,L\sqrt{k}$
Watertight inner bottom and bulkheads	$3,5 + 4,5\,s + 0,0026\,L\sqrt{k}$

6.2.2 The gross thickness of the laterally loaded plate panels, in mm, is not to be less than the value obtained in NR600, Ch 4, Sec 3, [2.2.2].

6.2.3 The permissible stresses are those defined in NR600, Ch 2, Sec 3, Tab 2.

6.3 Ordinary stiffeners

6.3.1 The gross section modulus w_g, in cm^3, and the gross shear sectional area $A_{sh,g}$, in cm^2, of the horizontal or vertical ordinary stiffeners subjected to lateral pressure are to be not less than the values obtained in NR600, Ch 4, Sec 4, [2.2.2].

6.3.2 The permissible stresses are those defined in NR600, Ch 2, Sec 3, Tab 3.

6.4 Primary supporting members

6.4.1 Structural model

This sub-article deals with the yielding check of the primary supporting members analysed through a beam structural model.

Depending on the structural arrangement, direct calculations based on a three-dimensional beam model with gross scantlings may be requested by the Society.

The local buckling check may be carried out according to NR600, Ch 4, Sec 2, [2.3].

6.4.2 Checking criteria for isolated beam analysis

The scantling of the primary supporting members is to be carried out as defined in [6.3.1] for the ordinary stiffeners, with the permissible stresses defined in NR600, Ch 2, Sec 3, Tab 4.

6.4.3 Checking criteria for three-dimensional beam model analysis

Where the three-dimensional beam model takes into account the overall loading of the main structure in addition to the local loads applied to the primary supporting members, it is to be checked that the equivalent stress σ_{VM} and shear stress τ_{12} fulfil the following conditions:

$\sigma_{VM} \leq 0,80\ R_y$

$\tau_{12} \leq 0,40\ R_y$

Where the three-dimensional beam model does not take into account the overall loading of the main structure in addition to the local loads applied to the primary supporting members, it is to be checked that the equivalent stress σ_{VM} and shear stress τ_{12} fulfil the following conditions:

$\sigma_{VM} \leq 0,55\ R_y$

$\tau_{12} \leq 0,40\ R_y$

6.5 Reinforcement of the flat bottom forward area

6.5.1 Where the minimum forward draught, in m, provided for ocean transit operation is less than 0,04 L, local reinforcements of the flat bottom forward area are to be provided as defined in:

- NR600, Ch 3, Sec 3, [3] for the dynamic pressure
- NR600, Ch 4, Sec 3 for scantlings of the plating
- NR600, Ch 4, Sec 4 for scantlings of the ordinary stiffeners, and
- NR600, Ch 4, Sec 5 for scantlings of the primary supporting members.

7 Other structures

7.1 Superstructures and deckhouses

7.1.1 The superstructures and deckhouses are to be in accordance with Sec 8, [3].

7.2 Spudcan and bottom mat scantlings

7.2.1 Plating

The net thickness of the spudcan/mat plate panels subjected to lateral pressure is to be not less than the value obtained, in mm, from the following formula:

$$t = 14,9s\sqrt{\frac{p_s}{\sigma_a}}$$

where:

s : Spacing, in m, of the ordinary stiffeners

p_s : Still water sea pressure as defined in [4.5]

σ_a : Allowable stress in static load case, as defined in Sec 7, [4.2.3].

7.2.2 Ordinary stiffeners

The net section modulus w, in cm^3, and the net shear sectional area A_{sh}, in cm^2, of the spudcan/mat stiffeners are to be not less than the values obtained from the following formulae:

$$w = \beta_b \frac{p_s}{12\sigma_a}\left(1 - \frac{s}{2\ell_s}\right) s \ell_s^2 10^3$$

$$A_{sh} = 10\beta_s \frac{p_s}{\sigma_a} s \ell_s$$

where:

β_s, β_b : Coefficients defined in Pt D, Ch 1, Sec 7, Tab 9 of the Offshore Rules

p_s, σ_a, s : As defined in [7.2.1]

ℓ_s : Span, in m, of the ordinary stiffeners, measured between the primary supporting members (see Pt B, Ch 4, Sec 3, [3.2] of the Ship Rules).

7.2.3 Primary supporting members

A three-dimensional finite element model is generally required to check the scantlings of the primary supporting members.

Still water sea pressure p_s, as defined in [4.5], is to be taken into account in the finite element calculation.

The impact loads on legs P_y and P_z, as given in [5.2.1], are also to be considered in the finite element calculation.

The primary supporting members of spudcans and bottom mat are to be in compliance with the following criteria:

- yielding criteria:

  refer to Pt B, Ch 3, Sec 3, [5] of the Offshore Rules
- buckling criteria:

  refer to Pt B, Ch 3, Sec 3, [6] of the Offshore Rules
- fatigue criteria, if relevant:

  refer to Sec 5, [6.5].

SECTION 7 STRENGTH OF LEGS

Symbols

ν : Poisson's ratio. Unless otherwise specified, ν = 0,3 is to be considered

α : Stress factor, as defined in [1.3.1]

D : Outer diameter of a cylindrical leg, in mm

t : Shell thickness of the leg, in mm

w_y : Section modulus of the leg about y-axis, in cm^3

w_z : Section modulus of the leg about z-axis, in cm^3

P : Compressive axial force in the leg, in kN, derived from the global analysis in elevated position and the transit analysis, as obtained, respectively, from Sec 5, [6.4.2] and Sec 6, [3.2.1]

M_{by} : Bending moment of the leg about y-axis, in kN·m, derived from the global analysis in elevated position and the transit analysis, as obtained, respectively, from Sec 5, [6.4.2] and Sec 6, [3.2.3]

M_{bz} : Bending moment of the leg about z-axis, in kN·m, derived from the global analysis in elevated position and the transit analysis, as obtained, respectively, from Sec 5, [6.4.2] and Sec 6, [3.2.3]

p_h : Hydrostatic pressure as defined in Sec 5, [6.4.2]

$P_{\_i}$: Axial force acting on the considered structural member i of a lattice leg, in kN, as obtained from Sec 5, [6.4.2] and Sec 6, [3.2.3]

M_{by_i} : Bending moment about y-axis in the considered structural member i of a lattice leg, in kN·m, as obtained from Sec 5, [6.4.2] and Sec 6, [3.2.3]

M_{bz_i} : Bending moment about z-axis in the considered structural member i of a lattice leg, in kN·m, as obtained from Sec 5, [6.4.2] and Sec 6, [3.2.3]

$T_{\_i}$: Shear force acting on the considered structural member i of a lattice leg, in kN, as obtained from Sec 5, [6.4.2] and Sec 6, [3.2.3]

M_{t_i} : Torsion moment acting on the considered structural member i of a lattice leg, in kN·m, as obtained from Sec 5, [6.4.2] and Sec 6, [3.2.3]

h_w : Web height of the ordinary stiffener, in mm

t_w : Web thickness of the ordinary stiffener, in mm

t_f : Face plate thickness of the ordinary stiffener, in mm

t_p : Thickness of the attached plating, in mm

b_f : Face plate width of the ordinary stiffener, in mm

b_e : Width, in m, of the plating attached to the stiffener, for buckling check, as defined in Pt B, Ch 7, Sec 2, [4.1] of the Ship Rules

A_e : Sectional area, in cm^2, of the stiffener with an attached plating of width b_e

I_e : Moment of inertia, in cm^4, of the stiffener with an attached shell plating of width b_e, about its neutral axis parallel to the plating

$D_{\_i}$: Outer diameter of member i, in mm

$t_{\_i}$: Shell thickness of member i, in mm

$A_{\_i}$: Cross-sectional area of member i, in cm^2

A_{Sh_i} : Shear area of member i, in cm^2

$I_{\_i}$: Minimum moment of inertia of member i about its principal axis, in cm^4

I_{p_i} : Polar inertia of member i, in cm^4

w_{y_i} : Section modulus of member i about y-axis, in cm^3

w_{z_i} : Section modulus of member i about z-axis, in cm^3

$\ell_{\_i}$: Span of member i, in m

x : Subscript symbol relating to the axial axis of the structural element

y : Subscript symbol relating to the strong bending axis of the structural element

z : Subscript symbol relating to the weak bending axis of the structural element

_i : Subscript symbol relating to the considered structural member i (chords or bracings) of a lattice leg.

1 General

1.1 Purpose

1.1.1 The present Section specifies the allowable stress criteria for the evaluation of the global and local strengths of the leg structure with respect to yielding, buckling and local punching of the elements of the structure.

1.2 References

1.2.1 Industry standards

a) Technical and Research Bulletin 5-5A, Guidelines for Site Specific Assessment of Mobile Jack-up Units published by the Society of Naval Architects and Marine Engineers (SNAME)

b) AISC Specification for Structural Steel Buildings

c) API RP 2A-WSD Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms - Working Stress Design - latest edition.

1.3 Stress factor

1.3.1 For structural strength calculation, the basic allowable stress factor α, as defined in the Offshore Rules, Pt B, Ch 3, Sec 3, [5.4.2], is to be taken as follows, depending on the load cases:

- "Static" and "Preloading": $\alpha = 0,6$
- "Operating" and "Severe storm": $\alpha = 0,8$
- "Transit" and "Leg impact": $\alpha = 0,8$
- "Accidental": $\alpha = 1,0$

Note 1: The load cases "Operating" and "Severe storm" refer to load case 2 in the Offshore Rules, Pt B, Ch 2, Sec 3.

Note 2: The basic allowable strength for load cases "Static" is increased by one-third for load cases 2 ("Operating" and "Severe storm") and by two-third for load cases 3 ("Accidental") defined in the Offshore Rules, Pt B, Ch 2, Sec 3, [6.3]. The same principle is to be applied when strength assessment is requested to be checked according to industry standards, such as quoted in [1.2.1], item c).

1.4 Convention

1.4.1 In the present Section, it is assumed that the tensile stress is positive whereas the compressive stress is negative.

2 Cylindrical and rectangular hollow section legs

2.1 General

2.1.1 The present Article gives requirements for the scantling of legs having cylindrical or rectangular sections.

2.2 Yielding

2.2.1 Equivalent stress for leg analysed through beam structural model

For uniaxial stress condition (e.g. obtained by beam calculation), the equivalent stress σ_c, in N/mm², at each point of the leg, is given by:

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

where:

σ : Normal stress, in N/mm²

τ : Shear stress, in N/mm².

2.2.2 Equivalent stress for leg analysed through finite element structural model

For biaxial stress condition (e.g. obtained by finite element calculation with plate elements), the equivalent stress σ_c, in N/mm², at each point of the leg, is given by:

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

where

σ_1, σ_2 : Membrane principal stresses in the element, in N/mm², including the effects of both overall and local loads.

