OFFSHORE STANDARD
DNV-OS-C102

STRUCTURAL DESIGN OF OFFSHORE SHIPS

OCTOBER 2000

DET NORSKE VERITAS

FOREWORD

DET NORSKE VERITAS (DNV) is an autonomous and independent foundation with the objectives of safeguarding life, property and the environment, at sea and onshore. DNV undertakes classification, certification, and other verification and consultancy services relating to quality of ships, offshore units and installations, and onshore industries worldwide, and carries out research in relation to these functions.

DNV Offshore Codes consist of a three level hierarchy of documents:

— *Offshore Service Specifications.* Provide principles and procedures of DNV classification, certification, verification and consultancy services.
— *Offshore Standards.* Provide technical provisions and acceptance criteria for general use by the offshore industry as well as the technical basis for DNV offshore services.
— *Recommended Practices.* Provide proven technology and sound engineering practice as well as guidance for the higher level Offshore Service Specifications and Offshore Standards.

DNV Offshore Codes are offered within the following areas:

A) Qualification, Quality and Safety Methodology

B) Materials Technology

C) Structures

D) Systems

E) Special Facilities

F) Pipelines and Risers

G) Asset Operation

Amendments April 2002

This Code has been amended, but not reprinted in April 2002. The changes are incorporated in the Web, CD and printable (pdf) versions. The amendments are shown in red colour in the Web and CD versions.

All changes affecting DNV Offshore Codes that have not been reprinted, are published separately in the current *Amendments and Corrections*, issued as a printable (pdf) file.

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CHAPTER 1

WORLD-WIDE OPERATION

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SECTION 1
INTRODUCTION

A. General

A 100 Area of application for Ch.1 and Ch.2 of this standard

101 Ch.1 of this standard provides requirements and guidance to the structural design of offshore ships constructed in steel intended for world wide operation. The hull girder capacity is based on the principles of the Load and Resistance Factor Design method referred to as the LRFD method as defined in DNV-OS-C101. The design wave bending moments and shear forces at an annual probability of 10^{-2} (100 year return period) are determined by means of direct calculations based on a site specific wave scatter diagram. The requirements given in Ch.1 are supplementary to the requirements for the main class. This implies that the unit shall comply with the main class requirements for the midship section modulus. These requirements are based on the wave bending moments for the North Atlantic at an annual probability of $10^{-1.3}$ (20 year return period).

102 Ch.2 of this standard provides requirements and guidance to the structural design of offshore ships constructed in steel intended for restricted operation in benign waters. Benign waters is in this context defined as the environments where required hull girder capacity calculated according to the LRFD method is less than the minimum section modulus calculated according to the main class requirements.

103 The standard has been written for general world-wide application. Govenmental regulations may include requirements in excess of the provisions of this standard depending on size, sype, location and intended service of the offshore unit/installation.

A 200 Objectives

201 The objectives of this standard are to:

— provide an internationally acceptable standard for design of ship-shaped offshore structures
— serve as a technical reference document in contractual matters between purchaser and manufacturer
— serve as a guideline for designers, purchaser, contractors and regulators.
— specify procedures and requirements for units and installations subject to DNV verification and classification services.

A 300 Classification

301 For use of this standard as technical basis for offshore classification as well as descriptions of principles, procedures and applicable class notations related to classification services, see DNV Offshore Service Specifications given in Table A1.

Table A1 DNV Offshore Service Specifications	
Reference	*Title*
DNV-OSS-101	Rules for Classification of Offshore Drilling and Support Units
DNV-OSS-102	Rules for Classification of Floating Production and Storage Units

302 Documentation requirements for classification are given by DNV-RP-A202.

B. General Application and Assumptions

B 100 General

101 It is assumed that the units will follow the normal class survey periods including regular dry-docking for inspection and maintenance. Units intended to stay on location for prolonged periods shall also comply with the requirements given in Appendix A.

102 The standard is regarded as supplementary to those given for assignment of the main class (⊞ 1A1 requirements).

103 The standard is in principle applicable to all types of offshore ships of conventional ship shape including the following variants:

— Floating production units (FPU)
— Floating storage and offloading units (FSO)
— Floating production, storage and offloading units (FPSO)
— Floating production, drilling, storage and offloading units (FPDSO)
— Drilling vessels
— Well stimulation or intervention vessels.

The vessels or units listed above will collectively be referred to as "units".

104 This standard is intended to cover several variations with respect to conceptual solutions as listed below:

— units intended for production normally equipped with topside structures to support the production facilities
— units intended for storage in the hull tanks with facilities for offloading to shuttle tankers
— units designed with a turret for mooring and riser connections. The turret may be of significant size and will affect the distribution of hull girder bending stresses
— units designed with a submerged disconnectable turret (buoy) normally located in the foreship or bow region
— units designed with spread mooring system, or similar solutions. Such solutions are normally restricted to benign environments.

105 Requirements concerning mooring and riser systems other than the interfaces with the structure of the units are not explicitly considered in this standard.

106 The standard is applicable to the turret structure.

C. Definitions

C 100 Floating storage and offloading units

101 A *floating production, drilling, storage and offloading unit* can be relocated, but is generally located on the same location for a prolonged period of time. The units normally consist of a hull, with turret, and production and drilling equipment on the deck. The unit is equipped for crude oil storage. The crude oil may be transported to shore by shuttle tankers via an offloading arrangement.

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201 A *floating production storage and offloading unit* can be relocated, but is generally located on the same location for a prolonged period of time. The units normally consist of a hull, with turret, and production equipment on the deck. The unit is equipped for crude oil storage. The crude oil may be transported to shore by shuttle tankers via an offloading arrangement.

C 300 Floating production, drilling, storage and offloading units

301 A *floating production, drilling, storage and offloading unit* can be relocated, but is generally located on the same location for a prolonged period of time. The units normally consist of a hull, with turret, and production and drilling equipment on the deck. The unit is equipped for crude oil storage. The crude oil may be transported to shore by shuttle tankers via an offloading arrangement.

C 400 Drilling vessels

401 A *drilling vessel* is generally operating on the same location for a limited period of time. The unit follows the normal class survey program. The unit is normally equipped with dynamic positioning system with several thrusters. The units normally consist of a hull with moonpool and drilling equipment on the deck. The unit may also be equipped for limited oil storage for testing.

C 500 Well stimulation or intervention vessel

501 *A well stimulation vessel* or *well intervention vessel* is generally operating on the same location for a limited period of time. The unit follows the normal class survey program. The unit is normally equipped with a dynamic positioning system with several thrusters. The units normally consist of a hull with moonpool and equipment for well stimulation or maintenance (e.g. coil tubing) on the deck. The unit may also be equipped for limited oil storage for testing.

C 600 Turret

601 A *turret* is a device providing a connection point between the unit and the combined riser- and mooring- systems, allowing the unit to rotate around the turret (weather vane) without twisting the risers and mooring lines.

C 700 Symbols

701 General symbols and definition of terms applicable for offshore units are given in the Rules for Classification of Ships Pt.3 Ch.1 Sec.1.

702 The characters given in Table C1 are used in this standard.

Table C1 Characters

Character	Explanation
V	speed in knots
C_W	wave coefficient as given in Rules for Classification of Ships Pt.3 Ch.1 Sec.4
P_{dp}	design load on weather deck
h_0	vertical distance from the waterline at draught T to the load point (m)
z	vertical distance from the baseline to the load point (m)
y	horizontal distance from the centre line to the load point (m)
f	vertical distance from the waterline to the top of the unit's side at transverse section considered (m)
b_1	breadth of deckhouse at position considered
B_1	maximum breadth of unit on the weather deck at position considered
h_s	significant wave height
M_g	characteristic bending moment resistance of the hull girder
M_S	characteristic design still water bending moment based on actual cargo and ballast conditions
M_W	characteristic wave bending moment based on an annual probability of exceedance of 10^{-2}

Table C1 Characters (Continued)

Character	Explanation
Q_g	characteristic shear resistance of a longitudinal shear element in the hull girder
Q_S	characteristic design still water shear force in the longitudinal shear element based on actual cargo and ballast conditions
Q_W	characteristic wave shear force in the longitudinal shear element based on an annual probability of exceedance of 10^{-2}
γ_m	material factor
γ_s	load factor for still water loads (permanent + variable functional loads)
γ_w	environmental load factor
A_{ps}	area of panel (plate and stiffeners)
z	distance from panel to plastic neutral axis
σ_{cr}	characteristic longitudinal stress on the compression side corresponding to critical buckling capacity of the panel
σf	characteristic yield stress of panel on the tension side
Ap	area of panel (plate area only)
τ_{cr}	characteristic shear stress in panel

C 800 Abbreviations

801 The abbreviations given in Table C2 are used in this standard.

Table C2 Abbreviations

Abbreviation	In full
ALS	Accidental limit states
DFF	Design fatigue factor
FLS	Fatigue limit states
LRFD	Load and resistance factor design
NDT	Non-destructive testing
SCF	Stress concentration factors
SLS	Service limit states
ULS	Ultimate limit states

D. References

D 100 DNV Offshore Standards, Rules and Classification Notes

101 The offshore standards and rules given in Table D1 are referred to in this standard.

Table D1 DNV Offshore Standards, Rules and Classification Notes

Reference	Title
DNV-OS-C101	Design of Offshore Steel Structures, General (LRFD method)
DNV-OS-C401	Fabrication and Testing of Offshore Structures
Classification Note 30.1	Buckling Strength Analysis
Classification Note 30.5	Environmental Conditions and Environmental Loads
Classification Note 30.7	Fatigue Assessment of Ship Structures
DNV-RP-C203	Fatigue Strength Analysis of Offshore Steel Structures
	Rules for Classification of Ships

SECTION 2
SELECTION OF MATERIAL AND EXTENT OF INSPECTION

A. Selection of Material

A 100   General

101   A material specification shall be established for all structural materials. The materials shall be suitable for their intended purpose and have adequate properties in all relevant design conditions.

102   Selection of steel grade is based on the principles and requirements given in DNV-OS-C101.

103   In structural cross-joints where high tensile stresses are acting perpendicular to the plane of the plate, the plate material shall be tested to prove the ability to resist lamellar tearing (Z-quality).

