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 service documents consist of amongst other the following types of documents:
— Service Specifications. Procedural requirements.
— Standards. Technical requirements.

The Standards and Recommended Practices 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
H) Marine Operations
J) Cleaner Energy
O) Subsea Systems
CHANGES

- **General**
  This document supersedes DNV-OS-C102, October 2008. It is merging the former standards DNV-OS-C102 and DNV-OS-C107 to one single standard DNV-OS-C102.

- **Scope**
  - Give precise strength requirements for procedures and acceptance criteria when using direct calculations by finite element analysis.
  - More detailed explanation and strength requirement related to topside structure and topside interface to the hull ship structure.
  - The material standard specified in the ship rules should be preferred for selection of material class and material grade for offshore ships.

- **Main changes in April 2011**
  - All strength assessments are changed from exiting load and resistance factor design (LRFD) method to the working stress method (WSD).
  - The existing offshore standards “Structural design of offshore ships, DNV-OS-C102” and “Structural design of ship-shaped drilling and well service units (DNV-OS-C107)” are merged into one standard. This means that all offshore ship shaped units are collected into the same new standard (DNV-OS-C102). The existing offshore standard for Structural design of ship-shaped drilling and well service units (DNV-OS-C107) will be phased out.
  - Procedures and acceptance criteria for direct strength calculations are explained more in detail.
  - Introduced a separate section for Topside structures and Topside interface to hull structure.
  - Selection of material and inspection principles is harmonized against the ship rules.
  - Introduced DAT notation when design temperature is below -10°C for selection of material class and material grade.
  - Introduced an Appendix for conversion of tanker for oil to FPSO.
# CONTENTS

## Sec. 1 Introduction

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. General</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>A 100 General</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>A 200 Objectives</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>A 300 Classification</td>
<td></td>
<td>9</td>
</tr>
</tbody>
</table>

## B. Assumptions and Applications

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 100 General</td>
<td></td>
<td>9</td>
</tr>
</tbody>
</table>

## C. Definition

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>C 100 Verbal forms</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>C 200 Terms</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>C 300 Symbols</td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>C 400 Abbreviations</td>
<td></td>
<td>11</td>
</tr>
</tbody>
</table>

## D. References

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>D 100 DNV Offshore Standards, Rules and Classification Notes</td>
<td></td>
<td>11</td>
</tr>
</tbody>
</table>

## Sec. 2 Material Selection and Inspection Principles

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Introduction</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>A 100 General</td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

## B. Selection of Material

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 100 General</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>B 200 Design and service temperatures</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>B 300 Hull structure</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>B 400 Topside structure and elements not covered by Rules for Classification of Ships Pt.3 Ch.1</td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

## C. Inspection Principles

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>C 100 General</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>C 200 Hull structure</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>C 300 Topside structure and elements not covered by hull structure requirements</td>
<td></td>
<td>13</td>
</tr>
</tbody>
</table>

## Sec. 3 Design Principles

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Introduction</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>A 100 Overall design principles</td>
<td></td>
<td>16</td>
</tr>
</tbody>
</table>

## B. Design Conditions

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 100 Modes of operation</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>B 200 Transit and non-operational conditions</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>B 300 Operating conditions</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>B 400 Extreme conditions</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>B 500 Wave load analysis</td>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>

## C. Working Stress Design, WSD

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>C 100 General</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>C 200 Load combinations</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>C 300 Permissible usage factor</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>C 400 Usage factor for peak stress</td>
<td></td>
<td>19</td>
</tr>
</tbody>
</table>

## Sec. 4 Design Loads

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Introduction</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>A 100 General</td>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>

## B. Static Loads

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 100 General</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>B 200 Still water hull girder loads</td>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>

## C. Environmental Loads

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>C 100 General</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>C 200 Wave induced loads</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>C 300 Wind loads</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>C 400 Green sea</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>C 500 Sloshing loads in tanks</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>C 600 Bottom slamming</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>C 700 Bow impact</td>
<td></td>
<td>22</td>
</tr>
</tbody>
</table>
Sec. 5 Hull Strength ................................................................. 23

A. Introduction ............................................................................. 23
A 100 General ........................................................................... 23
A 200 Corrosion addition .......................................................... 24

B. Compliance with Main Class Requirement, 1A1 ...................... 24
B 100 Local scanning requirement ............................................ 24