2.2.3 Checking criteria

The equivalent stress σ_c, in N/mm², is not to exceed the allowable stress σ_a for the loading condition considered, according to the following criterion:

$$\sigma_c \leq \sigma_a$$

where:

σ_a : Allowable stress, in N/mm², given by:

$$\sigma_a = 1,1\ \alpha\ R_f$$

2.3 Overall buckling

2.3.1 Actual leg axial stress

The actual leg axial stress σ_{ax}, in N/mm², is to be obtained, at each point of the leg, from the following formula:

$$\sigma_{ax} = 10\frac{P}{A}$$

2.3.2 Actual leg bending stress

The actual leg bending stresses σ_{by} and σ_{bz}, in N/mm², with respect to the local reference system of the leg, are to be obtained, at each point of the leg, from the following formulae:

$$\sigma_{by} = \frac{M_{by}}{w_y}10^3$$

$$\sigma_{bz} = \frac{M_{bz}}{w_z}10^3$$

2.3.3 Allowable compressive stress

Provided the geometric conditions defined in Tab 1 are satisfied, the allowable compressive stress σ_{ca}, in N/mm², is to be obtained from the following formulae:

$$\sigma_{ca} = \sigma_E \quad \text{for } \sigma_E \leq \frac{R_{eH}}{2}$$

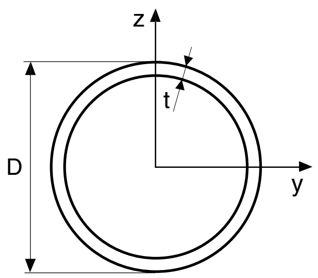
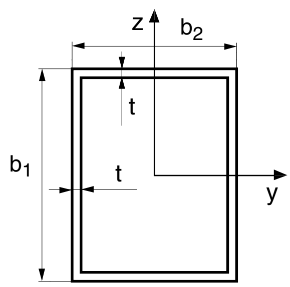
$$\sigma_{ca} = R_{eH}\left(1 - \frac{R_{eH}}{4\sigma_E}\right) \quad \text{for } \sigma_E > \frac{R_{eH}}{2}$$

where:

σ_E : Column buckling stress, in N/mm², to be obtained from the following formula:

$$\sigma_E = \frac{7\pi^2 EI}{8A(2\ell)^2}10^{-4}$$

Table 1 : Geometric conditions

Leg cross-section	Geometric conditions
Cylindrical section leg 	• $\frac{D}{t} \le \frac{22000}{R_f}$ • $t \ge 6mm$
Rectangular hollow section leg 	• $\frac{b_1}{t} \le \frac{625}{\sqrt{R_f}}$ • $\frac{b_2}{t} \le \frac{625}{\sqrt{R_f}}$ • $t \ge 6mm$ • $\frac{b_1}{b_2} \le 6$

2.3.4 Allowable bending stress

Provided the geometric conditions defined in Tab 1 are satisfied, the allowable bending stress σ_{cb} , in N/mm², is to be obtained from the following formulae:

a) Cylindrical section legs

- for $\frac{D}{t} \le \frac{14000}{R_f}$:

  $\sigma_{cb} = 1,25\ R_f$

- for $\frac{14000}{R_f} < \frac{D}{t} \le \frac{22000}{R_f}$:

  $$\sigma_{cb} = 1,25\left(\frac{2800t}{DR_f} + 0,8\right)R_f$$

For cylindrical section leg, σ_{cby} and σ_{cbz} are to be taken equal to σ_{cb} .

For D/t ratio outside the above range, refer to the industry standards quoted in [1.2.1].

b) Rectangular hollow section legs

- for $\frac{b_k}{t} \le \frac{500}{\sqrt{R_f}}$:

  $\sigma_{cb} = 1,10\ R_f$

- for $\frac{500}{\sqrt{R_f}} < \frac{b_k}{t} \le \frac{625}{\sqrt{R_f}}$:

$$\sigma_{cb} = 1,1\ R_f\left[1,36 - \left(7,15\ \frac{b_k\sqrt{R_f}}{t}10^{-4}\right)\right]$$

where:

b_k : Breadth, in mm, of the side k of the rectangular hollow section leg (k = 1 or 2), as defined in Tab 1.

σ_{cb} is to be calculated for both strong and weak bending axes, respectively named σ_{cby} and σ_{cbz} in the present Section.

For b_k/t ratio outside the above range, refer to the industry standards quoted in [1.2.1].

2.3.5 Checking criteria

It is to be checked that the scantling of the leg is in compliance with the following criteria:

$$\frac{|\sigma_{ax}|}{\alpha\sigma_{ca}} + \frac{8}{9}\left[\left(\frac{|\sigma_{by}|}{\alpha\sigma_{cby}}\right)^{\eta} + \left(\frac{|\sigma_{bz}|}{\alpha\sigma_{cbz}}\right)^{\eta}\right]^{\frac{1}{\eta}} \le 1 \qquad \text{for} \qquad \frac{|\sigma_{ax}|}{\alpha\sigma_{ca}} \ge 0,2$$

$$\frac{|\sigma_{ax}|}{2\alpha\sigma_{ca}} + \left[\left(\frac{|\sigma_{by}|}{\alpha\sigma_{cby}}\right)^{\eta} + \left(\frac{|\sigma_{bz}|}{\alpha\sigma_{cbz}}\right)^{\eta}\right]^{\frac{1}{\eta}} \le 1 \qquad \text{for} \qquad \frac{|\sigma_{ax}|}{\alpha\sigma_{ca}} < 0,2$$

where:

η :
- η = 2 for cylindrical section legs
- η = 1 for the other section legs

σ_{ax} : Actual leg axial stress for the considered loading case, in N/mm², as defined in [2.3.1]

σ_{by} : Actual leg bending stress for the considered loading case with respect to y-leg axis, in N/mm², as defined in [2.3.2]

σ_{bz} : Actual leg bending stress for the considered loading case with respect to z-leg axis, in N/mm², as defined in [2.3.2]

σ_{ca} : Allowable compressive stress, in N/mm², as defined in [2.3.3]

σ_{cby} : Allowable bending stress with respect to y-leg axis, in N/mm², as defined in [2.3.4]

σ_{cbz} : Allowable bending stress with respect to z-leg axis, in N/mm², as defined in [2.3.4].

2.4 Curved shell plating of cylindrical legs

2.4.1 Hoop stress

The shell plating of cylindrical legs is to be able to withstand hoop stress due to the hydrostatic pressure. Recognized standards, such as quoted in [1.2.1], item c), are to be considered for the design criteria.

2.4.2 Combination of global forces with hydrostatic pressure

The shell plating scantling of cylindrical legs is to be checked considering the combinations of tensile and compressive axial forces with the hydrostatic pressure. Recognized standards, such as quoted in [1.2.1], item c), are to be considered for the design criteria.

2.5 Straight shell plating of rectangular hollow section legs

2.5.1 Thickness of laterally loaded plate panels

The thickness of laterally loaded plate panels subjected to in-plane normal stress is to be not less than the value obtained, in mm, from the following formula:

$$t = 14,9s\sqrt{\frac{p_h}{\alpha\lambda_L R_f}}$$

where:

$$\lambda_L = \sqrt{1-0,95\left(\frac{|\sigma_{ax}|+|\sigma_b|}{R_f}\right)^2} - 0,225\frac{|\sigma_{ax}|+|\sigma_b|}{R_f}$$

σ_{ax} : Actual leg axial stress for the considered loading case, in N/mm², as defined in [2.3.1]

σ_b : Maximum actual leg bending stress σ_{by} or σ_{bz} for the considered loading case, in N/mm², as defined in [2.3.2].

2.5.2 Critical buckling stress of plate panels

The critical buckling stress of plate panels is to comply with the following formula:

$$|\sigma_{ax}| + |\sigma_b| \le \alpha\sigma_c$$

where:

σ_{ax} , σ_b : As defined in [2.5.1]

σ_c : Critical buckling stress, in N/mm², calculated from the following formulae:

$$\sigma_c = \sigma_E \quad \text{for } \sigma_E \le \frac{R_f}{2}$$

$$\sigma_c = R_f\left(1-\frac{R_f}{4\sigma_E}\right) \quad \text{for } \sigma_E > \frac{R_f}{2}$$

with:

σ_E : Euler buckling stress, in N/mm², to be obtained from the following formula:

$$\sigma_E = \frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t}{b}\right)^2 K_1 \varepsilon 10^{-6}$$

K_1 : Buckling factor defined in Tab 2, with $\zeta = a / b$

ε : Coefficient to be taken equal to:

- for $\zeta \ge 1$: $\varepsilon = 1,00$
- for $\zeta < 1$ and side b stiffened by:
  - flat bar: $\varepsilon = 1,05$
  - bulb section: $\varepsilon = 1,10$
  - angle or T-section: $\varepsilon = 1,21$
  - primary supporting members: $\varepsilon = 1,30$

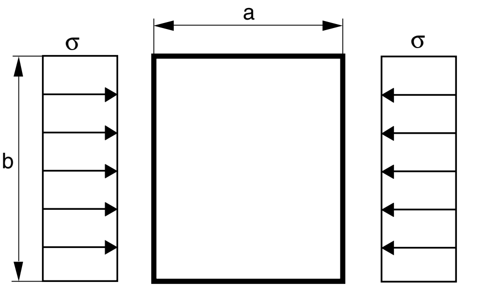
with $\zeta = a / b$

a, b : Lengths, in m, of the sides of the plate panel, as shown in Fig 1.

Table 2 : Buckling factor K_1 for plane panels

Aspect ratio	Buckling factor K_1
$\zeta \ge 1$	4,00
$\zeta < 1$	$\left(\zeta + \frac{1}{\zeta}\right)^2$

Figure 1 : Buckling of a simply supported rectangular plate panel subjected to compression



2.6 Ordinary stiffeners subjected to lateral pressure and axial compressive stress

2.6.1 Yielding criteria

The section modulus w, in cm³, and the shear sectional area A_{Sh} , in cm², of the vertical ordinary stiffeners subjected to lateral pressure are to be not less than the values obtained from the following formulae:

$$w = \frac{p_h}{12\alpha(R_f - (|\sigma_{ax}| + |\sigma_b|))} s \ell_s^2 10^3$$

$$A_{Sh} = 10\frac{p_h}{\alpha R_f}\left(1 - \frac{s}{2\ell_s}\right) s \ell_s$$

where:

σ_{ax} : Actual leg axial stress for the considered loading case, in N/mm², as defined in [2.3.1]

σ_b : Maximum actual leg bending stress σ_{by} or σ_{bz} for the considered loading case, in N/mm², as defined in [2.3.2].