104   For stiffeners, the grade of material may determined based on the thickness of the web.

105   Structural elements used only in temporary conditions, like fabrication, are not considered in this standard.

A 200   Structural categorisation

201   According to DNV-OS-C101 material shall be categorised into a *special*, *primary* or *secondary* category. With reference to the application of material classes as given in the Rules for Classification of Ships Pt.3 Ch.1 or Pt.3 Ch.2 the relationship between the material classes and structural categories is as given in Table A1.

Table A1 Relationship between material classes and structural categories	
Material class	*Structural category*
I, II	Secondary
III	Primary
IV, V	Special

For stiffened plates, the plates are considered as *primary* category whilst the stiffeners are considered as *secondary* category.

202   Typical elements for offshore ships, which are not given in the Rules for Classification of Ships Pt.3 Ch.1 or Pt.3 Ch.2, are given in 300 and 400.

A 300   Special category - typical locations

301   The following locations are considered special category:

— highly stressed elements in way of moonpool
— highly stressed elements in way of support structure for turret
— highly stressed elements in way of main supporting structures of heavy substructures and equipment e.g. anchor line fairleads, supporting structure for winches, crane pedestals, gantry, topside support stools, flare boom, davits, hawser brackets for shuttle tanker, towing brackets etc.

A 400   Primary category - typical locations

401   The following locations are considered primary category:

— turret structure
— pipe rack stanchions
— drillfloor substructure
— helicopter deck substructure
— flare supporting structure

A 500   Design temperatures

501   External structures above the lowest ballast waterline shall be designed for temperatures equal to the lowest daily mean temperature for the area(s) in which the unit is specified to operate.

502   External structures below the lowest ballast waterline need normally not to be designed for temperatures lower than 0 °C.

503   The double bottom structure including the tank top needs normally not to be designed for temperatures lower than 0 °C.

504   Internal structures in way of permanently heated rooms need normally not to be designed for temperatures lower than 0 °C.

B. Inspection

B 100   General

101   Structural joints shall be inspected according to the principles and requirements given in DNV-OS-C101.

102   Requirements for type and extent of inspection are given in DNV-OS-C401, dependent on assigned inspection category for the welds. The requirements are based on the consideration of fatigue damage and general fabrication quality.

103   The inspection category for units covered by this standard shall relate to the structural category as shown in Table B1.

Table B1 Inspection categories	
Inspection category	*Structural category*
I	Special
II	Primary
III	Secondary

104   When determining the locations of required non-destructive testing (NDT), consideration should be given to relevant fabrication parameters including; location of block (section) joints, manual versus automatic welding, start and stop of weld etc.

SECTION 3
DESIGN BASIS AND PRINCIPLES

A. Design Basis

A 100 Operational modes

101 A unit shall be designed for all relevant modes of operation. Typically, the assessment of the unit shall be based on the following operational modes:

— all operating conditions, intact and damaged, at the design location(s)
— all transit conditions
— docking condition afloat
— dry-docking condition.

A 200 Still water load conditions

201 All relevant still water loading conditions shall be considered to determine the limit curves for maximum permissible bending moments and shear forces.

A 300 Environmental loads

301 Environmental conditions shall in principle be described using relevant data for the period and areas in which the unit is to operate.

302 For world-wide operation the environmental loads from direct calculations for assessment of hull capacity in the ULS condition shall be based on the North Atlantic scatter diagram as defined in Classification Note 30.5.

303 The environmental loads for assessment of fatigue life shall be based on the North Atlantic scatter diagram as defined in Classification Note 30.5.

A 400 Prolonged survey periods

401 Units intended to stay on location for a prolonged survey period, i.e. without dry-docking, shall also comply with the requirements in Appendix A.

B. Strength Assessment

B 100 Compliance with main class requirements

101 The requirements given in this standard are supplementary to the requirements for main class.

102 The main class requirements for plates and stiffeners exposed to local loads ensure sufficient safety level for local capacity, and need no further assessment unless otherwise noted.

103 Non-operating conditions like transit conditions, docking condition afloat and dry-docking condition, are considered to be covered by the main class requirements.

104 In the transit condition, the design values of global accelerations for assessment of topside facilities and supporting structure may be taken from the wave load analysis provided the assessment is in accordance with 302. The wave load analysis shall in such cases be based on an annual probability of exceedance of $10^{-1.3}$ (20 year return period).

105 The main class requirements for plates and stiffeners on transverse bulkheads are considered to provide sufficient structural capacity.

106 Hull structural elements with less importance for overall structural integrity such as deckhouses, elements within the fore and aft unit structure, may be assessed according to the main class requirements unless otherwise noted. See also Sec.6 B303.

Guidance note:
Fore and aft unit is normally areas outside 0.4 L amidships or the cargo area whichever is the larger.

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B 200 Global strength

201 For the intact and damage operating conditions, the hull girder capacity shall be based on the LRFD method as defined in DNV-OS-C101. The hull girder will typically comprise the following elements:

— decks
— longitudinal bulkheads
— plate flanges on transverse web frames, longitudinal girders and stringers
— plate flanges of stringers and web frames on the transverse bulkheads.

202 The structural capacity of the hull girder shall comply with the ULS and ALS requirements given in the respective sections in this standard.

203 The required section modulus above the minimum main class requirements may correspond to the actual required capacity at the considered transverse section.

204 SLS is not required by DNV. If SLS is specified in the design brief as a relevant condition for the design, the global and/or local strength shall be assessed according to DNV-OS-C101.

205 The strength of the hull girder shall be assessed based on the load conditions that result in maximum longitudinal tension and compression stresses in deck and bottom plating. This will normally be the extreme full load and ballast condition. The effect of topside facilities shall be included in the hull girder assessment for these load conditions.

206 The effect of large openings in the hull (e.g. moonpool) which affect the distribution of global stresses shall be considered accounting for three dimensional effects.

B 300 Local strength assessment

301 Local strength assessment shall be carried out for typical elements like:

— supporting structure for topside structure
— supporting structure for thrusters
— turret
— crane pedestals
— bilge keels (on turret-moored and spread moored units)
— bow recess area for submerged type of turrets.

302 The supporting structure for topside structure (e.g. topside modules, derrick, flare etc.) shall be assessed according to the LRFD format. The extent of the supporting structure is limited to the structural members affected by the local loads from the topside structure. Structural capacity of the supporting structure shall be assessed according to DNV-OS-C101.

303 Supporting structure for thrusters are normally considered for a specified thrust using the acceptance criteria given in the Rules for Classification of Ships Pt.3 Ch.1.

304 The turret shall be analysed according to the LRFD format based on the specific loads from the mooring system in the operational mode. Both global and local response of the turret shall be considered. In addition the local structure shall be considered for the special load cases as defined in Sec.8 C101.

305 The supporting structure for the turret shall be assessed

based on the LRFD format. Hull deformations shall be considered.

C. Fatigue Assessment

C 100 General principles

101 Fatigue capacity shall be carried out according to Classification Note 30.7 or DNV-RP-C203.

102 The fatigue capacity is calculated assuming that the linear accumulated damage (Palmgren – Miner rule). The different methods given in Classification Note 30.7 are used at different stages in the design loop. Applicable method can also be selected depending on the results from a screening process to identify fatigue critical details.

SECTION 4
DESIGN LOADS

A. Introduction

A 100   General

101   The loads shall in general be determined according to the principles in DNV-OS-C101 for all structural elements assessed in compliance with the LRFD format.

102   Design load criteria given by operational requirements shall be fully considered. Examples of such requirements may be:

— drilling, production, workover and combination thereof
— consumable re-supply procedures and frequency
— maintenance procedures and frequency
— possible load changes in extreme conditions.

B. Design Loads for Minimum Structural Capacity

B 100   General principles

101   To define the minimum design basis, the design sea pressures and pressures from liquid in tanks according to the Rules for Classification of Ships Pt.3 Ch.1 shall be used for assessment of elements like plates and stiffeners, girders, frames, web frames and stringers. The acceptance criteria for these elements shall be as given in the Rules for Classification of Ships Pt.3 Ch.1.

C. Design Loads for Global Hull Girder Capacity Assessment

C 100   Application

101   The design loads given in D and E are used to assess the hull girder capacity (global). Loads used in the global check shall be consistent. This implies that the longitudinal stresses based on global load conditions in D and E shall be combined with transverse stresses based on sea pressures and tank pressures as defined in DNV-OS-C101.

D. Still Water Loads

D 100   General

101   With reference to DNV-OS-C101, the still water loads consist of the permanent and variable functional loads.

102   Permanent functional loads relevant for offshore units are:

— mass of the steel of the unit including permanently installed modules and equipment, such as accommodation, helicopter deck, cranes, drilling equipment, flare and production equipment.
— mass of mooring lines and risers.

103   Variable functional loads are loads that may vary in magnitude, position and direction during the period under consideration.

104   Typical variable functional loads are:

— hydrostatic pressures resulting from buoyancy
— crude oil

— ballast water
— fuel oil
— consumables
— personnel
— general cargo
— riser tension.

105   The variable functional loads utilised in structural design should normally be taken as either the lower or upper design value, whichever gives the more unfavourable effect.

106   Variations in operational mass distributions (including variations in tank filling conditions) shall be adequately accounted for in the structural design.

107   All relevant still water load conditions shall be defined and limit curves for hull girder bending moment and shear forces shall be established. The shear force limit curves shall be corrected for actual load condition and structural arrangement as given in the Rules for Classification of Ships Pt.3 Ch.1 Sec.5 D.

108   The shape of the limit curves for the still water bending moments and shear forces are defined in the Rules for Classification of Ships Pt.3 Ch.1. If the extreme still water bending moment and/or shear exceed the main class minimum values, the limit curve should be based on all relevant load combinations.

109   Limit curves for the still water loading conditions shall be presented for operational and transit mode separately.

E. Environmental Loads

E 100   General

101   Environmental loads are loads caused by environmental phenomena. The characteristic value of an environmental load is the maximum or minimum value (whichever is the most unfavourable) corresponding to a load effect with a prescribed probability of exceedance.

102   The long-term variation of environmental phenomena such as wind, waves and current shall be described by recognised statistical distributions relevant to the environmental parameter considered, see DNV-OS-C101. Information on the joint probability of the various environmental loads may be taken into account if such information is available and can be adequately documented.