C. Hull Girder Longitudinal Strength ....................................... 25
C 100 Application ....................................................................... 25
C 200 General ........................................................................... 25
C 300 Analysis model ............................................................... 25
C 400 Design loading conditions ............................................... 26
C 500 Hull girder yield check .................................................... 26
C 600 Hull girder buckling capacity check .............................. 26

D. Transverse Strength .............................................................. 27
D 100 Application ....................................................................... 27
D 200 General ........................................................................... 27
D 300 Analysis model ............................................................... 27
D 400 Design loading condition ................................................ 27
D 500 Material yield check ....................................................... 27
D 600 Buckling capacity check .................................................. 28

E. Local Detailed Stress Analysis ............................................... 28
E 100 Application ....................................................................... 28
E 200 General ........................................................................... 28
E 300 Analysis model ............................................................... 28
E 400 Design loading condition ................................................ 28
E 500 Acceptance criteria ......................................................... 28

F. Fatigue Strength ................................................................. 29
F 100 Application ....................................................................... 29
F 200 Analysis model ............................................................... 29
F 300 Design loading conditions ............................................... 29
F 400 Design criteria ............................................................... 29

Sec. 6 Strength of Topside Structures ........................................... 30

A. Introduction ............................................................................. 30
A 100 General ........................................................................... 30
A 200 Definition of load point .................................................... 31

B. Local Static Loads .............................................................. 31
B 100 Local loads on topside structures ..................................... 31

C. Local Requirements to Plates and Stiffeners ......................... 32
C 100 Plates ............................................................................. 32
C 200 Stiffeners ....................................................................... 32
C 300 Green sea loads ............................................................. 33

D. Local Requirements to Simple Girders ................................ 33
D 100 General ........................................................................... 33
D 200 Minimum thickness ....................................................... 33
D 300 Effective flange of girders ............................................... 34
D 400 Effective web of girders .................................................. 34
D 500 Strength requirement of simple girders ......................... 34

E. Global Static Loads .............................................................. 34
E 100 Global static loads in topside structure ......................... 34

F. Global Dynamic Loads ...................................................... 35
F 100 Global dynamic loads in topside structure ..................... 35
F 200 Design accelerations ...................................................... 35
F 300 Transit conditions ......................................................... 35
F 400 Operating conditions .................................................... 36

G. Hull Deformation .............................................................. 36
G 100 General ........................................................................... 36