2.6.2 Buckling criteria

The critical buckling stress of ordinary stiffeners is to comply with the following formula:

$$|\sigma_{ax}| + |\sigma_b| \le \alpha\sigma_c$$

where:

σ_{ax} , σ_b : As defined in [2.6.1]

σ_c : Critical buckling stress, in N/mm², calculated from the following formulae:

$$\sigma_c = \sigma_E \quad \text{for } \sigma_E \le \frac{R_f}{2}$$

$$\sigma_c = R_f\left(1-\frac{R_f}{4\sigma_E}\right) \quad \text{for } \sigma_E > \frac{R_f}{2}$$

σ_E : Minimum Euler buckling stress, in N/mm², defined by:

$\sigma_E = \text{Min}(\sigma_{E1} ; \sigma_{E2} ; \sigma_{E3})$

with σ_{E1} , σ_{E2} and σ_{E3} defined respectively in the following item a), item b) and item c).

a) The Euler column buckling stress of axially loaded stiffeners σ_{E1} , in N/mm², is obtained from the following formula:

$$\sigma_{E1} = \pi^2 E \frac{I_e}{A_e \ell_s^2} 10^{-4}$$

b) The Euler torsional buckling stress of axially loaded stiffeners σ_{E2}, in N/mm², is obtained from the following formula:

$$\sigma_{E2} = \frac{\pi^2 E I_w}{10^4 I_p \ell_s^2}\left(\frac{K_C}{m^2} + m^2\right) + 0{,}385 E \frac{I_t}{I_p}$$

where:

I_w : Sectorial moment of inertia, in cm⁶, of the stiffener about its connection to the attached plating:

- for flat bars:

$$I_w = \frac{h_w^3 t_w^3}{36} 10^{-6}$$

- for T-sections:

$$I_w = \frac{t_f b_f^3 h_w^2}{12} 10^{-6}$$

- for angles and bulb sections:

$$I_w = \frac{b_f^3 h_w^2}{12(b_f + h_w)^2}[t_f(b_f^2 + 2 b_f h_w + 4 h_w^2) + 3 t_w b_f h_w]\ 10^{-6}$$

I_p : Polar moment of inertia, in cm⁴, of the stiffener about its connection to the attached plating:

- for flat bars:

$$I_p = \frac{h_w^3 t_w}{3} 10^{-4}$$

- for stiffeners with face plate:

$$I_p = \left(\frac{h_w^3 t_w}{3} + h_w^2 b_f t_f\right) 10^{-4}$$

I_t : St. Venant's moment of inertia, in cm⁴, of the stiffener without attached plating:

- for flat bars:

$$I_t = \frac{h_w t_w^3}{3} 10^{-4}$$

- for stiffeners with face plate:

$$I_t = \frac{1}{3}\left[h_w t_w^3 + b_f t_f^3\left(1 - 0{,}63\frac{t_f}{b_f}\right)\right] 10^{-4}$$

m : Integer number of half waves, to be taken such that (see also Tab 3):

$m^2 (m - 1)^2 \le K_C < m^2 (m + 1)^2$

with:

$$K_C = \frac{C_0 \ell_s^4}{\pi^4 E I_w} 10^6$$

C_0 : Spring stiffness of the attached plating:

$$C_0 = \frac{E t_p^3}{2{,}73 s} 10^{-3}$$

c) The Euler buckling stress of the stiffener webs σ_{E3}, in N/mm², is obtained from the following formulae:

- for flat bars:

$$\sigma_{E3} = 16\left(\frac{t_W}{h_W}\right)^2 10^4$$

- for stiffeners with face plate:

$$\sigma_{E3} = 78\left(\frac{t_W}{h_W}\right)^2 10^4$$

Table 3 : Torsional buckling of axially loaded stiffeners Number m of half waves

K_C	$0 \le K_C < 4$	$4 \le K_C < 36$	$36 \le K_C < 144$
m	1	2	3

2.7 Horizontal ring stringers of cylindrical legs

2.7.1 The horizontal ring stringer scantlings of cylindrical legs are to be able to withstand hydrostatic pressure. Recognized standards, such as quoted in [1.2.1], item c), are to be considered for design criteria.

3 Lattice legs

3.1 Methodology

3.1.1 Chords and bracings

The present Article provides a methodology for the analysis of round hollow structural section bracings and chords from beam model. In case other geometries are encountered, the design methodology is to be accepted by the Society.

The present methodology is based on detailed models of the legs, as described in Sec 5, [2.3.3], and loaded with overall loads derived from the global analysis in elevated position and the transit analysis, as obtained respectively in Sec 5, [6.4.2] and Sec 6, [3.2.1]. Each structural member, i.e. chord and bracing, is to comply with the stress criteria defined from [3.4.1] to [3.4.6].

3.1.2 Tubular joints

The tubular joints are to be designed according to the standards quoted in [1.2.1], items b) or c), with respect to the allowable strength design method.

Fatigue resistance of the tubular joints is also to be checked by appropriate calculation, in accordance with the provisions of Sec 5, [6.5].

3.2 Actual stresses for chords and bracings

3.2.1 Actual axial stress

The actual axial stress σ_{ax_i} in the considered structural member i, in N/mm², is given by:

$$\sigma_{ax\_i} = 10\frac{P_{\_i}}{A_{\_i}}$$

3.2.2 Actual bending stresses

The actual bending stresses σ_{by_i} and σ_{bz_i} in the considered structural member i, with respect to the local y and z axes of the member, in N/mm², are given by:

$$\sigma_{by\_i} = \frac{BM_{by\_i}}{w_{y\_i}}10^3$$

$$\sigma_{bz\_i} = \frac{BM_{bz\_i}}{w_{z\_i}}10^3$$

where:

$$B = \frac{C_m}{1 - \frac{1,6\ \sigma_{ax\_i}}{\sigma_{Euler}}} \geq 1$$

σ_{ax_i} : Actual axial stress in the considered structural member i, as defined in [3.2.1], for the considered loading case

σ_{Euler} : Euler critical buckling stress, in N/mm², given by:

$$\sigma_{Euler} = \frac{\pi^2 EI_{\_i}}{A_{\_i}(K\ell_{\_i})^2}10^{-4}$$

K : Effective length factor:
- in general: K = 1,0
- for diagonal bracings:
  K = 0,8 may be considered

C_m : Coefficient defined as follows:
- For members not subjected to transverse loading between their supports in the plane of bending:

  $$C_m = 0,6 - 0,4\frac{M_1}{M_2}$$

  where M_1/M_2 is the ratio of the smaller to the larger bending moments at the ends of that portion of the considered member i unbraced in the plane of bending under consideration. M_1/M_2 is positive when the member is bent in reverse curvature, negative when it is bent in single curvature
- For members subjected to transverse loading between their supports:
  C_m = 0,85 for members with restrained ends
  C_m = 1,0 for members with unrestrained ends.

3.2.3 Actual shear stress

The actual shear stress τ_{s_i} in the considered structural member i, in N/mm², is given by:

$$\tau_{s\_i} = 20\frac{T_{\_i}}{A_{\_i}}$$

3.2.4 Actual torsional stress

The actual torsional stress τ_{t_i} in the considered structural member i, in N/mm², is given by:

$$\tau_{t\_i} = \frac{M_{t\_i}D_{\_i}}{2I_{p\_i}}10^3$$

3.3 Allowable stresses for chords and bracings

3.3.1 Allowable tensile stress

The allowable tensile stress σ_{at_i} in the considered structural member i, in N/mm², is to be obtained from the following formula:

$\sigma_{at\_i} = R_f$

3.3.2 Allowable compressive axial stress

The allowable compressive axial stress σ_{ca_i} in the considered structural member i, in N/mm², is to be obtained from the following formulae:

$$\sigma_{ca\_i} = \sigma_{E\_i} \quad \text{for} \quad \sigma_{E\_i} \leq \frac{R_f}{2}$$

$$\sigma_{ca\_i} = R_f\left(1 - \frac{R_f}{4\sigma_{E\_i}}\right) \quad \text{for} \quad \sigma_{E\_i} > \frac{R_f}{2}$$

where:

σ_{E_i} : Column buckling stress, in N/mm², to be obtained from the following formula:

$$\sigma_{E\_i} = \frac{7\pi^2 EI_{\_i}}{8A_{\_i}(2\ell_{\_i})^2}10^{-4}$$

3.3.3 Allowable bending stress

The allowable bending stress σ_{cb_i} in the considered structural member i, in N/mm², is to be obtained from the following formulae:

- Cylindrical members
  - for $\frac{D_{\_i}}{t_{\_i}} \leq \frac{14000}{R_f}$:

    $\sigma_{cb\_i} = 1,25\ R_f$
  - for $\frac{14000}{R_f} < \frac{D_{\_i}}{t_{\_i}} \leq \frac{22000}{R_f}$:

    $$\sigma_{cb\_i} = 1,25\left(\frac{2800t_{\_i}}{D_{\_i}R_f} + 0,8\right)R_f$$
  - for $\frac{22000}{R_f} < \frac{D_{\_i}}{t_{\_i}} \leq \frac{90000}{R_f}$:

    $$\sigma_{cb\_i} = 1,25\frac{20400t_{\_i}}{D_{\_i}}$$
- Other member geometries
  The allowable bending stress is to be defined according to [1.2.1], item b).

3.3.4 Allowable shear stress

The allowable shear stress τ_{as_i} in the considered structural member i, in N/mm², is to be obtained as follows:

$$\tau_{as\_i} = \text{Max}\left(\frac{160000}{\sqrt{\frac{\ell_{sh\_i}}{D_{\_i}}}\left(\frac{D_{\_i}}{t_{\_i}}\right)^{5/4}}\ ;\ \frac{78000}{\left(\frac{D_{\_i}}{t_{\_i}}\right)^{3/2}}\right)$$

without exceeding 0,6 R_f

where:

ℓ_{sh_i} : Distance, in m, along the member length from the beginning to the maximum shear force.

3.3.5 Allowable torsional stress

The allowable torsional stress τ_{at_i} in the considered structural member i, in N/mm², is to be obtained as follows:

$$\tau_{at\_i} = \text{Max}\left(\frac{246000}{\sqrt{\frac{\ell_{\_i}}{D_{\_i}}}\left(\frac{D_{\_i}}{t_{\_i}}\right)^{5/4}} ; \frac{120000}{\left(\frac{D_{\_i}}{t_{\_i}}\right)^{3/2}} \right)$$

without exceeding 0,6 R_f.

3.4 Checking criteria for chords and bracings

3.4.1 Tensile stress

For members subjected to axial tensile force, it is to be checked that the scantling is in compliance with the following criterion:

$$\sigma_{ax\_i} \le \alpha\sigma_{at\_i}$$

where:

σ_{ax_i} : Actual axial stress, in N/mm², in the considered structural member i, as defined in [3.2.1], and for the considered load case

σ_{at_i} : Allowable tensile stress, in N/mm², in the considered structural member i, as defined in [3.3.1].