103   Consideration shall be given to responses resulting from the following listed environmental loads:

— wave induced loads
— wind loads
— current loads
— snow and ice loads
— sloshing in tanks
— green water on deck
— slamming (e.g. on bow and bottom in fore and aft ship)
— vortex induced vibrations (e.g. resulting from wind loads on structural elements in a flare tower).

E 200   Wave induced loads

201   The wave loads shall be determined by methods giving adequate description of the kinematics of the liquid, reflecting the site specific environment in which the unit is intended to operate, see DNV-OS-C101 and Classification Note 30.5.

202   Global linear wave induced loads such as bending mo-

ments and shear forces shall be calculated by using either strip theory or three dimensional sink source (diffraction) formulation.

203 Linear wave induced loads are normally calculated by 3D sink-source theory. Strip theory may be used provided:

$$\frac{L_{pp}}{B} \geq 3.0$$

Guidance note:

Three-dimensional effects in fore and aft ship will reduce the drag force compared to a strip theory approach.

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204 When a 3-D diffraction program is used, due consideration shall be given to the analytical model to determine the hull response with sufficient accuracy.

205 The following wave induced linear responses shall be calculated:

— motions in six degrees of freedom
— vertical bending moment at a sufficient number of positions along the hull. The positions shall include the areas where the maximum vertical bending moment and shear force occur and at the turret position. The vertical wave induced bending moment shall be calculated with respect to the section's neutral axis
— horizontal bending moment
— torsional moment if relevant
— accelerations
— axial forces
— external sea pressure distribution.

206 The mass model shall be made sufficiently detailed to give centre of gravity, roll radius of inertia and mass distribution as correct as practically possible.

207 Non-linear effects such as slamming, water on deck and bow flare forces shall be considered with respect to local and global consequences.

208 The midship bending moments and shear forces shall be calculated considering the weather vaning characteristics of the unit. E.g. for turret moored units, the calculations are normally carried out for head seas.

209 Torsional moments may be of interest depending on the structural design.

210 The wave shear forces shall be determined at a sufficient number of sections along the hull to fully describe the limit curve for the maximum value.

211 If roll resonance occurs within the range of wave periods likely to be encountered, the effect of non-linear viscous roll damping shall be taken into account.

212 Viscous effects, such as eddies around the hull, act mainly as a damping mechanism, especially at large roll angles, and these effects shall be included.

213 The effects from roll damping devices, like bilge keels, shall be evaluated. The roll damping shall be evaluated for the return period in question.

E 300   Mooring loads

301 A unit may be kept on location by various methods.

These methods may include several different types of station-keeping systems such as internal and submerged turret systems, external turret, buoy, fixed spread mooring and dynamic positioning. Each mooring system configuration will impose loads on the hull structure. These loads shall be considered in the structural design of the unit, and combined with other relevant load components.

E 400   Sloshing loads in tanks

401 In partly filled tanks sloshing occurs when the natural periods of the tank fluid is close to the periods of the motions of the unit. Factors governing the occurrence of sloshing are:

— tank dimensions
— tank filling level
— structural arrangements inside the tank (wash bulkheads, web frames etc.)
— transverse and longitudinal metacentric height (GM)
— draught
— natural periods of unit and cargo in roll (transverse) and pitch (longitudinal) modes.

402 The pressures generated by sloshing of the cargo or ballast liquid shall be considered according to the requirements given in the Rules for Classification of Ships Pt.3 Ch.1 Sec.4 C300.

Guidance note:

The Rules for Classification of Ships differentiate between ordinary sloshing loads (non-impact) and sloshing impact loads.

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E 500   Green water

501 The green water is the overtopping by water in severe wave conditions. The forward part of the deck and areas aft of midship will be particularly exposed to green water. Short wave periods are normally the most critical.

502 Appropriate measures shall be considered to avoid or minimise the green water effects on the hull structure, accommodation, deckhouses and topside equipment. These measures include bow shape design, bow flare, bulwarks and other protective structure. Adequate drainage arrangements shall be provided.

503 Structural members exposed to green water shall be designed to withstand the induced loads. Green sea loads is considered as local loads, but shall be combined with the effect from global response.

504 In lack of more exact information, for example from model testing, the design pressure acting on weather deck shall be:

$$p = ab(p_{dp} - (4 + 0.2k_s)h_0) \quad (kN/m^2)$$

Minimum pressure is 5.0 kN/m².

The design pressure on topside support structure, unprotected bulkheads of deck houses and superstructures located forward of 0.15 L from F.P. shall be calculated according to the pressures given in Table E1, whichever is the greatest for the position in question.

Table E1 Design pressure for topside supports, deckhouses and superstructure

Structure	Pressure kN/m²
Unprotected front bulkheads	$p_1 = 5.7 k_{hs} (2 + L/120)(k_w C_w - h_0) c$
	$p_2 = 3.4 (2 + L/120)[(h_s/8.5)^{0.25} 1.07 k_w C_w - h_0] c$
	$p_3 = 12.5 + 0.05 L$ for first 4 m above the fore-castle deck $p_3 = 6.25 + 0.025 L$ elsewhere
Unprotected sides and topside supports	$p_4 = P_{dp} - (4 + 0.2k_s) h_0$ minimum p_3
Unprotected aft end bulkheads	$p_5 = 0.85 p_4$ minimum p_3

a = 1.0 for weather decks forward of 0.15 L from F.P., or forward of deckhouse front, whichever is the foremost position

= 0.8 for weather decks elsewhere

b = 1.5 at unit's side and 1.75 at the centre line. Linear interpolation shall be used for intermediate locations

P_{dp} = $P_l + 135 \dfrac{y}{B + 75} - 1.2 (T - z)$ (kN/m²)

P_l = $k_s C_w + k_f$

if

= $(k_s C_w + k_f)\left[0.8 + 0.15 \dfrac{V}{\sqrt{L_1}}\right]$ if $\dfrac{V}{\sqrt{L_1}} > 1.5$

V = speed in knots, minimum 8

C_B = block coefficient

k_s = $3 C_B + \dfrac{2.5}{C_B}$ at A.P. and aft

= 2.0 between 0.2 L and 0.7 L from aft

= $3 C_B + \dfrac{4.0}{C_B}$ at F.P. and forward

Between specified areas, k_s shall be varied linearly.

h_0 = vertical distance from the waterline at draught T to the load point (m)

z = vertical distance from the baseline to the load point, maximum T (m)

y = horizontal distance from the centre line to the load point, minimum B/4 (m)

C_w = as given in Rules for Classification of Ships Pt.3 Ch.1 Sec.4 B200

k_f = the smallest of T and f

f = vertical distance from the waterline to the top of the unit's side at transverse section considered, maximum 0,8 C_W (m)

L_1 = unit length, need not be taken greater than 300 (m)

c = $0.3 + 0.7(b_1/B_1)$ For unprotected parts of machinery casings, c is not to be taken less than 1.0

b_1 = breadth of deckhouse at position considered

B_1 = maximum breadth of unit on the weather deck at position considered (b_1/B_1) not to be taken less than 0.25

k_{hs} = $-0.016 h_s^2 + 0.62 h_s - 3.15$

h_s = significant wave height maximum 20.0 m

k_w = $1.3 - 0.6 \dfrac{x}{l_x}$ for $\dfrac{x}{l_x} \le 0.5$

= $0.3 + 1.4 \dfrac{x}{L}$ for $\dfrac{x}{L} > 0.5$

x = longitudinal distance in m from A.P. to the load point.

Guidance note:
Note that the speed V = 8 knots should also be used as minimum for moored or dynamically positioned units to ensure sufficient minimum pressure.

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505 The required local scantlings shall be according to the Rules for Classification of Ships Pt.3 Ch.1 using the design pressure as given in 504.

506 Glass thickness of windows in unprotected front bulkheads as well as the design of the fastening arrangement to the bulkheads shall be considered using the design pressures given in Table E1.

507 Topside members located in the midship or aft area of the unit shall be based on p_4 in Table E1.

Guidance note:
It is advised that provisions are made during model testing for suitable measurements to determine design pressures for local structural design. This implies that model tests should be performed at design draught, for sea states with a spectrum peak period approximately 70 to 100% of the pitch resonance period of the unit. The unit model should be equipped with load cells on the weather deck at positions of critical structural members or critical topside equipment.

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E 600   Slamming in the fore and aft ship

601 The most important locations to be considered with respect to slamming are the forward bottom structure, the bow flare and accommodation structure in the fore ship.

602 The frequency of occurrence and severity of slamming are significantly influenced by the following:

— draught
— hull shape
— environment
— heading
— relative velocity of unit
— location of superstructure.

603 The bow region, as referred to in the following, is normally to be taken as the region forward of a position 0.1 L aft of F.P. and above the summer load waterline.

604 The effects of slamming on the structure shall be considered particularly with regard to local strength aspects and limitations to ballast draft conditions.

605 In lack of more exact information, for example from model testing, relevant requirements for bottom slamming of the Rules for Classification of Ships Pt.3 Ch.1 Sec.6 H200 shall be applied.

The expression for coefficient c_2 in the Rules for Classification of Ships Pt.3 Ch.1 Sec.6 H200 shall be changed to:

$$c_2 = 1675\left(1 - \frac{12T_{BF}}{L}\right)$$

606 For global structural response, the local panel bow impact pressures may be multiplied by 0.375 when applied as a mean pressure over a larger area involving the main girder system like transverse frames and stringers.