H. Complex Girder Systems .................................................... 37
H 100 General ........................................................................... 37
H 200 Design loads ............................................................... 37
H 300 Impact from surrounding structure .............................. 37
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Subsections</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Acceptance Criteria</td>
<td>I 100 Material yield cheek, I 200 Local liquid tanks</td>
</tr>
<tr>
<td>J.</td>
<td>Buckling Stability</td>
<td>J 100 Bars, beams, columns and frames, J 200 Flat platted structures and stiffened panels, J 300 Tubulars, J 400 Capacity checks according to other codes</td>
</tr>
<tr>
<td>K.</td>
<td>Fatigue strength</td>
<td>K 100 General</td>
</tr>
<tr>
<td>Sec. 7</td>
<td>Topside Interface to hull structure</td>
<td>A 100 General</td>
</tr>
<tr>
<td>Sec. 8</td>
<td>Fatigue Capacity Assessment</td>
<td>A 100 General</td>
</tr>
<tr>
<td>Sec. 9</td>
<td>Accidental Conditions</td>
<td>A 100 General</td>
</tr>
<tr>
<td>Sec. 10</td>
<td>Welding and Weld Connections</td>
<td>A 100 General requirements</td>
</tr>
<tr>
<td>Section</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>J.</td>
<td>Corrosion Control</td>
<td>58</td>
</tr>
<tr>
<td>J 100</td>
<td>General</td>
<td>58</td>
</tr>
<tr>
<td>App. A</td>
<td>Conversion of Tanker to Floating Offshore Installation</td>
<td>59</td>
</tr>
<tr>
<td>A.</td>
<td>Introduction</td>
<td>59</td>
</tr>
<tr>
<td>A 100</td>
<td>General</td>
<td>59</td>
</tr>
<tr>
<td>B.</td>
<td>Strength</td>
<td>59</td>
</tr>
<tr>
<td>B 100</td>
<td>General</td>
<td>59</td>
</tr>
<tr>
<td>B 200</td>
<td>Local scantling requirement</td>
<td>59</td>
</tr>
<tr>
<td>B 300</td>
<td>Transverse strength</td>
<td>59</td>
</tr>
<tr>
<td>B 400</td>
<td>Longitudinal strength</td>
<td>59</td>
</tr>
<tr>
<td>B 500</td>
<td>Topside and topside interface to hull structure</td>
<td>60</td>
</tr>
<tr>
<td>B 600</td>
<td>Minimum thickness list</td>
<td>60</td>
</tr>
<tr>
<td>C.</td>
<td>Fatigue</td>
<td>60</td>
</tr>
<tr>
<td>C 100</td>
<td>General</td>
<td>60</td>
</tr>
<tr>
<td>C 200</td>
<td>Previous trade</td>
<td>60</td>
</tr>
<tr>
<td>C 300</td>
<td>Operation</td>
<td>60</td>
</tr>
<tr>
<td>C 400</td>
<td>Areas to be checked</td>
<td>60</td>
</tr>
<tr>
<td>C 500</td>
<td>Mean stress effect</td>
<td>60</td>
</tr>
<tr>
<td>D.</td>
<td>Topside Interface to hull structure</td>
<td>61</td>
</tr>
<tr>
<td>D 100</td>
<td>General</td>
<td>61</td>
</tr>
<tr>
<td>App. B</td>
<td>Longitudinal Strength according to the LRFD Method</td>
<td>62</td>
</tr>
<tr>
<td>A.</td>
<td>Introduction</td>
<td>62</td>
</tr>
<tr>
<td>A 100</td>
<td>General</td>
<td>62</td>
</tr>
<tr>
<td>B.</td>
<td>Hull Girder Longitudinal Strength</td>
<td>62</td>
</tr>
<tr>
<td>B 100</td>
<td>Hull girder bending and shear checks</td>
<td>62</td>
</tr>
<tr>
<td>B 200</td>
<td>Hull girder yield check</td>
<td>63</td>
</tr>
<tr>
<td>B 300</td>
<td>Hull girder buckling capacity</td>
<td>63</td>
</tr>
</tbody>
</table>
SECTION 1
INTRODUCTION

A. General

A 100 General

101 This standard comprises sections with provisions applicable to all types of offshore floating ship shaped units, and sections with provisions for specific types of units such as well intervention/drilling units and FPSOs.

102 This standard is based on the principles of the Working Standard Design, WSD. In WSD the target component level is achieved by keeping the calculated stress for different load combinations equal to or lower than the maximum stress. The maximum permissible stress is defined by multiplication of the capacity, of the structural member with permissible usage factors.

A 200 Objectives

201 The objectives of this standard are to:

— provide an internationally acceptable standard for design of offshore ship-shaped units
— 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 subject to DNV classification services
— base the design of the hull and topside on the same principles and methodology for all transit and operational scenarios
— provide, as far as possible, consistent loads for both topside and hull design.

A 300 Classification

301 Classification principles, procedures and applicable class notations related to classification services of offshore units are specified in the DNV Offshore Service Specifications given in Table A1.

302 Documentation for classification shall be in accordance with the NPS DocReq (DNV Nauticus Production System for documentation requirements) and DNV-RP-A201.

<table>
<thead>
<tr>
<th>Table A1 DNV Offshore Service Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reference</strong></td>
</tr>
<tr>
<td>DNV-OSS-101</td>
</tr>
<tr>
<td>DNV-OSS-102</td>
</tr>
</tbody>
</table>

302 Documentation for classification shall be in accordance with the NPS DocReq (DNV Nauticus Production System for documentation requirements) and DNV-RP-A201.

B. Assumptions and Applications

B 100 General

101 It is assumed that the units will comply with the requirement for retention of the Class as defined in the DNV-OSS-101 or DNV-OSS-102.

102 This standard is applicable to hull and topside of ship-shaped offshore units, such as well intervention units, drilling units, floating production and storage units, constructed in steel for both non-restricted and restricted operations.

103 The environmental loads used for the longitudinal strength calculations for the operational conditions are based on the 10^-2 annual probability of exceedance (100 year return period).

104 Shelf State requirements are not covered by this standard.

Guidance note:
The 100 year return period is used to ensure harmonisation with typical Shelf State requirements and the code for the construction and equipment of mobile offshore drilling units (MODU code).