3.4.2 Compressive stress

For members subjected to compressive force, it is to be checked that the scantling is in compliance with the following criterion:

$$\sigma_{ax\_i} \le \alpha\, \sigma_{ca\_i}$$

where:

σ_{ax_i} : Actual axial stress, in N/mm², in the considered structural member i, as defined in [3.2.1], and for the considered load case

σ_{ca_i} : Allowable compressive stress, in N/mm², in the considered structural member i, as defined in [3.3.2].

3.4.3 Shear stress

For members subjected to shear force, it is to be checked that the scantling is in compliance with the following criterion:

$$\tau_{s\_i} \le \alpha\, \tau_{as\_i}$$

where:

τ_{s_i} : Actual shear stress, in N/mm², in the considered structural member i, as defined in [3.2.3], and for the considered load case

τ_{as_i} : Allowable shear stress, in N/mm², in the considered structural member i, as defined in [3.3.4].

3.4.4 Combined tensile axial and bending force

For members subjected to both bending and tensile axial forces, it is to be checked that the scantling is in compliance with the following criteria:

$$\frac{\sigma_{ax\_i}}{\alpha\sigma_{at\_i}} + \frac{8}{9}\left[\left(\frac{|\sigma_{by\_i}|}{\alpha\sigma_{cb\_i}}\right)^2 + \left(\frac{|\sigma_{bz\_i}|}{\alpha\sigma_{cb\_i}}\right)^2\right]^{\frac{1}{2}} \le 1 \quad \text{for} \quad \frac{\sigma_{ax\_i}}{\alpha\sigma_{at\_i}} \ge 0,2$$

$$\frac{\sigma_{ax\_i}}{2\alpha\sigma_{at\_i}} + \left[\left(\frac{|\sigma_{by\_i}|}{\alpha\sigma_{cb\_i}}\right)^2 + \left(\frac{|\sigma_{bz\_i}|}{\alpha\sigma_{cb\_i}}\right)^2\right]^{\frac{1}{2}} \le 1 \quad \text{for} \quad \frac{\sigma_{ax\_i}}{\alpha\sigma_{at\_i}} < 0,2$$

where:

σ_{ax_i} : Actual axial stress, in N/mm², in the considered structural member i, as defined in [3.2.1], and for the considered load case

σ_{by_i} : Actual bending stress, in N/mm², in the considered structural member i with respect to the local y-axis of the member, as defined in [3.2.2], and for the considered load case

σ_{bz_i} : Actual bending stress, in N/mm², in the considered structural member i with respect to the local z-axis of the member, as defined in [3.2.2], and for the considered load case

σ_{at_i} : Allowable tensile stress, in N/mm², in the considered structural member i, as defined in [3.3.1]

σ_{cb_i} : Allowable bending stress, in N/mm², in the considered structural member i, as defined in [3.3.3].

3.4.5 Combined compressive axial and bending force

For members subjected to both bending and compressive axial forces, it is to be checked that the scantling is in compliance with the following criteria:

$$\frac{|\sigma_{ax\_i}|}{\alpha\sigma_{ca\_i}} + \frac{8}{9}\left[\left(\frac{|\sigma_{by\_i}|}{\alpha\sigma_{cb\_i}}\right)^2 + \left(\frac{|\sigma_{bz\_i}|}{\alpha\sigma_{cb\_i}}\right)^2\right]^{\frac{1}{2}} \le 1 \quad \text{for} \quad \frac{|\sigma_{ax\_i}|}{\alpha\sigma_{ca\_i}} \ge 0,2$$

$$\frac{|\sigma_{ax\_i}|}{2\alpha\sigma_{ca\_i}} + \left[\left(\frac{|\sigma_{by\_i}|}{\alpha\sigma_{cb\_i}}\right)^2 + \left(\frac{|\sigma_{bz\_i}|}{\alpha\sigma_{cb\_i}}\right)^2\right]^{\frac{1}{2}} \le 1 \quad \text{for} \quad \frac{|\sigma_{ax\_i}|}{\alpha\sigma_{ca\_i}} < 0,2$$

where:

σ_{ax_i} : Actual axial stress, in N/mm², in the considered structural member i, as defined in [3.2.1], and for the considered load case

σ_{by_i} : Actual bending stress, in N/mm², in the considered structural member i with respect to the local y-axis of the member, as defined in [3.2.2], and for the considered load case

σ_{bz_i} : Actual bending stress, in N/mm², in the considered structural member i with respect to the local z-axis of the member, as defined in [3.2.2], and for the considered load case

σ_{ca_i} : Allowable compressive stress, in N/mm², in the considered structural member i, as defined in [3.3.2]

σ_{cb_i} : Allowable bending stress, in N/mm², in the considered structural member i, as defined in [3.3.3].

3.4.6 Combined axial, bending, shear and torsional force

When the actual torsional stress is above 20% of the allowable torsional stress, the scantling is to comply with the following formula:

$$\left(\frac{|\sigma_{ax\_i}|}{\alpha\sigma_{ca\_i}} + \frac{|\sigma_{b\_i}|}{\alpha\sigma_{cb\_i}}\right) + \left(\frac{|\tau_{s\_i}|}{\alpha\tau_{as\_i}} + \frac{|\tau_{t\_i}|}{\alpha\tau_{at\_i}}\right)^2 \leq 1$$

where:

σ_{ax_i} : Actual axial stress, in N/mm², in the considered structural member i, as defined in [3.2.1], and for the considered load case

σ_{b_i} : Combined bending stress, in N/mm², defined by the following formula:

$$\sigma_{b\_i} = \sqrt{\sigma^2_{by\_i} + \sigma^2_{bz\_i}}$$

σ_{by_i} : Actual bending stress, in N/mm², in the considered structural member i with respect to the local y-axis of the member, as defined in [3.2.2], and for the considered load case

σ_{bz_i} : Actual bending stress, in N/mm², in the considered structural member i with respect to the local z-axis of the member, as defined in [3.2.2], and for the considered load case

τ_{s_i} : Actual shear stress, in N/mm², in the considered structural member i, as defined in [3.2.3], and for the considered load case

τ_{t_i} : Actual torsional stress, in N/mm², in the considered structural member i, as defined in [3.2.4], and for the considered load case

σ_{ca_i} : Allowable compressive stress, in N/mm², in the considered structural member i, as defined in [3.3.2]

σ_{cb_i} : Allowable bending stress, in N/mm², in the considered structural member i, as defined in [3.3.3]

τ_{as_i} : Allowable shear stress, in N/mm², in the considered structural member i, as defined in [3.3.4]

τ_{at_i} : Allowable torsional stress, in N/mm², in the considered structural member i, as defined in [3.3.5].

4 Additional local analysis

4.1 General

4.1.1 The present Article is applicable to all structural leg details not previously mentioned in this Section. In particular, spudcans/bottom mat scantling and leg scantling subjected to local punching are to be checked in accordance with [4.2] and [4.3] and with the special provisions given in [4.4] and [4.5].

4.1.2 The local structural detail analysis is to be carried out using relevant methodologies. Resistance check is to be performed in accordance with the criteria given in [4.2] and [4.3].

4.2 Stress criteria

4.2.1 Equivalent stress for details analysed through isolated beam structural model

The equivalent stress σ_c , in N/mm², at each point, is given by:

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

where:

σ : Normal stress, in N/mm²

τ : Shear stress, in N/mm².

Above stresses are the result of the addition of the overall and local loads.

4.2.2 Equivalent stress for details analysed through finite element structural model

The equivalent stress σ_c , in N/mm², at each point, is given by:

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

where

σ_1 , σ_2 : Membrane principal stresses (except otherwise specified), in N/mm², in the element under study, including the effects of both overall and local loads.

4.2.3 Yielding criteria

The equivalent stress σ_c , in N/mm², is not to exceed the allowable stress σ_a for the loading condition considered, according to the following criterion:

$\sigma_c \leq \sigma_a$

where:

σ_a : Allowable stress, in N/mm², given by:

$\sigma_a = 1,1\ \alpha\ R_f$

4.2.4 Buckling criteria

The local buckling is to be checked using recognized techniques and standards as described in the Offshore Rules, Pt B, Ch 3, Sec 3, [6].

4.3 Fatigue

4.3.1 The Society may require to check the fatigue strength of any details in accordance with the provision of Sec 5, [6.5].

4.4 Spudcans and bottom mat

4.4.1 The pressure distribution to be applied on the spudcans or the bottom mat is to be submitted by the Party applying for classification.

The pressure distribution is to take into account the nature and the behaviour of the soil.

The provisions related to load applications are provided in Sec 5, [6.4] and Sec 6, [4.5].

4.4.2 A three-dimensional finite element model is required for the strength checking of the spudcan and bottom mat scantling.

The extension of the model is to be agreed by the Society.

4.5 Local punching

4.5.1 Methodology

Local leg scantling is to be checked against local punching due to guide contact forces in elevated position as well as in transit condition.

The global loads of the studied member are to be taken into account in addition to the punching force. The combination of both punching and global loads is to be such that the results give the worst stress configuration.

In principle, the local punching for rectangular hollow and cylindrical sections is to be checked, performing a finite element analysis and using the criteria defined in [4.2.3] and [4.2.4]. Punching of lattice leg is usually carried out using a beam model.

As local plate bending is designed for local punching, skin stresses are to be considered in the analysis.

4.5.2 Lattice leg

The contact force on the studied chord is to be modelled using punctual load.

Chords are to be checked using the criteria defined in [3].

4.5.3 Rectangular hollow section leg

The reaction forces in way of the guides are to be distributed according to the design load report submitted by the designer.

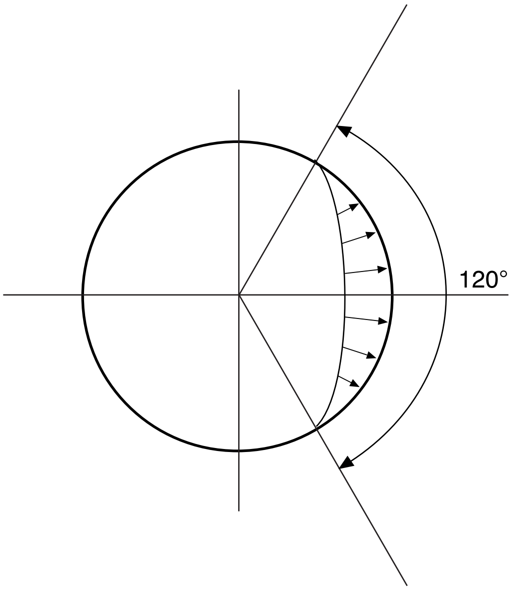
Depending on the local stiffnesses and the clearance between guides and legs, the Society may require non-linear contact analysis, on a case-by-case basis.