607 The design of the bow structure exposed to impact loads shall be carried out according to Rules for Classification of Ships Pt.3 Ch.1 Sec.7 E300. However, the design bow impact pressure for local panel design shall be taken as:

$$P_{sl} = k_l C(2.2 + 1.5 \tan \alpha)$$
$$(0.4 V \sin\varphi + 0.6\varphi \sqrt{L})^2 (kN/m^2)$$

k_l = $(1 + 25/L)^2$

C = $0.18 (C_w - 0.5 h_0)$, maximum 1.0

C_w = wave coefficient given in Rules for Classification of Ships Pt.3 Ch.1 Sec.4 B200

h_0 = vertical distance (m) from the waterline at draught T to point considered

α = flare angle taken as the angle between the side plating and a vertical line, measured at the point considered. With reference to Figure 1, the flare angle may normally be taken in accordance with:

$$\tan \alpha = \frac{a_1 + a_2}{h_d}$$

V = Speed in knots, minimum 8.0

β = angle between tangent of the waterline at the point considered and the longitudinal centreline

φ = angle between tangent of the waterline at the point considered and the direction of the incoming waves

$\varphi = (\beta + 30)$, maximum 90 degrees
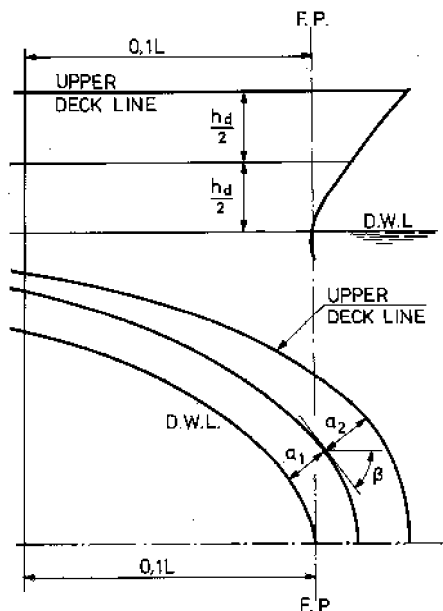
Figure 1
Flare angle

608 If there is great difference between a_1 and a_2, more than one plane between the design waterline and upper deck or fore-castle deck, if any, may have to be considered.

F. Deformation Loads

F 100 General

101 Relevant deformation loads for units covered by this standard shall be considered according to the principles given in DNV-OS-C101.

G. Accidental Loads

G 100 General

101 Accidental loads are loads related to abnormal operation or technical failure.

102 Attention shall be given to layout and arrangements of facilities and equipment in order to minimise the adverse effects of accidental events.

G 200 Safety assessment

201 Accidental events that will be a basis for the design shall be stated in the design brief. Such events are normally identified in a risk analysis. Typical events are:

— dropped objects (e.g. from crane handling)
— fire
— explosion
— collision
— unintended flooding and counter flooding situations
— abnormal wave events.

H. Fatigue Loads

H 100 General

101 Repetitive loads, which may lead to possible significant fatigue damage, shall be considered. Such loads may comprise the following:

— wave induced loads
— wind loads (especially when vortex induced vibration may occur)
— loads on crane pedestals
— variation of filling level in cargo tanks (low cycle).

102 The effects of both local and global dynamic response shall be properly accounted for when determining response distributions of repetitive load effects.

103 Hull vibration is not covered by this standard.

SECTION 5
STRUCTURAL ANALYSES FOR CAPACITY CHECKS

A. Introduction

A 100   General requirements

101 The structural response shall be determined by recognised analytical methods. Computer programs used shall have documented test results.

102 The required types of analyses will depend on the structural design, but in general the following is required:

— finite element analysis for global hull girder strength assessment
— finite element analyses for strength assessment of local areas where the structural response cannot be adequately determined by the global analysis
— finite element analyses to determine stress concentration factors.

B. Longitudinal Stresses

B 100   General

101 Global longitudinal stresses should normally be calculated by a finite element analysis. Typical extent of the model may be three cargo tanks.

102 For units with moonpool or turret, a finite element analysis shall be carried out to describe the stress distribution in way of the openings, in particular in deck and bottom, and at termination of longitudinal strength elements.

C. Transverse Stresses

C 100   General

101 Transverse stresses shall normally be determined based on a 3-dimensional finite element analysis. The transverse stresses are normally derived from the same 3-cargo tank model as described in B101.

C 200   Global shear stresses

201 Global shear stresses shall be calculated considering the vertical shear force at the transverse section in question as well as the actual shear flow distribution in the section. The shear force shall be corrected according to the Rules for Classification of Ships Pt.3 Ch.1 Sec.5 D.

SECTION 6
ULTIMATE LIMIT STATE (ULS)

A. Introduction

A 100   General

101   According to the LRFD format, see DNV-OS-C101, two sets of partial coefficient combinations shall be analysed. These combinations are referred to as the a) and b) combinations.

102   The material factor to be used in the ULS assessment of the hull girder is 1.15.

103   The capacity assessment in the ULS condition shall include buckling and yield checks.

104   Buckling capacity checks shall be performed in accordance with DNV-OS-C101 Sec.5.

B. Hull Girder Longitudinal Strength

B 100   Hull girder yield check

101   The global hull and main girder system nominal stresses derived from direct strength calculations shall comply with the yield criteria given below:

$$\sigma_e \le \frac{1}{\gamma_m} f_y$$ for operating conditions (100 years return period for environmental loads)

σ_e =   nominal equivalent stress
γ_m =   material factor = 1.15
f_y =   yield stress of the material

102   Local linear peak stresses in areas with pronounced geometrical changes, such as in moonpool corners, frame corners etc., may exceed the yield stress criterion in 101 provided plastic mechanisms are not developed in the adjacent structural parts.

Guidance note:
Linear peak equivalent stress of $400 \dfrac{f_y}{f_{yNS}}$ N/mm^2

is generally acceptable,

f_{yNS} and f_y are the yield stresses for mild steel and the actual material, respectively.

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B 200   Hull girder bending and shear checks

201   The hull girder capacity shall be checked for design bending and shear stresses in the operating conditions. The capacity checks shall carried out according to the two equations below:

$$\gamma_s M_s + \gamma_w M_w \le M_g / \gamma_m$$

$$\gamma_s Q_s + \gamma_w Q_w \le Q_g / \gamma_m$$

M_g =   characteristic bending moment resistance of the hull girder
M_S =   characteristic design still water bending moment based on actual cargo and ballast conditions
M_w =   characteristic wave bending moment based on an annual probability of exceedance of 10^{-2}
Q_g =   characteristic shear resistance of a longitudinal shear element in the hull girder
Q_S =   characteristic design still water shear force in the longitudinal shear element based on actual cargo and ballast conditions
Q_W =   characteristic wave shear force in the longitudinal shear element based on an annual probability of exceedance of 10^{-2}
γ_m =   material factor
γ_s =   load factor for still water loads (permanent + variable functional loads)
γ_w =   environmental load factor.

Guidance note:
Typical longitudinal shear elements are unit's side, inner side and longitudinal bulkheads that contribute to the global shear capacity of the hull girder. Each of such elements should be considered separately subjected to the shear force in the element.

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202   The ULS partial load coefficients for assessment of global capacity, are given in Table B1.

Table B1 Partial coefficients for the Ultimate Limit States		
Combination	*Load category*	
	Still water loads	*Environmental loads*
a)	1.2	0.7
b)	1.0	1.15

203   The environmental loads for hull girder global response are mainly wave induced loads. Other environmental loads can normally be neglected.

204   The dimensioning condition for different M_w/M_s ratios is shown in Figure 1. Offshore units also complying with the main class requirements will typically have M_w/M_s ratios of 1.4 to 1.6. In such cases the b) combination is dimensioning.

205   Combination a) need not be assessed for the hull girder capacity if:

$$M_W \ge 0.44 \, M_s$$

Guidance note:
Note that the M_s in the equations given above include the global effect of top side loads.

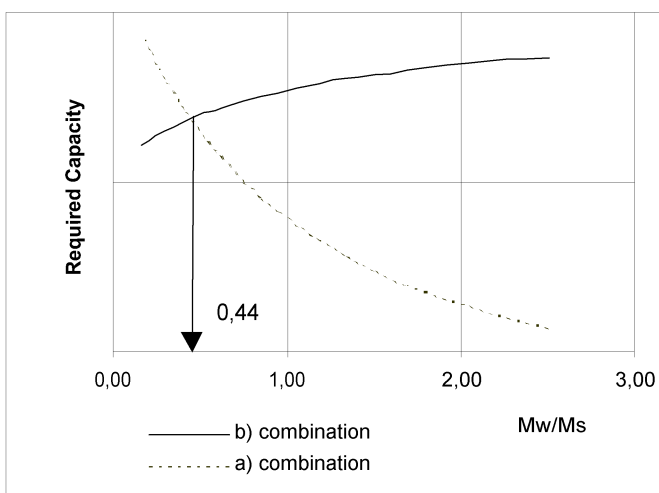---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Figure 1
Dimensioning combination

B 300 Hull girder bending capacity

301 Gross scantlings may be utilised in the calculation of hull structural resistance, provided a corrosion protection system in accordance with DNV-OS-C101, is maintained.

302 Global hull girder capacity assessment shall be performed for all main structural members such as:

— continuous decks, bottom and inner bottom
— unit's side, inner unit's side and longitudinal bulkheads
— longitudinal stringers and longitudinal girders.

303 ULS capacity assessment shall also be carried out outside 0.4 L amidships for the longitudinal elements given in 302.

304 The characteristic ultimate bending capacity of the hull girder shall be calculated according to 308. The characteristic ultimate longitudinal compression stress for each panel in 308 corresponds to the buckling capacity of the panel when exposed to design transverse stresses, shear stress and lateral pressure.

305 The characteristic ultimate longitudinal tension stress correspond to the von Mises yield stress in the panel when exposed to design transverse stresses, shear stress and lateral pressure.

306 The transverse stresses shall be based on consistent loads using actual internal and external pressures corresponding to the worst combination of still water loads and wave position.

307 All stresses and pressure shall be based on an annual probability of exceedance of 10^{-2}.

308 The buckling capacity of each panel shall be determined according to Classification Note 30.1.

B 400 Global shear capacity

401 The characteristic ultimate shear capacity of each longitudinal shear element shall be determined according to 402. The characteristic ultimate shear stress for each panel in 402 corresponds to the buckling capacity of the panel when exposed to design longitudinal and transverse stresses and lateral pressure. The longitudinal and transverse stresses shall be based on consistent loads using actual internal and external pressures corresponding to the worst combination of still water loads and wave position. All stresses and pressure shall be based on an annual probability of exceedance of 10^{-2}. The buckling capacity of each panel shall be determined according to Classification Note 30.1.

Guidance note:
The Classification Note 30.1 buckling capacity check for a plate include yield check. If the shear capacity of a longitudinal element is carried out by use of other recognised means, the yield capacity should also be considered in the buckling check.