105 Requirements concerning mooring and riser system are not considered in the standard.
C. Definition

C 100 Verbal forms

101 Shall: Indicates a mandatory requirement to be followed for fulfilment or compliance with the present standard. Deviations are not permitted unless formally and rigorously justified, and accepted by all relevant contracting parties.

102 Should: Indicates a recommendation that a certain course of action is preferred or particularly suitable. Alternative courses of action are allowable under the standard where agreed between contracting parties but shall be justified and documented.

103 May: Indicates a permission, or an option, which is permitted as part of conformance with the standard.

C 200 Terms

201 Standard terms are given in DNV-OS-C101.

202 Drilling vessel: A unit used for drilling in connection with exploration and/or exploitation of oil and gas. The unit is generally operating on the same location for a limited period of time and is normally equipped with dynamic positioning system with several thrusters. The unit follows the normal class survey program.

203 Well intervention vessel: A unit equipped for performing wire-line intervention (without riser) of subsea wells and or coiled tubing of subsea. The unit is generally operating on the same location for a limited period of time and is normally equipped with dynamic positioning system with several thrusters. The unit follows the normal class survey program.

204 Floating production and offloading unit: A unit used for the production of oil with arrangement for offloading to a shuttle tanker. The units normally consist of a hull, with turret or spread mooring arrangement, and production facilities above the main deck. The unit can be relocated, but is generally located on the same location for a prolonged period of time.

205 Floating storage and offloading unit: A unit used for storage of oil with arrangement for offloading to a shuttle tanker. The units normally consist of a hull, with turret or spread mooring system. The unit is equipped for crude oil storage. The unit can be relocated, but is generally located on the same location for a prolonged period of time.

206 Floating production, storage and offloading unit: A unit used for the production and storage of oil with arrangement for offloading to a shuttle tanker. The unit is equipped for crude oil storage. The unit is normally moored to the seabed with production facilities on the main deck. The unit can be relocated, but is normally located on the same location for a prolonged period of time.

207 Floating production, drilling, storage and offloading unit: A unit used for drilling, storage and production of oil with arrangement for offloading to a shuttle tanker. The unit is equipped for crude oil storage.

208 LNG/LPG Floating Production and Storage units: A unit with facilities for oil and gas production and storage. The unit is typically permanently moored. Due to the complexity of the unit more comprehensive safety assessment are typically carried out. The unit is normally equipped with solutions for quick disconnection of mooring lines between the shuttle tanker and the oil and gas producing and storage unit.

209 Turret: A device providing a connection point between the unit and the combined riser- and mooring-systems, allowing the unit to freely rotate (weather vane) without twisting the risers and mooring lines.

210 Temporary mooring: Anchoring in sheltered waters or harbours exposed to moderate environmental loads.

211 Structural design brief: A document providing criteria and procedures to be adopted in the initial stages of the design process. The structural design brief should include analytical methods, procedures and methodology used for the structural design taking all relevant limiting design criteria into account. Owner’s additional specification, if any, should be clearly described in the structural design brief.

212 Service life: The expected life time of the unit

213 Fatigue life: Service life × Design Fatigue Factor (DFF)

214 Probability of exceedance:

- $10^{-4}$: Aprr. daily return period
- $10^{-8}$: Aprr. 20 years return period
- $10^{-8.7}$: Aprr. 100 years return period

215 Annual probability:

- $10^{-1}$: 10 years return period
- $10^{-2}$: 100 years return period
C 300 Symbols

301 The following Latin characters are used in this standard:

<table>
<thead>
<tr>
<th>Table C1 Latin characters used</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
</tr>
<tr>
<td>CW</td>
</tr>
<tr>
<td>aV</td>
</tr>
<tr>
<td>aT</td>
</tr>
<tr>
<td>aL</td>
</tr>
<tr>
<td>MwV</td>
</tr>
<tr>
<td>Mwh</td>
</tr>
<tr>
<td>QwV</td>
</tr>
</tbody>
</table>

302 The following Greek characters are used in this standard:

<table>
<thead>
<tr>
<th>Table C2 Greek characters used</th>
</tr>
</thead>
<tbody>
<tr>
<td>η0</td>
</tr>
<tr>
<td>β</td>
</tr>
<tr>
<td>ηp</td>
</tr>
</tbody>
</table>

C 400 Abbreviations

401 The abbreviations given in Table C3 are used in this standard. Definitions are otherwise given in DNV-OS-C101 'Design of Offshore Steel Structures, General' (LRFD method).