4.5.4 Cylindrical section leg

The reaction forces in way of the guides are to be distributed according to the design load report submitted by the designer. If this distribution is not specified, the contact force is to be distributed according to Fig 2, i.e. over a 120° angle with a cosine distribution. Particular attention is to be paid on the deformation of the leg which is to be contained by the guide structure.

Depending on the local stiffnesses and the clearance between guides and legs, the Society may require non-linear contact analysis, on a case-by-case basis.

Figure 2 : Punching force distribution on cylindrical section leg



SECTION 8 EQUIPMENT, APPURTENANCES AND OUTFITTINGS

1 Supports for hull attachments and appurtenances

1.1 General

1.1.1 The present Article is applicable to all major supports for hull attachments, such as:

- topsides
- drilling equipment
- derrick
- flare tower
- offloading stations
- helideck
- boat landing platforms / stairtowers.

1.2 Structural strength

1.2.1 The hull attachment and the affected supporting structure under the deck or inboard the side shell are to comply with Part B of the Offshore Rules.

The yielding stress criteria are given in Pt B, Ch 3, Sec 3, [5] of the Offshore Rules.

The buckling stress criteria are given in Pt B, Ch 3, Sec 3, [6] of the Offshore Rules and Sec 7, [3] of the present Rule Note, when relevant.

1.2.2 The structure is to be able to withstand the forces calculated for static, towing, operating, extreme and damage conditions. The forces are to be calculated by the constructing shipyard or attachment designer.

1.2.3 For the spectral fatigue analysis, the damage ratio is to be not greater than the values given in Sec 5, Tab 5.

1.3 Calculations

1.3.1 Finite element calculation

A three-dimensional finite element model of the support structure is to be submitted. A fine mesh of the construction details is required. The mesh size is to be typically 100 mm x 100 mm.

1.3.2 Load cases

The model is to take into account:

- the forces generated by the support structure on the hull
- the global loads induced by the hull or the leg to the local connections in both floating and elevated positions, if any.

2 Crane connections

2.1 Rules to be applied

2.1.1 Crane connections with hull structure are to comply with the requirements of NR608 Classification of Lifting Units, Section 4.

3 Superstructures and deckhouses

3.1 General

3.1.1 The superstructures and deckhouses are to be in accordance with the requirements of Pt B, Ch 8, Sec 4 of the Ship Rules.

For the application of these requirements, the following parameters are to be considered:

A_R : Roll single amplitude of the unit, in rad, as specified in Sec 6

A_P : Pitch single amplitude of the unit, in rad, as specified in Sec 6

h_W : Wave parameter, in m, given by:

$$h_W = 11{,}44 - \left|\frac{L - 250}{110}\right|^3$$

L : Rule length, in m, of the unit, as defined in Sec 6.

The front bulkhead is to be determined with respect to the towing direction.

3.1.2 When the superstructures are not directly located on the deck of the hull but supported by pillars, a global strength calculation of the structure supporting the superstructures is to be submitted according to methods, standards or codes recognized by the Society.

The lateral pressures on the superstructures are to be calculated as defined in Pt B, Ch 8, Sec 4, [2] of the Ship Rules. When the height of the supporting pillars is equivalent to a standard superstructure height, the lowest tier of the superstructure is to be considered as second tier of superstructure; when the height of the supporting pillars is equivalent to two standard superstructure heights, the lowest tier of the superstructure is to be considered as third tier of superstructure, and so on.

4 Helicopter deck

4.1 Reference standards

4.1.1 If the additional class notation **HEL** is assigned to the unit, the arrangement maintenance are to be in accordance with the Civil Aviation Publication 437 "Offshore Helicopter Landing Areas – Guidance on Standards" (CAP 437) and the MODU code.

4.2 Structure

4.2.1 The scantlings of the structure are to be in accordance with the requirements of Pt B, Ch 8, Sec 11 of the Ship Rules.

The accelerations a_{X1}, a_{Z1}, a_{Y2} and a_{Z2} for the calculation of the inertial forces during transit, as specified in Pt B, Ch 8, Sec 11 of the Ship Rules, may be assessed by hydrodynamic calculation. If the hydrodynamic calculation is not available, the accelerations to be considered are those caused by roll and pitch motions of 15° single amplitude at a period of 10 s.

5 Hull outfitting

5.1 Bulwarks and guardrails

5.1.1 Bulwarks and guardrails are to comply with the requirements of Pt B, Ch 9, Sec 2 of the Ship Rules.

In topsides, the perimeter of all the open deck areas, walkways around accommodation spaces, catwalks and openings are also to be protected with similar guardrails.

5.2 Shipboard fittings

5.2.1 Pt B, Ch 9, Sec 4 of the Ship Rules applies for the design of shipboard fittings and supporting hull structures associated with mooring.

5.2.2 For non-rectangular hulls, the breadth B to be taken for the equipment number calculation is the maximum breadth of the unit.

5.3 Towing equipment

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

5.3.2 The stress criteria to be considered for checking the hull connection (including the affected supporting structure under the deck) are given in Pt B, Ch 3, Sec 3 of the Offshore Rules. The basic allowable stress factor α to be used is: $\alpha = 1,0$.

6 Launching appliances

6.1 Launching appliances used for survival craft or rescue boat

6.1.1 The scantlings of deck ordinary stiffeners and primary supporting members are to follow the requirements of Pt B, Ch 7, Sec 2, [2.5] of the Ship Rules.

SECTION 9 CONSTRUCTION SURVEY - WELDING - TESTS AND TRIALS

1 Construction survey

1.1 General

1.1.1 The construction survey is to be performed in compliance with Pt B, Ch 3, Sec 6 of the Offshore Rules and NR426, Construction Survey of Steel Structures of Offshore Units and Installations.

2 Welding and weld connections

2.1 Reference

2.1.1 Industry standards

ANSI/AWS D1-1: Structural Welding Code.

2.2 General

2.2.1 The weld connection design of all the structural members of self-elevating units, including the tubular connections, is to comply with the requirements of NR426, Construction Survey of Steel Structures of Offshore Units and Installations.

2.3 Weld category

2.3.1 A weld is to be classed in the same category as the structural category (see Sec 2) of the element on which welding is performed. In case of a weld connecting two elements classed in different structural categories, the weld is to be classed in the category of the higher classed element.

2.3.2 Attention is drawn on the fact that welding on a permanent backing flat bar is not allowed for the special category and is subject to approval for the other categories, particularly in case of possible corrosion and cyclic loadings.

2.4 Weld types

2.4.1 General

The weld preparation is to comply with the requirements given in NR426, Sec 3.

The distance between welds are not to be less than the values required in NR426, Sec 3, [2.4].

2.4.2 Butt weld assembly

In case of welding of plates with different thicknesses, tapering is to be fitted as specified in NR426, Sec 3, [2.5].

2.4.3 Full penetration angle welds

Full penetration angle welds are required for the assembly of highly stressed elements having an important role to play in the structure and in which fatigue phenomena are likely to occur. This may be particularly the case for elements of special and first categories.

When full penetration is applied locally in way of hot spot, the length of the full penetration welds is not to be less than the greater of the following values:

a) length of the area where the tension stress normal to the welds exceeds 0,3 times the tensile strength of the filler metal

b) length of the area where the shear stress parallel to the welds exceeds 0,3 times the tensile strength of the filler metal

c) 400 mm.

The tension and shear stresses required in items a) and b) are to be obtained from a fine mesh finite element model. The size of the elements is not to be greater than 100 mm x 100 mm. The stress values calculated at the element centroid are to be used.

The length of the areas defined in items a) and b) is to include a whole number of 100 mm x 100 mm elements.

2.4.4 Tubular connections

Design of the nodes and their welding procedures are to be submitted for examination to the Society at the design stage, as stipulated in NR426, Sec 3, [1].

For special and first category elements, all the welds are to be full penetration welds.

2.4.5 Fillet weld assembly

These restricted penetration fillet welds are related to the connection of stiffeners to plates, securing brackets, etc.

The throat thickness value is to comply with the requirements given in [2.6] and [2.7]. The throat thickness for double fillet welds need not to exceed 0,45 e, where:

e : Thickness, in mm, of the thinner plate of the assembly.

Moreover, the throat thickness of the fillet welds is not to be less than:

- 3,5 mm in the general case
- 3,5 mm for high tensile steel assemblies with $e \le 8$ mm
- 4 mm for high tensile steel assemblies with 8 mm $< e \le 12$ mm
- 5 mm for high tensile steel assemblies with $e > 12$ mm.

2.4.6 Discontinuous welds and scallop welds

Discontinuous welds and scallop welds are generally not allowed.

2.5 Post welded treatment

2.5.1 Grinding

For structural elements subject to fatigue cycles, grinding of the weld connections may be required to improve the fatigue life.

2.5.2 Post weld heat treatment (PWHT)

For very thick assemblies subject to high restraint and essential to the structural safety of the unit or installation, a post weld heat treatment may be applied.

Such a treatment, where considered by the Builder, is to be indicated with all its operating conditions in the welding programme and on the construction drawings, as stipulated in NR426, Sec 3, [4.6].

2.6 Hull

2.6.1 Pt B, Ch 11, Sec 1 of the Ship Rules is to be applied for the weld design of all the structures of the self-elevating units, except those listed in [2.7.1].

2.7 Other structures

2.7.1 The following requirements apply to the weld design of the legs, spudcans, leghouses and structure supporting appurtenances.

2.7.2 The weld scantling (throat of fillet welds, partial and full penetration welds) is to be determined based on direct calculation approach. A recognized methodology such as defined in the standard quoted in [2.1.1] is to be used.

2.7.3 Hollow section legs

For ordinary stiffeners and primary supporting members, the throat thickness of the fillet weld T connections is not to be less than the value specified in Pt B, Ch 11, Sec 1 of the Ship Rules, considering the values of welding factor w_F given in Tab 1.

2.7.4 Lattice legs

The design of the tubular connections is to take into consideration the welding procedures, in particular the post weld heat treatment (PWHT), if applied.

The connections of chords with rack elements are to be of full penetration. In case of chords made of several structural members, their connections are also to be of full penetration.

Table 1 : Welding factor w_F for hollow section legs

Connection		w_F
of	to	
vertical ordinary stiffeners	leg plating **(1)**	0,13
primary members	leg plating	0,25
ordinary stiffeners (including collar plates)	primary supporting members (PSM) **(2)**	0,35

(1) In legs intended to be ballasted with water, continuous welding with w_F = 0,35 is to be adopted.