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402 The global shear is calculated as follows:

$$Q_g = \sum_j \tau_{cr_j} A_{p_j}$$

A_p = area of panel in the shear element (plate area only)

τ_{cr} = characteristic ultimate shear stress in panel corresponding to buckling capacity according to Classification Note 30.1

j = includes all panels in the longitudinal shear element.

Guidance note:
The number of panels in each longitudinal shear element should be sufficient to describe the shear distribution in the element and to account for plate thickness variation.

Global shear capacity check can in principle be carried out in the same manner as the global moment capacity check since all stress components and lateral pressure are included in the capacity check of each panel. However, in the sections with the highest shear stresses, an acceptable procedure will be to carry out one moment capacity check for each local panel for the design wave resulting in maximum bending moment combined the associates shear stress, and one shear capacity check according to equation in 402 based on maximum section shear force and associated bending moment.

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C. Transverse Structural Strength

C 100 General

101 Transverse strength refers the strength of main transverse members such as transverse bulkheads and web frames. The transverse strength should be evaluated using a finite element model, and the effects of process equipment deck loads should be included. The transverse strength shall meet the requirements given in the Rules for Classification of Ships Pt.3 Ch.1 Sec.13.

D. Turret and Moonpool Areas

D 100 General

101 The following areas shall be considered as relevant, with respect to structural response from the mooring loads, combined with other relevant loads:

— structure in way of moonpool opening
— turret structure including support
— structure in way of loading buoy support
— gantry structure including support.

D 200 Structure in way of moonpool opening

201 The structural strength shall be evaluated considering all relevant, realistic load conditions and combinations, see Sec.4. In particular load combinations due to the following shall be accounted for in the design:

— loads from the turret bearings
— overall hull bending moments and shear forces

— internal and external pressure, covering the intended range of draughts and load conditions, including non-symmetric cases as applicable
— ovalisation of moonpool.

202 Particular attention shall be given to critical interfaces between the hull and the turret structure.

203 Continuity of primary longitudinal structural elements should be maintained as far as practicable in way of the turret opening. Reductions in hull section modulus shall be kept at a minimum and compensation shall be made where necessary.

D 300 Turret structure

301 The ULS is checked according to the requirements in DNV-OS-C101.

302 A finite element analysis of the turret structure shall be performed, see Sec.3, demonstrating that the structural strength of the turret is acceptable. The structural strength shall be evaluated considering all relevant, realistic load conditions and combinations, see Sec.4. Boundary conditions for the model shall reflect the actual configuration of the interface with the hull girder.

303 Local analyses shall be performed for structural areas, which are critical for the structural integrity of the turret. The following list contains typical areas which should be considered:

— structure in vicinity of riser connection(s)
— riser hang-off structure
— structure in way of fairleads
— hang-off structure for mooring line
— local structure transferring bearing reactions
— chain lockers
— pipe supports (single supports and complex structures)
— equipment supports
— foundation for transfer system (especially for swivel solutions)
— lifting appliances and pad-eyes including structure in way of these.

E. Topside Facilities Structural Support

E 100 General

101 The supporting structure is defined as the area where the stress pattern in the structural elements is significantly affected by the topside loads.

102 The strength of the supporting structure for the topside facilities shall be evaluated considering all relevant operational load conditions and combinations. For loads in transit conditions, see Sec.3 B103.

103 The following loads shall be considered:

— permanent loads (weight of structures, process and drilling equipment, piping etc.)
— variable loads (equipment functional loads related to liquid, machinery, piping reaction forces, helicopter, cranes etc.)
— wave loads
— wave accelerations (inertia loads)
— hull girder vertical deflections
— wind on topside facilities
— snow and ice
— green water
— longitudinal strain of upper deck due to global bending.

E 200 Partial load coefficients

201 The partial load coefficients to be used are given in Table E1.

Table E1 Partial coefficients for the Ultimate Limit States			
Combination	*Load category*		
	G	Q	E
a)	1.3	1.3	0.7
b)	1.0	1.0	1.3
Load categories are:			
G = permanent load			
Q = variable functional load			
E = environmental loads			

202 The ULS assessment shall be carried out according to the requirements in DNV-OS-C101. Both a) and b) combinations shall be considered.

203 If the supporting structure experience hull girder longitudinal bending stresses, the values of the longitudinal stresses in the b) combination may also be used in the a) combination, as a conservative approach.

F. Fore and Aft Ship

F 100 General

101 The local requirements for the structural members in the fore and aft ship including deck houses and accommodation shall comply with the technical requirements given in the Rules for Classification of Ships Pt.3 Ch.1, see also Sec.3 B100.

102 The main longitudinal structural members needed for the global continuity and hull integrity shall be assessed according to B200. For evaluation of slamming, sloshing and green water effects, see Sec.4.

SECTION 7
FATIGUE LIMIT STATES (FLS)

A. Introduction

A 100 General

101 The general requirements and guidance concerning fatigue criteria are given in DNV-OS-C101 Sec.7. The fatigue capacity shall be determined according to Classification Note 30.7 or DNV-RP–C203. Evaluation of the fatigue limit state shall include consideration of all significant loads contributing to fatigue damage.

102 The required fatigue life of new units shall be minimum 20 years assuming that the unit complies with the DNV requirements for dry-docking inspection. The effect of mean stresses should normally be ignored.

103 The fatigue life shall be calculated considering the combined effects of global and local structural response. The expected dynamic load history shall be the basis for the calculations.

104 Local effects, due to:

— slamming
— sloshing
— vortex shedding
— dynamic pressures
— mooring and riser systems

shall be considered in the fatigue damage assessment, if relevant.

105 Calculations carried out in connection with the fatigue limit state may be based on gross thicknesses (i.e. without deducting the corrosion additions), provided a corrosion protection system in accordance with DNV-OS-C101 is maintained.

106 In the assessment of fatigue life, consideration shall be given to the stress concentration factors including those due to:

— large openings affecting the global stress distribution
— fabrication tolerances, including due regard to tolerances
— openings and penetrations
— local effects at connections or attachment of structural elements, e.g. scallops, brackets etc.

B. Design Fatigue Factors

B 100 General

101 Units covered by this standard have considerable redundancy. All elements can therefore be classified as, "without substantial consequences for total structural failure". Offshore units covered by this standard have regular dry-docking for inspection and repair, and the term "splash" zone has no significance. It implies that all elements are accessible for inspection and repair. A design fatigue factor of 1.0 may therefore, be applied to all structural elements.

C. Structural Details and Stress Concentration Factors

C 100 General

101 Fatigue sensitive details in the hull shall be documented to have sufficient fatigue strength. Particular attention should be given to the following details:

— main deck, including deck penetrations, bottom structure and side shell
— hull longitudinal stiffener connections to transverse frames and bulkheads
— hopper tank knuckles and other relevant discontinuities
— attachments, foundations, supports etc. to main deck and bottom structure
— topside and hull connections
— hull and turret connections
— fairleads and supporting structure
— openings and penetrations in longitudinal members
— transverse frames
— submerged turret and supporting structure
— flare tower
— riser interfaces
— major process equipment foundations.

102 Calculations of stress concentration factors of local details may be undertaken in accordance with Classification Note 30.7. For details not covered by Classification Note 30.7, or documented in other recognised publications, detailed finite element analysis should be carried out for determination of SCFs, according to the procedure given in Classification Note 30.7.

103 Intersection between unit's side longitudinals and transverse bulkheads shall be fitted with double sided brackets.

> **Guidance note:**
> In order to cover typical unit structural details, the design should allow for the following stress concentration factors:
>
> - the deck should at least be designed for $K_g K_w \geq 2.5$. Openings may require higher values of SCF
> - brackets on side longitudinals have typical $K_g K_w$ of 1.8 to 2.4.
>
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D. Design Loads and Calculation of Stress Ranges

D 100 Load factors

101 In the fatigue calculations, a load factor of 1.0 shall be used on all dynamic loads.

D 200 Fatigue loads

201 An overview of fatigue loads is given in Sec.4. Site specific environmental data shall be used for calculation of long term stress range distribution. Units intended for multi field developments shall base the fatigue life on the expected duration on each location employing the scatter diagram for each field. The most severe environmental loads may be applied for the complete lifetime of the unit, as a conservative approach.

202 A representative range of load conditions shall be considered. It is generally acceptable to consider the ballast and the fully loaded condition with appropriate amount of time in each condition.

> **Guidance note:**
> 60% in full load and 40% in ballast for the two conditions may be used unless otherwise documented.
>
> ---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

203 An appropriate range of wave directions and wave energy spreading shall be considered.

Guidance note:

For weather waning units, and in lack of more detailed documentation, head sea direction may be considered with $\cos^2$ wave energy spreading.

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The following dynamic loads shall be included in a FLS analysis as relevant:

— global wave bending moments
— external dynamic pressure due to wave and unit motion
— internal dynamic pressure due to unit motion
— sloshing pressures due to fluid motion in tanks for units with long or wide tanks
— loads from equipment and topside due to unit motion and acceleration.

D 300   Topside structures

301   The following loads shall be considered for the topside structure:

— vertical and horizontal hull deformations due to wave bending moment acting on the hull
— wave induced accelerations (inertia loads)
— vortex induced vibrations from wind
— vibrations caused by operation of topside equipment
— external dynamic pressure due to wave and unit motion.

302   Additionally, the following low cycle loads should be considered where relevant for the topside structure:

— hull deformations due to temperature differences
— hull deformations due to change in filling condition e.g. ballasting or deballasting.

D 400   Turret structure, bow recess and moonpool area

401   The following loads shall be considered for the fatigue design of turret structures:

— dynamic loads of mooring lines
— dynamic loads (tension and bending moment) from risers
— varying hydrodynamic pressure due to wave load
— varying hydrodynamic pressure due to unit accelerations, including added mass effects
— bearing reactions loads
— inertia loads due to accelerations of the unit
— fluctuating reactions in pipe supports due to thermal and pressure induced pipe deflections.

D 500   Calculation of global dynamic stress ranges

501   Global stress ranges shall be determined from the global hull bending stresses, axial stresses and torsional stresses. Torsional stresses may be relevant for structures with extremely large deck openings. If applicable, both vertical and horizontal bending moments shall be included. Shear lag effects and stress concentrations shall be considered.