<table>
<thead>
<tr>
<th>Table C3 Abbreviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbreviation</td>
</tr>
<tr>
<td>DFF</td>
</tr>
<tr>
<td>NDT</td>
</tr>
<tr>
<td>SCF</td>
</tr>
<tr>
<td>WSD</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Table D1 DNV Offshore Standards, Rules, Classification Notes and Recommended Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
</tr>
<tr>
<td>DNV-OS-C101</td>
</tr>
<tr>
<td>DNV-OS-C201</td>
</tr>
<tr>
<td>DNV-OS-C401</td>
</tr>
<tr>
<td>DNV-OS-B101</td>
</tr>
<tr>
<td>DNV-OS-C301</td>
</tr>
<tr>
<td>DNV-RP-C201</td>
</tr>
<tr>
<td>DNV-RP-C202</td>
</tr>
<tr>
<td>DNV-RP-C205</td>
</tr>
<tr>
<td>Classification Note 30.7</td>
</tr>
<tr>
<td>DNV-RP-C203</td>
</tr>
<tr>
<td>DNV-RP-C206</td>
</tr>
</tbody>
</table>
SECTION 2
MATERIAL SELECTION AND INSPECTION PRINCIPLES

A. Introduction

A 100 General
101 This section describes the selection of steel materials and inspection principles to be applied in design and construction of offshore ship-shaped units.

B. Selection of Material

B 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 In structural cross-joints where high tensile stresses are acting perpendicular to the plane of the plate, the plate material shall be tested according to Rules for Classification of Ships Pt.2 Ch.2 Sec.1 to prove the ability to resist lamellar tearing (Z-quality). Continuous deck plate under crane pedestal shall have Z-quality steel with minimum extension of 500mm. If the pedestal is continuous through the deck plate within 0.6L amidship, the pedestal plate shall have Z-quality steel with minimum extension of 500 mm above and below the deck.
103 For stiffeners, the grade of material may be determined based on the thickness of the web.
104 Structural elements used only in temporary conditions, e.g. fabrication, are not considered in this standard.

B 200 Design and service temperatures
201 The design temperature for a unit is the reference temperature in air for assessing areas where the unit can be transported, installed and operated. The design temperature is to be lower or equal to the lowest mean daily average temperature in air for the relevant areas. For seasonal restricted operations the lowest mean daily average temperature in air for the season may be applied for external structures above the lowest ballast waterline shall be set equal to the design temperature for the area(s) in which the unit is specified to operate.
202 The service temperature is a reference temperature on various structural parts of the unit used as a criterion for the selection of steel grades.
203 The service temperature for external structures above the lowest ballast waterline shall be set equal to the design temperature for the area(s) in which the unit is specified to operate. External structure is defined, with respect to design temperature, as the plating with stiffening to an inwards distance of 0.5 metre from the shell plating.
204 The service temperature for external structures below the lowest ballast waterline needs normally not to be set lower than 0°C.
205 The service temperature for internal structures in way of permanently heated rooms needs normally not to be set lower than 0°C. Crude oil tanks may be considered to be permanently heated.
206 The service temperature for internal structures in oil storage tanks need normally not to be set lower than 0°C except for the upper strake in longitudinal bulkheads and top wing tanks.

B 300 Hull structure
301 The material grade shall be selected according to the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.2 if the design temperature is equal or above -10°C based on lowest mean daily average temperature.
302 Lower Design Temperatures than -10°C may be specified. The requirements for material class and grade shall then be based on the DNV Rules for Classification of Ships Pt.5 Ch.1 Sec.7.

In the Rules for Classification of Ships Pt.3 Ch.1 materials are categorized into Material Classes. The purpose of the structural categorization is to ensure adequate material and suitable inspection to avoid brittle fracture, and to ensure sufficient fracture resistance of a material (stress intensity factor) to avoid crack sizes which may develop into brittle fracture at certain stress situations.

B 400 Topside structure and elements not covered by Rules for Classification of Ships Pt.3 Ch.1
401 Structural members are classified into Material Classes according to the following criteria:
— significance of member in terms of consequence of failure
— stress condition at the considered detail that together with possible weld defects or fatigue cracks may provoke brittle fracture.
Guidance note:
The consequence of failure may be quantified in terms of residual strength of the structure when considering failure of the actual component.