(2) All the ordinary stiffeners participating to the global strength of the legs are to be continuous when they cross primary supporting members. They are to be welded on both sides of the web of these PSM.

3 Tests and trials

3.1 Strength and watertightness testing

3.1.1 All the compartments and watertight members of the hull and leg shell-type structure are to be tested for strength and watertightness checking, in accordance with Pt B, Ch 3, Sec 7 of the Offshore Rules.

3.2 Jacking systems

3.2.1 The jacking systems are to be tested in compliance with the provisions given in Sec 10.

3.2.2 Proof and running tests are to be performed as per an agreed program as stipulated in NR266, Requirements for Survey of Materials and Equipment for the Classification of Ships and Offshore Units.

3.3 Preloading test

3.3.1 For units without bottom mat, all the legs are to be preloaded to the maximum applicable combined gravity plus overturning load.

The reviewed preload procedure is to be included in the Operating Manual.

SECTION 10 JACKING SYSTEM

1 General

1.1 Scope

1.1.1 The present section provides requirements and guidance for jacking or other elevating systems fitted in the self-elevating units.

1.2 Application

1.2.1 The jacking systems are to be reviewed by the Society. It includes:

- review of design, manufacturing and testing documents
- witnessing of testing
- visits during the manufacturing
- inspection at suppliers works, as needed.

1.2.2 Piping, hydraulic and electrical systems associated to the jacking systems are to comply with [2] to [4].

1.3 Documentation to be submitted

1.3.1 Prior to the start of the construction, all plans, specifications and calculations listed in Tab 1 are to be submitted to the Society.

Table 1 : Documents to be submitted for jacking systems

Item No.	Status of the review **(1)**	Description of the document **(2)**
1	A	Jacking machinery arrangement
2	A	Assembly and details of the self-elevating system
3	A	Details of the hydraulic jacks and pins and the documents listed in Tab 6
4	A/I	For pinions, gears and racks, the documents required in Ship Rules, Pt C, Ch 1, Sec 6, as applicable **(3)**
5	A	Power transmitting parts
6	A	Details of the inflatable chambers and their associated energizing system
7	A	Brakes
8	A/I **(4)**	Casings
9	A	Shock pads
10	I	Calculation of the load distribution between jacking units
11	A	Calculation of the pressure parts
12	A	Functional diagram of control, monitoring and safety systems
13	A	Fatigue analysis
14	I	Load-carrying capacity of the self-elevating system
15	I	Material and equipment specification
16	A	Single line diagram of the power distribution system
17	A	Schematic diagrams of the motor starter cabinet(s)
18	A	General arrangement diagram of the lifting appliances showing all the essential electrical equipment (electric motor, control panels, limit switch, etc...) with regard to the hazardous areas, when applicable
19	A	Detailed specification of the safety system
20	A	Justification of the safety character of electrical equipment located in hazardous areas (when applicable)
21	A	General arrangement of the operator cabin and workstations
22	A	List of the monitored parameters for alarming/monitoring and safety systems
23	A	Specification/diagram of the communication system

(1) A = to be submitted for approval in four copies
I = to be submitted for information in duplicate.
(2) Constructional drawings are to be supplemented by the specification of the materials employed including the chemical composition, heat treatment and mechanical properties and, where applicable, the welding details, welding procedure and stress relieving procedure.
(3) For jacking system fitted with rack and pinion, the load capacity of spur and helical gears is to be submitted for approval.
(4) "A" for welded casing, "I" otherwise.

1.4 Design and construction

1.4.1 Principle

Jacking mechanisms should be:

a) *arranged so that a single failure of any component does not cause an uncontrolled descent of the unit;*

b) *designed and constructed for the maximum lowering and lifting loads of the unit as specified in the unit's operation manual in accordance with Note 1 below;*

Note 1: The operating manual for normal operation of self-elevating units is to include *information regarding the preparation of the unit to avoid structural damage during the setting or retraction of legs on or from the seabed or during extreme weather conditions while in transit, including the positioning and securing of legs, cantilever drill floor structures and drilling equipment or materials which might shift position.*

c) *able to withstand the forces imposed on the unit from the maximum environmental criteria for the unit; and*

d) *constructed such that the elevation of the leg relative to the unit can be safely maintained in case of loss of power (e.g., electric, hydraulic, or pneumatic power).*

1.4.2 Redundancies

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.

Jacking systems are in general to be arranged with redundancy so that a single failure of any critical component does not cause an uncontrolled descent of the unit or impairs the possibility to jack the unit to a safe position.

1.4.3 Limitation of loads

The maximum loads developed by the jacking mechanism and its prime movers are to be limited to prevent damage to the jacking system in case of mechanical blockage of legs.

1.4.4 Strength of components

The components of the jacking and holding mechanisms which are subjected to structural loads are to comply with the applicable requirements of Offshore Rules, Part B, Chapter 3.

1.4.5 Brakes

Brakes are to be of a fail-safe type. In case of power supply failure, brakes are to engage automatically and hold the jacking machinery.

1.4.6 Control, communication and alarms

a) *The elevating system should be operable from a central jacking control station.*

b) *The jacking control station should have the following:*

   1) *audible and visual alarms for jacking system overload and out-of-level. Units whose jacking systems are subject to rack phase differential should also have audible and visual alarms for rack phase differential; and*

   2) *instrumentation to indicate:*

      - *the inclination of the unit on two horizontal perpendicular axes;*
      - *power consumption or other indicators for lifting or lowering the legs, as applicable; and*
      - *brake release status.*

c) *A communication system should be provided between the central jacking control and a location at each leg.*

d) Suitable monitoring is to be provided at a manned control station to indicate failure of critical components referred to in [1.4.2].

As appropriate, this monitoring is to indicate the availability of power, the position of the fixation rack system (yoke), out-of-level, electrical power of current motor running, and motor overload.

e) For the purpose of load equalization between the jacking units, the unit torque (at the electric motor) is to be checked and adjusted if necessary. This is to be done once the platform was lifted and subjected to weather conditions which may have altered the distribution.

Note 1: The requirement of item e) does not apply if an automatic load control device is used.

1.4.7 Gearing system

Justification of the design results of the gearing system is to be submitted.

1.5 Holding capacity

1.5.1 For self-elevating units without a fixation rack system, the required holding capacity is to be based on the maximum load. The brake capacity (static friction torque) is to be not less than 1,3 times the maximum load, considering the mechanical efficiency of the drive gear.

Note 1: For self-elevating units without a fixation rack system, the maximum load is defined as the maximum reaction between a leg and the jacking machinery in severe storm condition.

1.5.2 For self-elevating units with a fixation rack system, the required holding capacity is to be based on the preload. The brake capacity (static friction torque) is to be not less than 1,2 times the preload, considering the mechanical efficiency.

2 Piping systems

2.1 Definition

2.1.1 Piping and piping systems

a) Piping includes pipes and their connections, flexible hoses and expansion joints, valves and their actuating systems, other accessories (filters, level gauges, etc.) and pump casings.

b) Piping systems include the piping and all the interfacing equipment such as tanks, pressure vessels, heat exchangers, pumps.

2.1.2 Design pressure

The design pressure of a piping system is the pressure considered by the manufacturer to determine the scantling of the system components. It is to be taken not less than the maximum working pressure expected in this system or the highest setting pressure of any safety valve or relief device, whichever is the greater.

The design pressure of a piping system located on the low pressure side of a pressure reducing valve where no safety valve is provided is not to be less than the maximum pressure on the high pressure side of the pressure reducing valve.

The design pressure of a piping system located on the delivery side of a pump or a compressor is not to be less than:

- the setting pressure of the safety valve for displacement pumps, or
- the maximum pressure resulting from the operating (head-capacity) curve for centrifugal pumps,

whichever is the greater.

2.1.3 Design temperature

The design temperature of a piping system is the maximum temperature of the medium inside the system.

2.1.4 Flammable oils

Flammable oils include fuel oils, lubricating oils, thermal oils and hydraulic oils.

2.2 Symbols and units

2.2.1 The following symbols and related units are commonly used in this Article:

p : Design pressure, in MPa

T : Design temperature, in °C

t : Rule required minimum thickness, in mm

D : Pipe external diameter, in mm.

2.3 Design and construction

2.3.1 Thickness of pressure piping

The thickness t, in mm, of pressure pipes is to be obtained from the following formula:

$$t = \frac{t_0 + b + c}{1 - \frac{a}{100}}$$

without being less than the minimum values given in Tab 2 for pipes in austenitic stainless steel,

where:

t_0 : Thickness coefficient, in mm, equal to:

$$t_0 = \frac{pD}{2Ke + p}$$

with:

p, D : As defined in [2.2.1]

K : Permissible stress, in N/mm², defined in [2.3.2]

e : Weld efficiency factor, to be:

- equal to 1 for seamless pipes and pipes fabricated according to a welding procedure approved by the Society
- specially considered by the Society for the other welded pipes, depending on the service and the manufacture procedure

b : Thickness reduction due to bending, in mm, defined in [2.3.3]

c : Corrosion allowance, in mm, defined in Tab 3

a : Negative manufacturing tolerance percentage:

- equal to 12,5 for hot laminated seamless steel pipes
- subject to special consideration by the Society in the other cases.

The thickness thus determined does not take into account the particular loads that the pipes may be subjected to. Attention is to be drawn, in particular, to the cases of high temperature and low temperature pipes.

Table 2 : Minimum wall thickness for austenitic stainless steel pipes

External diameter, in mm	Minimum wall thickness (mm)
from 10,2 to 17,2	1,0
from 21,3 to 48,3	1,6
from 60,3 to 88,9	2,0
from 114,3 to 168,3	2,3
219,1	2,6
273,0	2,9
from 323,9 to 406,4	3,6
> 406,4	4,0

Note 1: Diameters and thicknesses according to national or international standards may be accepted.

Table 3 : Corrosion allowance c for steel pipes

Piping system	c (mm)
Compressed air	1,0
Hydraulic oil	0,3
Lubricating oil	0,3
Fuel oil	1,0
Fresh water	0,8
Sea water	3,0

Note 1: For pipes passing through tanks, an additional corrosion allowance is to be considered in order to account for the external corrosion.

Note 2: The corrosion allowance of pipes efficiently protected against corrosion may be reduced by no more than 50%.

Note 3: When the corrosion resistance of alloy steels is adequately demonstrated, the corrosion allowance may be disregarded.

2.3.2 Permissible stress

The permissible stress K is depending on the material and the design temperature. It is given in:

- Tab 4 for carbon and carbon-manganese steel pipes
- Tab 5 for alloy steel pipes.

Intermediate values may be obtained by interpolation.