D 600   Calculation of local dynamic stress ranges

601   Local stress ranges are determined from dynamic pressures acting on panels, accelerations acting on equipment and topside and other environmental loads resulting in local stresses in parts of the structure.

602   Dynamic pressures shall be calculated by means of the hydrodynamic model. The transfer function for the dynamic pressure can be used to calculate local stress transfer functions. As a minimum, the following dynamic local stress components shall be considered:

— double hull stresses due to bending of double hull sections between bulkheads
— panel stresses due to bending of stiffened plate panels
— plate bending stresses due to local plate bending
— deflection induced stresses.

603   Further details regarding calculation of local stress components is given in Classification Note 30.7.

D 700   Combination of stress components

701   Global and local stresses shall be combined to give the total stress range for the detail in question. In general, the global and the local stress components differ in amplitude and phase. The method of combining these stresses for the fatigue damage calculation will depend on the location of the structural detail. A method for combination of loads is given in Classification Note 30.7.

E. Calculation of Fatigue Damage

E 100   Environmental loads

101   Fatigue analyses shall be based on the site specific environmental data and, take appropriate consideration of both global and local (e.g. pressure fluctuation) dynamic responses.

Guidance note:

These responses do not necessarily have to be evaluated in the same model but the cumulative damage from all relevant effects should be considered when evaluating the total fatigue damage.

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E 200   Methodology

201   The long term stress range distribution required for the fatigue analysis can either be established based on spectral methods or on a postulated form of the long-term stress range distribution defined by a maximum stress amplitude and a Weibull shape parameter.

202   Principal stresses should be used as basis for fatigue life calculations. Local plate surface stresses due to plate bending shall be used in the calculations.

203   Simplified fatigue life calculations based on a Weibull shape distribution of the long term response is acceptable for well defined structural details, i.e. with known stress concentration factors, primarily exposed to hull global bending stresses, provided ample fatigue life is documented.

204   Fatigue life calculations based on spectral methods are either employing component stochastic or full stochastic analysis, see Classification Note 30.7. A component based stochastic analysis implies that non linear effects can be applied to the relevant load component.

205   Local, detailed finite element analysis (e.g. unconventional details with insufficient knowledge about typical stress distribution) should be undertaken in order to identify local stress distributions, appropriate SCFs, and/or extrapolated stresses to be utilised in the fatigue evaluation, see Classification Note 30.7 for further details. Dynamic stress variations through the plate thickness may have to be considered in such evaluations.

206   Explicit account shall be taken for local details such as access openings, cut-outs and penetrations.

E 300   Applicable S-N-curves

301   The S-N curves, as defined in Classification Note 30.7, to be used in the fatigue calculation are given in Table E1.

302   Fatigue calculations for conversions of old tankers to production or storage units shall be based on the stresses from the actual scantlings.

Table E1 Applicable S-N curves

Elements	S-N curve for air or cathodic protection	S-N curve for corrosive environment	S-N curve for air or cathodic protection, one slope curve
Void spaces, external dry areas	x		x
Ballast or cargo tanks with acceptable corrosion protection system [1]	x		x
Unprotected surfaces in tanks		x [2]	
Shell plating below ballast waterline with acceptable corrosion protection system [1]	x		x
1) Corrosion protection system according to requirements in DNV-OS-C101			
2) The stresses shall be based on net thicknesses			

SECTION 8
ACCIDENTAL LIMIT STATES (ALS)

A. Introduction

A 100   General

101   The assessment of the structural capacity shall be based on the principles given in DNV-OS-C101. Relevant loads shall be determined based on DNV-OS-A101 unless otherwise documented in a risk analysis.

B. Dropped Objects

B 100   General

101   The possibility of dropped objects impacting on the structural components of the unit shall be considered in design. Resistance to dropped objects may be accounted for by indirect means, such as, using redundant framing configurations, or by using materials with sufficient toughness in affected areas.

102   The masses of the dropped objects from crane operation to be considered for design of the units are normally based on operational hook loads of the platform crane. Critical areas of dropped objects are to be determined based on crane operation sectors, crane reach and actual movement of slings assuming a drop direction within an angle to the vertical direction of 5 ° in air and 15 ° in water.

C. Fire

C 100   General

101   General guidance and requirements concerning accidental limit state events involving fire are given DNV-OS-A101.

D. Explosion

D 100   General

101   In respect to design considering loads resulting from explosions one, or a combination of the following main design philosophies are relevant:

— ensure that the probability of explosion is reduced to a level where it is not required to be considered as a relevant design load
— ensure that hazardous locations are located in unconfined (open) locations and that sufficient shielding mechanisms (e.g. blast walls) are installed
— locate hazardous areas in partially confined locations and design utilising the resulting relatively small overpressures
— locate hazardous areas in enclosed locations and install pressure relief mechanisms (e.g. blast panels) and design for the resulting overpressure.

102   Structural design accounting for large plate field rupture resulting from explosion loads should be avoided.

103   Structural support of the blast walls and the transmission of the blast load into main structural members shall be evaluated.

E. Loss of Heading Control

E 100   General

101   For units normally operated with heading control, either by weather vaning or by thruster assistance, the effect of loss of the heading control shall be evaluated.

102   The loss of heading control condition shall be considered in the topside and turret structure design.

F. Collision and Accidental Flooding

F 100   General

101   Collision with a typical supply boat is normally not affecting the structural integrity as long as the unit comply with stability requirements from national or international bodies. Collision with supply boat and accidental flooding are thus not considered in this standard.

SECTION 9
SPECIAL CONSIDERATIONS

A. Structural Details

A 100 General

101 For the design of structural details consideration should be given to the following:

— the thickness of internal structure in locations susceptible to excessive corrosion
— the design of structural details, such as those noted below, against the detrimental effects of stress concentrations and notches:

  — details of the ends and intersections of members and associated brackets
  — shape and location of air, drainage, and lightening holes
  — shape and reinforcement of slots and cut-outs for inspection
  — elimination or closing of weld scallops in way of butts, "softening" bracket toes, reducing abrupt changes of section or structural discontinuities.

— proportions and thickness of structural members to reduce fatigue damage due to engine, propeller or wave-induced cyclic stresses, particularly for higher strength steel members.

B. Bilge Keels

B 100 General

101 The requirements for design of bilge keels apply to turret moored units and to spread moored units. The bilge keel shall be welded directly onto the shell plate without doubling plates. Adequate transverse supporting brackets, or an equivalent arrangement, shall be provided. The loads due to ship motions shall be determined from the wave load analysis employing a viscous damping coefficient representative for seastates which contribute most to fatigue damage. The damping coefficient should be determined at 10^{-2} probability of exceedance.

102 Fatigue calculations should be carried out by means of a spectral analysis. A component stochastic analysis as described in Classification Notes 30.7 is acceptable. If the bilge keel is of a closed construction type, the transfer functions for stress responses from the wave dynamics and motion induced drag forces shall be determined separately. The transfer functions shall be combined in the cumulative damage calculations.

C. Location of Superstructure

C 100 General

101 Living quarters, lifeboats and other means of evacuation shall be located in non-hazardous areas and be protected and separated from production, storage, riser and flare areas.

D. Structure in Way of a Fixed Mooring System

D 100 General

101 Local structure in way of fairleads, winches, etc. forming part of the position mooring system is, as a minimum, to be capable of withstanding forces equivalent to 1.25 times the breaking strength of any individual mooring line. The strength evaluation should be undertaken utilising the most unfavourable operational direction of the anchor line. In the evaluation of the most unfavourable direction, account shall be taken of relative angular motion of the unit in addition to possible line lead directions. The material factor γ_m is 1.0 in this special case.

E. Loading Instrument

E 100 General

101 The loading instrument used to monitor the still water bending moments and shear forces as well as the stability of the unit shall be in compliance with the requirements of the Rules for Classification of Ships.

102 The limitations for still water bending moments and shear forces shall be in accordance with maximum allowable still water bending moments and shear forces specified in the operating manual.

F. Corrosion Protection

F 100 General

101 The corrosion protection arrangements shall be consistent with DNV-OS-C101.

SECTION 10
WELDING AND WELD CONNECTIONS

A. Introduction

A 100   General requirements

101   The technical requirements for the welding and weld connections shall, as a minimum, comply with the Rules for Classification of Ships Pt.3 Ch.1 Sec.12.

102   The extent and means of inspection during fabrication is defined in DNV-OS-C401.

B. Size of Welds

B 100   Direct calculations

101   As an alternative to the weld size according to this section, the welds may be designed according to the principles given in DNV-OS-C101 Sec.9 C600.

B 200   Double continuous fillet welds

201   Dimensioning of double continuous fillet welds are referred to the Rules for Classification of Ships Pt.3 Ch.1 Sec.12 Table C1. This table has been extended to include typical structural members for units covered by this standard. The C factors to be used are given in Table B1.

Table B1 Weld factor C		
Item	*60% of span*	*At ends*
Local buckling stiffeners	0.14	0.14
Stiffeners, frames, beams or longitudinals to shell, deck, oil tight or water tight girders or bulkhead plating, except in after peaksSecondary stiffeners in turret	0.16	0.26
Web plates of non-watertight girders except in after peak	0.20	0.32
Girder webs and floors in double bottomStiffeners and girders in after peaksMain girder system and decks in turretHorizontal stringers on transverse bulkheads	0.26	0.43
Watertight centre line girder to bottom and inner bottom platingBoundary connection of ballast and liquid cargo bulkhead: — longitudinal bulkheads — transverse bulkheads Hatch coamings at corners and transverse hatch end brackets to deckTop horizontal profile to coamingStrength deck plating to shell scuppers and discharges to deckShell plating of turret	0.52	
Fillet welds subject to compressive stresses only	0.25	
All other welds not specified above	0.43	

B 300   Fillet welds and deep penetration welds subject to high tensile stresses

301   Dimensioning of such welds are referred to Rules for Classification of Ships Pt.3 Ch.1 Sec.12 C200. Examples of welds in this category are:

— transverse bulkhead connection to the double bottom
— vertical corrugated bulkhead connection to the top of stooltank or directly to the inner bottom
— stooltanks to inner bottom and hopper tank
— structural elements in double bottom below bulkheads and stooltanks
— transverse girders in centre tanks to longitudinal bulkheads
— side shell, inner side and longitudinal bulkheads to double bottom.