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

402 Materials for topside modules, topside supporting structures, foundations and main supporting structures of heavy equipment attached to deck and hull shall be selected according to the principles in B300.

403 Materials for the specific structural members are not to be of lower grade than those corresponding to the material classes specified in Table B1.

Table B1 Material Classes

<table>
<thead>
<tr>
<th>Material class</th>
<th>Structural member</th>
<th>Equivalent structural category in the DNV-OS-C101</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>— Outfitting steel</td>
<td>Secondary</td>
</tr>
<tr>
<td></td>
<td>— Mezzanine decks, platforms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— Pipe support structure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— Laydown platforms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— Doubler plates, closer plates and support infill steels in topside structures 1)</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>— Main girders and columns in truss work type modules</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>— Main supporting structures for helideck 3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— Crane pedestal (shipboard and offshore)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— Flare tower</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— Foundations and main supporting structures of heavy machinery and equipment: e.g. thruster, gantry and rail, chain stoppers, offloading riser fairleads, anchor line fairleads, winches, davits, haswer brackets for shuttle tanker, towing brackets etc.</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>— Main supporting structures for derrick</td>
<td>Special</td>
</tr>
<tr>
<td></td>
<td>— Foundations and main supporting structures for flare tower and offshore crane pedestal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— Main supporting structures for turret</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>— Deck and bottom corner plates in way of moonpool</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— Main supporting structures for derrick</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— Foundations and main supporting structures for flare tower and offshore crane pedestal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— Main supporting structures for turret</td>
<td></td>
</tr>
</tbody>
</table>

1) To have the same minimum yield strength as the material to which they are attached
2) Stiffener and other local members (brackets, collar plates, web stiffeners) are classified as Class I.
3) For material selection of helideck and substructure, see DNV-OS-E401

Note: Main structures and main supporting structures are primary load bearing members such as plates, girders, web frames/bulkheads and pillars

404 Alternatively materials for the specific structural members specified in Table B1 may be selected based on equivalent structural category in accordance with the principles given in DNV-OS-C101.

C. Inspection Principles

C 100 General

101 The purpose of inspection is to detect defects that may grow into fatigue cracks during service life.

102 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.

C 200 Hull structure

201 For the inspection principles for hull structure, see unit specific provisions Sec.11 and Sec.12.

C 300 Topside structure and elements not covered by hull structure requirements

301 Fabrication and testing of topside structure shall comply with the requirements in DNV-OS-C401. The
requirements are based on the consideration of fatigue damage and assessment of general fabrication quality.

302 The inspection categories are related to the material class and structural categories as shown in Table C1.

<table>
<thead>
<tr>
<th>Table C1 Inspection categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection Category</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>I</td>
</tr>
<tr>
<td>II</td>
</tr>
<tr>
<td>III</td>
</tr>
</tbody>
</table>

303 The weld connection between two components shall be assigned inspection category according to the highest of the joined components. For stiffened plates, the weld connection between the plate and stiffener, stringer, and girder web to the plate may be inspected according to inspection category III.

304 If the fabrication quality is assessed by testing, or well known quality from previous experience, the extent of inspection required for elements within material class III may be reduced, but not less than for inspection category III.

305 Fatigue critical details within material class II or III shall be inspected according to requirements in inspection category I.

306 Welds in fatigue critical areas not accessible for inspection and repair during operation shall be inspected according to requirements in inspection category I.

307 The extent of NDT for welds in block joints and erection joints transverse to main stress direction shall not be less than for inspection category II.

308 Topside stools, or topside - hull connections, material class III, shall be inspected according to the requirements in inspection category I for the areas shown in Figure 1.

309 Inspection categories for offshore crane pedestals connection to deck are given in Figure 2.
Where:
Length 'a' to be 0.35l, minimum 120 mm
'a' does not need to be bigger than 500 mm
SECTION 3
DESIGN PRINCIPLES

A. Introduction

A 100 Overall design principles
101 This section defines the principles for design of the hull, topside structures and topside support structures.
102 The overall principles are based on the following:
   — safety of the structure can be demonstrated by addressing the potential structural failure mode(s) when the unit is subjected to loads scenarios encountered during transit, operation and in harbour.
   — structural requirements are based on a consistent set of loads that represent typical worst possible loading scenarios
   — unit has inherent redundancy. The unit’s structure works in a hierarchical manner and as such, failure of structural elements lower down in the hierarchy should not result in immediate consequential failure of elements higher up in the hierarchy
   — structural continuity is ensured. The hull, topside structures and topside interface to the hull structure should have uniform ductility.