Where, for carbon steel and alloy steel pipes, no value is given in Tab 4 or in Tab 5, K is to be taken as follows:

$$K = \mathrm{Min}\left(\frac{R_{m,20}}{2,7} ; \frac{R_e}{A} ; \frac{S_R}{A} ; S\right)$$

where:

$R_{m,20}$: Minimum tensile strength of the material at ambient temperature (20°C), in N/mm²

R_e : Minimum yield strength or 0,2% proof stress at the design temperature, in N/mm²

S_R : Average stress to produce rupture in 100000 h at design temperature, in N/mm²

S : Average stress to produce 1% creep in 100000 h at design temperature, in N/mm²

A : Safety factor to be taken equal to:

- 1,6 when R_e and S_R result from tests attended by the Society
- 1,8 otherwise.

The values of K adopted for materials other than carbon steel and alloy steel are to be specially considered by the Society.

Table 4 : Permissible stress K for carbon and carbon-manganese steel pipes

Specified minimum tensile strength (N/mm²)	Design temperature (°C)												
	≤ 50	100	150	200	250	300	350	400	410	420	430	440	450
320	107	105	99	92	78	62	57	55	55	54	54	54	49
360	120	117	110	103	91	76	69	68	68	68	64	56	49
410	136	131	124	117	106	93	86	84	79	71	64	56	49
460	151	146	139	132	122	111	101	99	98	85	73	62	53
490	160	156	148	141	131	121	111	109	98	85	73	62	53

Table 5 : Permissible stress K for alloy steel pipes

Type of steel	Specified minimum tensile strength (N/mm²)	Design temperature (°C)									
		≤50	100	200	300	350	400	440	450	460	470
1Cr1/2Mo	440	159	150	137	114	106	102	101	101	100	99
2 1/4Cr1Mo annealed	410	76	67	57	50	47	45	44	43	43	44
2 1/4Cr1Mo normalised and tempered below 750°C	490	167	163	153	144	140	136	130	128	127	116
2 1/4Cr1Mo normalised and tempered above 750°C	490	167	163	153	144	140	136	130	122	114	105
1/2Cr 1/2Mo 1/4V	460	166	162	147	120	115	111	106	105	103	102

Type of steel	Specified minimum tensile strength (N/mm²)	Design temperature (°C)									
		480	490	500	510	520	530	540	550	560	570
1Cr1/2Mo	440	98	97	91	76	62	51	42	34	27	22
2 1/4Cr1Mo annealed	410	42	42	41	41	41	40	40	40	37	32
2 1/4Cr1Mo normalised and tempered below 750°C	490	106	96	86	79	67	58	49	43	37	32
2 1/4Cr1Mo normalised and tempered above 750°C	490	96	88	79	72	64	56	49	43	37	32
1/2Cr 1/2Mo 1/4V	460	101	99	97	94	82	72	62	53	45	37

2.3.3 Thickness reduction due to bending

Unless otherwise justified, the thickness reduction b due to bending is to be obtained from the following formula:

$$b = \frac{Dt_0}{2,5\rho}$$

where:

ρ : Bending radius measured on the centre line of the pipe, in mm

D : As defined in [2.2.1]

t_0 : As defined in [2.3.1].

When the bending radius is not given, b is to be taken equal to t_0 / 10.

For straight pipes, b is to be taken equal to 0.

2.3.4 Tees

In addition to the provisions of [2.3.1] to [2.3.3], the thickness t of pipes on which a branch is welded to form a Tee is not to be less than the thickness t_T defined as follows:

$$t_T = \left(1 + \frac{D_1}{D}\right) t_0$$

where:

D_1 : External diameter of the branch pipe, in mm

D, t_0 : As defined respectively in [2.2.1] and [2.3.1].

Note 1: This requirement may be dispensed with for Tees extruded or provided with a reinforcement.

2.3.5 Junction of pipes

The junctions of pipes are to comply with the requirements of the Offshore Rules, Pt C, Ch 1, Sec 7, [2.5].

2.3.6 Protection against overpressure

The provisions for protection against overpressure of the pipes used in the jacking systems are detailed in the Offshore Rules, Pt C, Ch 1, Sec 7, [2.6].

2.3.7 Flexible hoses and expansion joints

Flexible hoses and expansion joints are to comply with the requirements of the Offshore Rules, Pt C, Ch 1, Sec 7 [2.7].

2.3.8 Valves and accessories

Valves and accessories are to comply with the requirements of the Offshore Rules, Pt C, Ch 1, Sec 7 [2.8].

2.3.9 Control and monitoring

a) General

1) Local indicators are to be provided at least for the following parameters:
    - pressure: in pressure vessels, at pump or compressor discharge, at the inlet of the equipment served, on the low pressure side of pressure reducing valves
    - temperatures: in tanks and pressure vessels, at heat exchanger inlet and outlet
    - levels: in tanks and pressure vessels containing liquids.
2) Safeguards are to be provided where an automatic action is necessary to restore acceptable values for a faulty parameter.
3) Automatic controls are to be provided where it is necessary to maintain the parameters related to piping systems at a pre-set value.

b) Level gauges

The level gauges used in flammable oil systems are to be of a type approved by the Society and are subject to the following conditions:

1) their failure or the overfilling of the tank is not to permit release of fuel into the space. The use of cylindrical gauges is prohibited. The Society may permit the use of oil-level gauges with flat glasses and self-closing valves between the gauges and the fuel tanks.
2) their glasses are to be made of heat-resistant material and efficiently protected against shocks.

2.4 Welding of steel piping

2.4.1 The welding of steel piping is to comply with the requirements for Class I of the Offshore Rules, Pt C, Ch 1, Sec 7, [3].

2.5 Arrangement and installation of piping systems

2.5.1 Flexible hoses and expansion joints

a) Flexible hoses and expansion joints are to be in compliance with [2.3.7]. They are to be installed in clearly visible and readily accessible locations.

b) The number of flexible hoses and expansion joints is to be limited and kept to a minimum.

c) In general, flexible hoses and expansion joints are to be limited to a length necessary to allow relative movements between fixed and flexibly mounted items of machinery/equipment or systems.

d) The installation of a flexible hose assembly or an expansion joint is to be in accordance with the manufacturer's instructions and use limitations, with a particular attention to the following points:
- orientation
- end connection support (where necessary)
- avoidance of hose contact that could cause rubbing and abrasion
- minimum bend radii.

e) Flexible hose assemblies or expansion joints are not to be installed where they may be subjected to torsion deformation (twisting) under normal operating conditions.

f) Where flexible hoses or an expansion joint are/is intended to be used in piping systems conveying flammable fluids that are in close proximity to heated surfaces, the risk of ignition due to failure of the hose assembly and subsequent release of fluids is to be mitigated, as far as practicable, by the use of screens or any other similar protection, to the satisfaction of the Society.

g) The adjoining pipes are to be suitably aligned, supported, guided and anchored.

h) Isolating valves are to be provided permitting the isolation of the flexible hoses intended to convey flammable oil or compressed air.

i) Expansion joints are to be protected against over extension or over compression.

j) Where they are likely to suffer from external damage, flexible hoses and expansion joints of the bellow type are to be provided with adequate protection.

2.5.2 Pressure gauges

Pressure gauges and other similar instruments are to be fitted with an isolating valve or cock at the connection with the main pipe.

2.6 Certification, inspection and testing of piping systems

2.6.1 The requirements for certification, inspection and testing of piping systems are given in the Offshore Rules, Pt C, Ch 1, Sec 7, [20].

3 Hydraulic systems

3.1 General

3.1.1 Definitions

A power unit is the assembly formed by a hydraulic pump and its driving motor.

An actuator is a component which directly converts hydraulic pressure into mechanical action.

3.1.2 Use limitations of hydraulic oils

Oils used for hydraulic power installations are to have a flashpoint not lower than 150°C and be suitable for the entire service temperature range.

The hydraulic oil is to be replaced in accordance with the specification of the installation manufacturer.

3.1.3 Location of hydraulic power units

Whenever practicable, the hydraulic power units are to be located outside the main engine or boiler rooms.

Where the requirement above is not complied with, shields or similar devices are to be provided around the units in order to avoid an accidental oil spray or jet on heated surfaces which may ignite oil.

3.2 Documentation to be submitted

3.2.1 The documents listed in Tab 6 are to be submitted.

3.3 General design

3.3.1 Design requirements

As far as practicable, hydraulic systems are to be so designed as to:

- avoid any overload of the system
- maintain the actuated equipment in the requested position (or the driven equipment at the requested speed)
- avoid overheating of the hydraulic oil
- prevent hydraulic oil from coming into contact with sources of ignition.

Table 6 : Hydraulic systems - Drawings, information and data to be submitted

No.	A/I **(1)**	Item
1	A	Diagram of hydraulic system
2	I	General arrangement plan, including nozzles and fittings
3	A	Sectional assembly
4	A	Safety valves (if any) and their arrangement
5	A	Material specifications
6	A	Welding details, including at least: • typical weld joint design • welding procedure specifications • post-weld heat treatments
7	I	Design data, including at least design pressure and design temperatures (as applicable)
8	I	Type of fluid or fluids contained
(1) A = Documents to be submitted for approval in four copies I = Documents to be submitted for information in duplicate.		

3.3.2 Availability

a) As a rule, hydraulic systems are to be so designed that, in the event that any one essential component becomes inoperative, the hydraulic power supply to essential services can be maintained. Partial reduction of the operating capability of the hydraulic system may be accepted, however, when it is demonstrated that the safe operation of the unit is not impaired.

b) When a hydraulic power system is simultaneously serving one jacking system and other systems, it is to be ensured that:
- operation of such other systems, or
- a single failure in the installation external to the essential system,

is not detrimental to the operation of the essential system.

c) Hydraulic systems are to be so designed that a single failure of any component of the system may not result in a sudden undue displacement of the load or in any other situation detrimental to the safety of the unit and persons on board.

3.4 Design of hydraulic pumps and accessories

3.4.1 Power units

Hydraulic power installations are to include at least two power units so designed that the services supplied by the hydraulic power installation can operate simultaneously with one power unit out of service. A reduction of the performance may be accepted.

Low power hydraulic installations not supplying essential services may be fitted with a single power unit, provided that alternative means, such as a hand pump, are available on board.

3.4.2 Pressure reduction units

Pressure reduction units used in hydraulic power installations are to be duplicated.

3.4.3 Filtering equipment

A device is to be fitted which efficiently filters the hydraulic oil in the circuit.

Where filters are fitted on the discharge side of the hydraulic pumps, a relief valve leading back to the suction or to any other convenient place is to be provided on the discharge of the pumps.

3.4.4 Provision for cooling

Where necessary, appropriate cooling devices are to be provided.

3.4.5 Provision against overpressure

Safety valves of sufficient capacity are to be provided at the high pressure side of the installation.

Safety valves are to discharge to the low pressure side of the installation or to the service tank.