B 400   Full penetration welds

401   Full penetration welds are in any case to be used in the following connections:

— intersection of main structural members in structural category special, such as:

  — crane pedestal to deck plating
  — topside support stools to main deck
  — flare to hull structure
  — drillfloor support structure to main deck
  — turret bearing support structure to main deck
  — moonpool cylinder to deck and bottom
  — transverse or longitudinal or radial girders or shear panels in moonpool connected to main deck or bottom or to moonpool cylinder

— rudder horns and shaft brackets to shell structure
— rudder side plating to rudder stock connection areas
— end brackets of hatch side coamings to deck and coaming
— edge reinforcements or pipe penetrations to strength deck (including sheer strake) and bottom plating within 0,6 L amidships, when transverse dimension of opening exceeds 300 mm, see Figure 1
— sea chest
— minimum 150 mm length of main bracket (both ends from the toe) on transverse web frames and on horizontal stringers on transverse bulkheads.
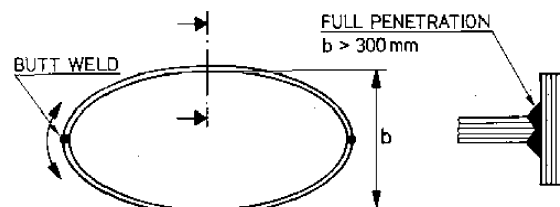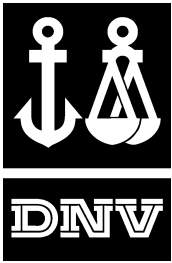

Figure 1
Deck and bottom penetrations

STRUCTURAL DESIGN OF OFFSHORE SHIPS

CHAPTER 2

BENIGN WATERS

CONTENTS   PAGE

DET NORSKE VERITAS

SECTION 1
INTRODUCTION

A. Objective

A 100   General

101   Ch.2 of this standard gives requirements and guidelines for offshore ships restricted to operate in benign waters.

102   Ch.2 also covers conversions of old tankers to production or storage units.

A 200   Assumptions

201   It is assumed that the units will follow the normal class survey periods including regular dry-docking for inspection and maintenance. Units intended to stay on location for prolonged periods shall also comply with the requirements given in Appendix A.

202   Ch.2 of this standard is regarded as supplementary to those given for assignment of main class.

203   In addition to the requirements given in Ch.2 of this standard Ch.1 Sec.9 and Ch.1 Sec.10 shall be complied with.

B. Definitions

B 100   Benign waters

101   Benign waters is defined as the environments where required hull girder capacity calculated according to the LRFD method is less than the minimum section modulus calculated according to the main class requirements. This implies that the requirements given in Ch.2 of this standard is relevant if:

$$M_{WB}\gamma_{fi}\gamma_{nc} \leq 1.17M_{WR} + 0.17\,M_S$$

M_{WB} = linear wave bending moment at an annual probability of exceedance 10^{-2} (100 years return period)

γ_{fi} = partial load coefficient = 1.15

γ_{nc} = non-linear correction factor 1.1 in sagging and
= 0.9 in hogging condition unless otherwise documented [1]

M_{WR} = absolute value of wave bending moment as given in the Rules for Classification of Ships Pt.3 Ch.1

M_S = absolute value of maximum still water bending moment

1)   The default values given are for ships of conventional hull form. The non-linear correction factors for unconventional hull forms shall be documented by direct calculations.

Applicable chapter of this standard for world wide and benign waters is illustrated as guidelines in Fig.1.
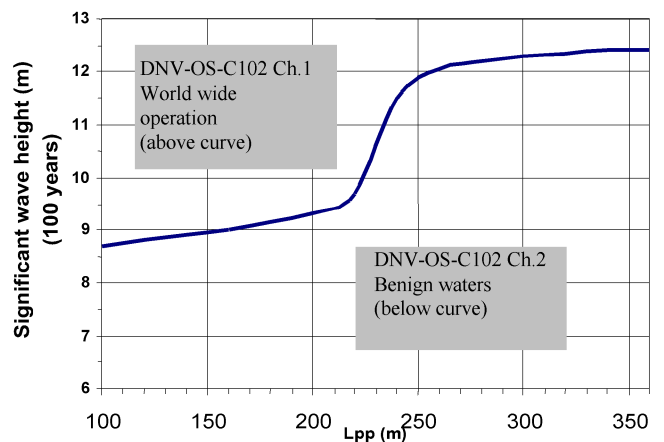

Figure 1
Applicable chapter of DNV-OS-C102

102   If the significant wave height is less than 8.5 m for a probability of exceedance of 10^{-2} (100 years return period), benign waters can be assumed without further calculation.

SECTION 2
SELECTION OF MATERIAL AND EXTENT OF INSPECTION

A. Selection of Material

A 100 General

101 Material specifications shall be established for all structural materials. The materials shall be suitable for their intended purpose and have adequate properties in all relevant design conditions.

102 Selection of steel grade is based on the principles and requirements given for main class. Alternatively the material can be selected according to Ch.1 Sec.2.

103 In structural cross-joints where high tensile stresses are acting perpendicular to the plane of the plate, the plate material shall be tested to prove the ability to resist lamellar tearing (Z-quality).

104 Structural elements used only in temporary conditions, like fabrication, are not considered.

A 200 Material classes

201 In addition to the structural elements given in Rules for Classification of Ships Pt.3 Ch.1 Sec.2 Table B1 and Table B2 respectively, Table A1 gives requirements for materials for some other structural elements.

Table A1 Application of material classes		
Structural member	*Within 0.4 L amidships*	*Outside 0.4 L amidships*
Highly stressed elements in way of moon-poolHighly stressed elements in way of support structure for turretHighly stressed elements in way of main supporting structures of heavy substructures and equipment e.g. anchor line fairleads, supporting structure for winches, crane pedestals, gantry, topside support stools, flare boom, davits, hawser brackets for shuttle tanker, towing brackets etc.	IV[1]	IV[1]
Turret structure	III	III
1) Not to be less than grade D/DH		

A 300 Design temperatures

301 External structures above the lowest ballast waterline shall be designed for temperatures equal to the lowest daily mean temperature for the area(s) in which the unit is specified to operate.

302 External structures below the lowest ballast waterline need normally not be designed for temperatures lower than 0 °C.

303 The double bottom structure including the tank top needs normally not to be designed for temperatures lower than 0 °C.

304 Internal structures in way of permanently heated rooms need normally not to be designed for temperatures lower than 0 °C.

B. Inspection

B 100 General

101 Structural joints shall be inspected according to the principles and requirements given in DNV-OS-C101.

102 Requirements for type and extent of inspection are given in DNV-OS-C401 dependent on assigned inspection category for the welds. The requirements are based on the consideration of fatigue damage and general fabrication quality.

103 The inspection category for units covered by this standard shall relate to the material class as shown in Table B1.

Table B1 Inspection categories	
Inspection category	*Material class*
I	IV and V
II	III
III	I

104 When determining the locations of required NDT, consideration should be given to relevant fabrication parameters including; location of block (section) joints, manual versus automatic welding, start and stop of weld etc.

SECTION 3
DESIGN BASIS AND PRINCIPLES

A. Design Basis

A 100 Operational modes

101 A unit shall be designed for all relevant modes of operation. Typically, the assessment of the unit shall be based on the following operational modes:

— all operating conditions, intact and damaged, at the design location(s)
— all transit conditions
— docking condition afloat
— dry-docking condition.

A 200 Still water load conditions

201 All relevant still water loading conditions shall be considered to determine the limit curves for maximum permissible bending moments and shear forces.

A 300 Environmental loads

301 If the main class requirements for minimum midship section modulus and moment of inertia are complied with, the wave bending moments and shear forces can be based on the main class formulation. No direct calculations of wave bending moments and shear forces are required in such cases.

302 The global strength may also be based on direct calculations of wave loads. The minimum required midship section modulus and moment of inertia may, in such cases, be reduced. The environmental conditions shall then in principle be described using relevant data for the period and areas in which the unit is to operate. Individual environmental loads shall be based on an annual probability of exceedance equal to 10^{-2} (100 years return period) for hull girder structural response calculations.

303 If the midship section modulus is less than the main class requirements, the environmental loads for assessment of hull capacity shall be based on the dimensioning scatter diagram for the areas in which the unit is to operate.

304 The environmental loads for assessment of fatigue life may be based on the actual scatter diagrams for the areas in which the unit is to operate. Alternatively the worst scatter diagram can be used as basis for calculation of fatigue life.

A 400 Prolonged survey periods

401 Units intended to stay on location for a prolonged survey period, i.e. without dry-docking, shall also comply with the requirements in Appendix A.

B. Strength Assessment Principles

B 100 General procedure

101 Subsection B applies to units where the global hull capacity based on the main class requirements is sufficient (North Atlantic at a probability of exceedance of 10^{-8} corresponding to 20 years return period).

102 The topside supporting structure in transit is assessed according to main class requirements.

103 In the operation conditions the assessment of the topside structure, turret, and the topside supporting structure shall, however, be assessed based on accelerations at a specific location.

104 The minimum midship section modulus according to the main class requirements may be reduced by maximum 25% provided the global hull capacity is assessed based on direct calculations of the site specific wave loads. The different alternative design principles are given in Table B1. The alternative 1 implies that the global hull girder capacity complies with the main class requirements and alternative 2 implies that the assessment is based on direct calculations.

Table B1 Alternative design principles					
Design basis	Global hull girder capacity		Topside supporting structure	Transverse strength	
	Alt. 1	Alt. 2	Transit	Alt. 1	Alt. 2
Z_{20}	x			*According to main class requirements*	*Based on direct calculations of site specific loads*
I_{20}	x				
Z_{100}		x			
I_{100}		x			
a_{20}	x		x		
a_{100}		x			
M_{w20}	x		x		
M_{w100}		x			
Q_{w20}	x		x		
Q_{w100}	x				

Z_{20} = minimum section modulus according to main class
I_{20} = minimum moment of inertia according to main class
Z_{100} = resulting section modulus according to Ch.1
I_{100} = resulting moment of inertia according to Ch.1
a_{20} = accelerations according to main class
a_{100} = accelerations according to Ch.1 (direct calculations)
M_{w20} = wave bending moment according to main class
M_{w100} = wave bending moment according to Ch.1 (direct calculations)
Q_{w20} = wave shear force according to main class
Q_{w100} = wave shear force according to Ch.1 (direct calculations)

105 Local requirements for plates and profiles shall be according to main class requirements.

B 200 Longitudinal strength

201 The effect of large openings in the hull (e.g. moonpool) which affect the distribution of global stresses, shall be considered accounting for three dimensional effects.

202 For the intact and damage operating conditions, the hull girder capacity is considered adequate if the main class requirements are complied with.

203 The minimum required midship section modulus and moment of inertia according to main class requirements may be reduced by maximum 25% provided the hull girder capacity is assessed according to Sec.6 B200.

B 300 Transverse strength

301 The capacity of the main transverse stiffening system like transverse bulkheads and transverse web frames shall comply with the to main class requirements.

B 400   Local strength assessment

401   Local strength assessment shall be carried out in accordance with Sec.6. Examples of typical local structural capacity assessment are:

— supporting structure for topside structure
— supporting structure for thrusters
— turret
— bow recess area for submersed type of turrets.

402   Supporting structure for thrusters are normally considered for a specified thrust using the acceptance criteria given in Rules for Classification of Ships Pt.3 Ch.1.

403   Structural capacity of the turret shall be based on the specific loads from the mooring system in the operational mode. Both global and local response of the turret shall be considered. Hull deformations shall be considered. In addition, the local structure shall be considered for the special load cases as defined in Sec.4.

C. Fatigue Assessment

C 100   General

101   The fatigue capacity shall be assessed according to the principles given in Ch.1 Sec.3 C.

102   Fatigue calculations for units converted from old tankers shall account for the load history of the unit and findings from the inspections. The S-N curves (for air or corrosive environments) used should consider the condition of the unit with respect to corrosion, original corrosion protection system and the corrosion protection system after the conversion. See Classification Note 30.7 for additional guidelines.

SECTION 4
DESIGN LOADS

A. Introduction

A 100   General

101   The loads shall in general be determined according to the principles in Ch.1 Sec.3.

102   Design load criteria given by operational requirements as described in Ch.1 Sec.4 shall be fully considered.

B. Still Water Loads

B 100   General

101   All relevant still water load conditions shall be defined and limit curves for hull girder bending moment and shear forces shall be established.

102   The shape of the limit curves for the still water bending moments and shear forces are defined in Rules for Classification of Ships Pt.3 Ch.1. If the extreme still water bending moment and/or shear exceed the main class minimum values, the limit curve should be based on all relevant load combinations.

103   Limit curves for the still water loading conditions shall be presented for operational and transit mode separately.

C. Environmental Loads

C 100   General

101   Definitions, general considerations and required methodology for determination of environmental loads are given in Ch.1 Sec.4.

C 200   Wave induced loads

201   If the structural assessment is based on direct calculated wave loads, bending moments, shear forces and accelerations, the wave loads shall be determined according to Ch.1 Sec.4.

C 300   Mooring loads

301   Mooring loads are to be determined according to Ch.1 Sec.4.

C 400   Sloshing loads in tanks

401   Sloshing in partly filled tanks is to be considered according to Ch.1 Sec.4 E400.

C 500   Green water

501   The effect of green water on weather deck and on deckhouses shall be considered according to Ch.1 Sec.4 E504.

D. Accidental Loads

D 100   General

101   Accidental loads shall be considered according to Ch.1 Sec.4 F.

E. Fatigue Loads

E 100   General

101   Fatigue loads shall be considered as in Ch.1 Sec.4.

SECTION 5
STRUCTURAL ANALYSES FOR CAPACITY CHECKS

A. Introduction

A 100   General requirements

101   The structural response shall be determined by recognised analytical methods. Computer programs used shall have documented test results.

102   The required types of analyses will depend on the structural design, but in general the following is required:

— finite element analysis for global hull girder strength assessment
— finite element analyses for strength assessment of local areas where the structural response cannot be adequately determined by the global analysis
— finite element analyses to determine stress concentration factors.

B. Longitudinal Stresses

B 100   General

101   Global longitudinal nominal stresses should normally be calculated by a finite element analysis. Typical extent of the model is three cargo tanks.

102   For units with moonpool or turret, a finite element analysis shall be carried out to describe the stress distribution in way of the openings, in particular in deck and bottom, and at termination of longitudinal strength elements.

C. Transverse Stresses

C 100   General

101   Transverse stresses shall normally be determined based on a 3-D finite element analysis. The transverse stresses are normally based on the three cargo tank model.

C 200   Global shear stresses

201   Global shear stresses shall be calculated considering the vertical shear force at the transverse section in question as well as the actual shear flow distribution in the section. The shear force shall be corrected according to Rules for Classification of Ships Pt.3 Ch.1 Sec.5 D.

SECTION 6
STRUCTURAL CAPACITY

A. General

A 100 General

101 The capacity of the hull girder can be assessed by alternative methods as given in Ch.1 Sec.3. The selected design principles shall be consistent.

102 The turret and turret or moonpool area, topside facilities' structural support and the fore and aft ship shall be assessed according to Ch.1 Sec.6.

B. Longitudinal Strength

B 100 Alternative 1 - Complying with the main class requirements

101 If the hull girder capacity is to be based on the main class requirements, the midship section modulus and moment of inertia shall comply with 102.

102 The midship section modulus about the transverse neutral axis is not to be less than:

$$Z_0 = \frac{C_{W0}}{f_1} L^2 (C_B + 0.7) \quad (cm^3)$$

The material factor f_1 shall be determined according to Rules for Classification of Ships Pt.3 Ch.1 Sec.2 B200.

The midship section moment of inertia about the transverse neutral axis is not to be less than:

$$I = 3C_{WO} L^3 B (C_B + 0.7) \quad (cm^4)$$

$$
\begin{aligned}
C_{W0} \quad &= \quad 10.75 - [(300-L)/100]^{3/2} \text{ for } L < 300 \\
&= \quad 10.75 \text{ for } 300 \le L \le 350 \\
&= \quad 10.75 - [(L-350)/150]^{3/2} \text{ for } L < 350
\end{aligned}
$$

C_B = block coefficient, but not less than 0.6

103 The requirements given in 102 are normally satisfied when calculated for the midship section only, provided the following rules for tapering are complied with:

a) Scantlings of all continuous longitudinal strength members are to be maintained within 0.4 L amidships. In special cases, based on consideration of type of unit, hull form and loading conditions, the scantlings may be gradually reduced towards the ends of the 0.4 L amidship part, bearing in mind the desire not to inhibit the unit's loading flexibility.

b) Scantlings outside 0.4 L amidships are gradually reduced to the local requirements at the ends, and the same material strength group is applied over the full length of the unit.

104 The hull scantlings are to be based on wave loads and accelerations according to the main class requirements.

B 200 Alternative 2 - Hull girder capacity based on direct calculations of wave loads

201 If the hull girder capacity is to be based on calculated wave loads according to the principles given in Ch.1 Sec.3, the midship section modulus and moment of inertia given in 102 can be reduced by maximum 25% provided the hull capacity comply with all of the requirements given in Ch.1 Sec.6 B.

C. Transverse Structural Strength

C 100 General

101 Transverse strength means the strength of main transverse members such as transverse bulkheads and web frames. The transverse strength should be evaluated using a finite element model. The load effects of process equipment and deck loads shall be included. The transverse strength shall comply with the requirements in Rules for Classification of Ships Pt.3 Ch.1.

APPENDIX A
PERMANENTLY INSTALLED UNITS

A. Introduction

A 100 General

101 The requirements and guidance given in this Appendix are supplementary requirements for units that are intended to stay on location for prolonged periods.

102 The requirements apply in principle to all types of offshore ships.

B. Inspection and Maintenance

B 100 Facilities for inspection on location

101 Inspections may be carried out on location based on approved procedures outlined in a maintenance system and inspection arrangement, without interrupting the function of the unit. The following matters should be taken into consideration to be able to carry out condition monitoring on location:

— arrangement for underwater inspection of hull, propellers, thrusters, rudder and openings affecting the units seaworthiness
— means of blanking of all openings including side thrusters
— use of corrosion resistant materials for shafts, and glands for propeller and rudder
— accessibility of all tanks and spaces for inspection
— corrosion protection of hull
— maintenance and inspection of thrusters
— ability to gas free and ventilate tanks
— provisions to ensure that all tank inlets are secured during inspection
— measurement of wear in the propulsion shaft and rudder bearings
— testing facilities of all important machinery.

C. Corrosion Protection

C 100 Maintenance program

101 A maintenance program shall be made taking into consideration that no dry-docking is planned for the unit.

D. Fatigue

D 100 Design fatigue factors

101 Design fatigue factors (DFF) are introduced as fatigue safety factors. DFF shall be applied to structural elements according to the principles given in DNV-OS-C101.

102 The DFF applied to the structural detail depend on the accessibility for inspection and repair.

103 The units can normally be ballasted to different draughts, and the term "splash" zone has thus no significance. Sufficient margin in respect to the lowest inspection waterline should however be considered depending on the expected wave heights during the inspection periods.

Guidance note:
Normally 1-2 m is considered sufficient margin on the lowest inspection waterline in world wide operation.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

The DFF applied to offshore ships will therefore be dependent on the accessibility for inspection and repair and the position of the lowest inspection waterline.

104 Examples of DFF assigned to different structural elements according to the principles given above are given in DNV-OS-C101.

105 Substantial consequences other than pure strength considerations may require higher design fatigue factors. Such factors should be given in the design brief.

106 When defining the appropriate design fatigue factor for a specific fatigue sensitive detail, consideration shall be given to the following:

— Evaluation of likely crack propagation paths (including direction and growth rate related to the inspection interval), may indicate the use of a higher design fatigue factor, such that:

a) Where the likely crack propagation indicates that a fatigue failure affect another detail with a higher design fatigue factor.

b) Where the likely crack propagation is from a location satisfying the requirement for a given "Access for inspection and repair" category to a structural element having another access categorisation.