3.4.6 Provision for venting

Cocks are to be provided in suitable positions to vent the air from the circuit.

3.4.7 Provision for drainage

Provisions are to be made to allow the drainage of the hydraulic oil contained in the installation to a suitable collecting tank.

3.5 Design of hydraulic tanks and other components

3.5.1 Hydraulic oil service tanks

Service tanks intended for hydraulic power installations supplying essential services are to be provided with at least:
- a level gauge complying with [2.3.9], item b)
- a temperature indicator
- a level switch complying with [3.7.2].

The free volume in the service tank is to be at least 10% of the tank capacity.

3.5.2 Hydraulic oil storage tanks

Hydraulic power installations supplying essential services are to include a storage tank of sufficient capacity to refill the whole installation, should the need arise.

For hydraulic power installations of less than 5 kW, the storage means may consist of sealed drums or tins stored in satisfactory conditions.

3.5.3 Hydraulic accumulators

The hydraulic side of the accumulators which can be isolated is to be provided with a relief valve or another device offering equivalent protection in case of overpressure.

3.6 Hydraulic cylinders

3.6.1 The minimum thickness t of the steel cylindrical shell of luffing or slowing hydraulic cylinders is obtained, in mm, from the following formula:

$$t = \frac{pD}{(2K - p)e}$$

where:

p : Design pressure, in MPa

D : Inside diameter of the cylinder, in mm

e : Weld efficiency factor, as defined in [2.3.1]

K : Permissible stress, in N/mm^2.

Where not otherwise specified, K may be taken as follows:

$$K = \text{Min}\left(\frac{R_{m,20}}{A} ; \frac{R_S}{B}\right)$$

A, B : Coefficients of utilisation, as defined in Tab 7

$R_{m,20}$: Minimum tensile strength at ambient temperature (20°C), in N/mm^2

R_S : Minimum between R_{eH} and $R_{p\ 0,2}$ (0,2% proof stress) at the design temperature T, in N/mm^2.

Table 7 : Coefficients of utilisation A and B

	Steel	Cast steel	Nodular cast iron
A	2,7	3,4	4,5
B	1,8	2,3	3,5

The thickness obtained is the "net" thickness, as it does not include any corrosion allowance. The thickness obtained from the above formula is to be increased by 0,75mm.

The Society reserves the right to increase the corrosion allowance value in the case of pressure vessels exposed to particular conditions accelerating the corrosion. The Society may also consider the reduction of this factor where particular measures are taken to effectively reduce the corrosion rate of the pressure vessel.

Irrespective of the value calculated by the formulae, the thickness t, in mm, is not to be less than the minimum thickness t_{min} defined as follows:

$t_{min} = 3 + D/1500$

No corrosion allowance needs to be added to t_{min} .

Note 1: The formula of t is applicable if the ratio external diameter/inside diameter is equal to or less than 1,5; if it is not the case, the cylinder is subject to special consideration.

3.6.2 The bottom and the head of the cylinder are to have a thickness complying with the applicable requirements of the Ship Rules, Pt C, Ch 1, Sec 3, [2.7].

In the thickness calculation, the reinforcement of the cover due to the fixation of the cylinder (often welded on the cover) with the crane is not taken into account.

3.6.3 Scantlings of the piston rods are to be checked for buckling, according to the following strength criterion:

$\omega \, \sigma_c \leq 0,55 \, R_e$

where:

- ω : Buckling coefficient defined in NR526, Sec 4, [1.4.3] with the effective length of buckling equal to twice the maximum reach of cylinder rod
- σ_c : Compression stress, in N/mm², corresponding to the design pressure p as defined in [3.6.1]
- R_e : Yield stress, in N/mm², considered in the calculations of cylinder rod resistance (see NR526, Sec 4, [1.3.1]).

Note 1: NR526 Rules for the Certification of Lifting Appliances onboard Ships and Offshore Units.

3.6.4 Cast steel or spheroidal graphite ferritic cast iron shells of hydraulic cylinders are to be ultrasonic-tested for internal soundness.

3.6.5 The fastening of cylinder bottoms and of cylinders is to be checked by direct calculations. The combined stress is not to exceed 0,55 R_e.

For welded bottoms, all welds are to be checked, using appropriate non-destructive methods.

3.6.6 The cylinders are to be hydraulic tested prior to be fitted on board, under the conditions defined in the Ship Rules, Pt C, Ch 1, Sec 3, [7.3.2].

3.7 Control and monitoring

3.7.1 Indicators

Arrangements are to be made for connecting a pressure gauge where necessary in the piping system.

3.7.2 Monitoring

Alarms and safeguards are to be provided in accordance with Tab 8 for hydraulic power installations intended for essential services, except steering gear, for which the provisions of Offshore Rules, Pt C, Ch 1, Sec 12 apply.

3.8 Inspection and testing

3.8.1 Pumps and hydraulic motors need not be inspected by the Society at the manufacturer's works, provided they are produced in series and manufactured according to a recognize standard. In addition, the acceptance of these devices is subject to the submission of the manufacturer's test certificates and to the satisfactory performance during the testing of the lifting appliances.

3.8.2 The hydraulic systems are to be hydraulically tested after assembly on board, under the conditions defined in the Offshore Rules, Pt C, Ch 1, Sec 12, [3.6].

Table 8 : Hydraulic oil systems

Symbol convention H = High, HH = High high, G = group alarm L = Low, LL = Low low, I = individual alarm X = function is required, R = remote	Monitoring		Automatic control				
			System			Auxiliary	
Identification of system parameter	Alarm	Indication	Slow-down	Shut-down	Control	Stand by Start	Stop
Pump pressure	L						
Service tank level	L **(1)** **(2)**						X **(2)**

Note 1: Some departures from Tab 8 may be accepted by the Society in the case of small units, units operating in restricted zones or platforms installed in sheltered coastal areas.

Note 2: Tab 8 does not apply to steering gears.

(1) The low level alarm is to be activated before the quantity of lost oil reaches 100 litres or 70% of the normal volume in the tank, whichever is the less.

(2) For hydraulic cranes where no electrical system has been provided, the requirement may be waived if the level gauge, the pressure gauge and the temperature gauge indicators are always visible by the crane operator. In addition, a warning label is to be placed on the tank, reminding that, prior to the start of any crane operation, the oil level is to be checked.

4 Electrical systems

4.1 Generality

4.1.1 This Article gives requirements for jacking systems in addition to the relevant provisions given in the Offshore Rules, Pt C, Ch 2 and Pt C, Ch 3.

4.1.2 Reference

a) IEC 61892-5 - Mobile and fixed offshore units - Electrical installations - Part 5: Mobile units

b) IEC 61892-6 - Mobile and fixed offshore units - Electrical installations - Part 6: Installation

4.2 Jacking gear motors and motor controller

4.2.1 General

Installation of jacking gear motors is to be in accordance with IEC 61892-6, except installation of groups of motors which is to be in compliance with [4.2.2] to [4.2.5].

4.2.2 Group installation

On each leg, two or more motors of any load may be connected to a single branch circuit.

4.2.3 Overcurrent protection

The branch circuit is to be provided with short circuit protection set at no more than ten times the sum of the full load currents of the motors.

4.2.4 Running protection

A visual and audible alarm is to be given at the jacking control station to indicate the overload condition in any of the jacking motors.

4.2.5 Metering

The monitoring of motor power specified in [1.4.6], item d), need only to monitor the branch circuit and not each individual motor.

4.3 Testing on board

4.3.1 The elevating machinery is to be function-tested for at least one complete cycle of all the conditions specified in [1.4.6], item e), and with the full preload. During these tests, all alarms, brake functions and interlocks are to be checked.

Shock pad deflections, electric motor input torque and speed and pinion-rack meshes are to be checked for all load conditions.

4.3.2 After the lifting test, the brake torques are to be checked and adjusted if necessary.

APPENDIX 1 HYDRODYNAMIC ANALYSIS OF SELF-ELEVATING UNITS IN FLOATING CONDITION

1 General

1.1 Principle

1.1.1 The values of wave induced loads and motions when the unit is in floating position may be assessed through direct calculations.

1.1.2 The hydrodynamic analysis is to be carried out using a recognized software. In particular, the use of a software based on three-dimensional potential flow-based diffraction radiation theory is required. Software is to be documented.

2 Modelling principles

2.1 Environmental data

2.1.1 General

The particular provisions of Sec 4 are applicable.

2.2 Hydrodynamic model

2.2.1 The model should take into account the following effects:

- the hull forms with appendices, if any
- the lightweight distribution (including structure weight, equipment weight, leg weight, etc.)
- the loading conditions (see [2.3]).

The wetted surface of the unit is to be modelled by a sufficient number of elements. The element size in the model is to be consistent with the wave parameters (wave length and amplitude in particular).

2.2.2 The values taken for roll damping are to be duly justified.

2.3 Loading conditions

2.3.1 The following loading conditions are to be taken into account:

- field transit condition
- ocean transit condition
- installation condition while lowering the legs (see Sec 6, [5.2.1]).

2.4 Sensitivity analysis

2.4.1 A sensitivity analysis is required during hydrodynamic analysis. It is to be performed based on the variations of wave parameters (peak period, wave spectrum parameter, direction, etc.) and other parameters (trim, unit loading, etc.), if deemed relevant.

3 Floating unit responses

3.1 Response amplitude operators (RAOs)

3.1.1 The response amplitude operators and natural periods are to be calculated for each degree of freedom.

The RAOs are to be calculated:

- for different headings, generally every 15°.

  The number of heading intervals may be reduced, to the satisfaction of the Society
- for wave circular frequencies covering the anticipated sea states and spectra, and, as a minimum, from 0,1 rad/s to 2,0 rad/s, with a step in wave circular frequencies not exceeding 0,05 rad/s.

  Refinements are to be performed around natural periods of the unit, in particular in roll and pitch.

3.2 Hull girder loads, motions and accelerations

3.2.1 The hydrodynamic analysis is to result in the following parameters:

- motions of the hull, including natural frequencies of roll, pitch and heave motions
- relative wave elevation over the length of the hull
- total accelerations in the three directions, at the top of each leg and jackhouse and/or inertia loads applied on the legs (by direct integration of accelerations along the leg length)
- total accelerations in the three directions, at relevant positions of the appurtenances
- wave induced global load distribution, if relevant, over the length of the hull.

These parameters are usually to be calculated based on a short-term distribution, which is to be submitted.

3.2.2 The values of the wave induced loads and unit motions for transit conditions are to be determined based on significant metocean data with a return period at least equal to 10 years (probability level of $10^{-7,7}$), except when otherwise specified by the Party applying for classification.

In no case, the motions and accelerations obtained are to be less than the values given in Sec 3, [3.2.3].