B. Design Conditions

B 100 Modes of operation
101 All relevant modes of operation shall be considered. Typically, the assessment of the unit shall be based on the following operational modes:
   — all transit conditions
   — all operating conditions, intact and damaged, at the design location(s)
   — all inspection and repair conditions.
102 Changes in the design conditions of offshore ship-shaped units are usually accompanied by significant changes in draught, ballast, riser connections, mooring line tension, etc. Limited variation of some of these parameters may be contained within a specific design condition.
103 The suitability of offshore ship-shaped units is dependent on the environmental conditions in the areas of the intended operation. A well intervention/drilling unit may be intended for World Wide operation or operation in a specific region or site(s). A production unit may be planned to operate at a specific site. Such a site may be harsh environment or benign waters.

B 200 Transit and non-operational conditions
201 Unrestricted transit is defined as moving the unit from one geographical location to another, and shall be based on the DNV Rules for Classification of Ships Pt.3 Ch.1.
202 Non-operational conditions like e.g. survey condition are considered to be covered by DNV Rules for Classification of Ships Pt.7.
203 The design accelerations for the topside structures and topside interface to hull may be taken from either a wave load analysis or DNV Rules for Classification of Ships Pt.3 Ch.1.

B 300 Operating conditions
301 Operating conditions are defined as conditions wherein a unit is on location for purposes of production, drilling or other similar operations, and combined environmental and operational loadings are within the appropriate design limits established for such operations (including normal operations, extreme, and accidental).
302 The operational profile shall be established with specific environmental limiting conditions such as sea state and wind based on site specific representative for the area(s) in which the units are to operate. The applied environmental conditions should be stated in the structural design brief.
303 The operating condition shall account for the combination of wave effects and wind effects.
304 All the operating limitation used for the design and safe operation shall be stated in the operating manual.

B 400 Extreme conditions
401 Extreme condition is defined as a condition during which a unit may be subjected to the extreme environmental loadings such as hurricane or typhoon for which the unit is designed. The operation e.g. drilling
or production is normally stopped due to the severity of the environmental loadings. The unit may be either afloat or moored to the sea bed, or leave the site under its own propulsion or assistance from tugs, as applicable.

402 Survival scenario is to be established, if applicable. For units with disconnectable mooring system e.g. submerged turret, the environmental limiting conditions for disconnection or reconnection of the mooring system are to be specified.

403 If the vessel intends to leave the site and seek for sheltered waters in extreme weather, this actual extreme condition can be omitted from the design condition.

B 500 Wave load analysis

501 The wave load analysis may be carried out for operating conditions with specific wave environments at the considered site, and may also be carried out for transit conditions as alternative to the requirements given in the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.5.

502 The design loading conditions for ultimate strength shall be based on the units loading manual and shall in addition include part load conditions as relevant for the specific type of unit. For selection of still water load conditions to be used as basis for the wave load analysis (with a return period of 20 or 100 years), the most demanding loading conditions defined in the loading manual shall be determined. The most demanding loading conditions are normally selected as those giving maximum still water bending stresses in longitudinal material in different parts of the unit.

503 The wave heading profile given in Table B1 and B2 should be used for the ultimate strength and fatigue strength respectively, unless otherwise documented.

504 The sectional loads are normally calculated at the neutral axis of the section considered.

505 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.

<table>
<thead>
<tr>
<th>Table B1 Design basis of wave load analysis for ultimate strength</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wave environment</strong></td>
</tr>
<tr>
<td>Return period</td>
</tr>
<tr>
<td>Wave spectrum</td>
</tr>
<tr>
<td>Wave heading profile</td>
</tr>
<tr>
<td>Wave spreading</td>
</tr>
</tbody>
</table>

1) See unit specific provisions Sec.11 and Sec.12
2) JONSWAP spectrum is normally used, ref. DNV-RP-C205
3) Other heading profile for operation and extreme condition may be used, if documented.

<table>
<thead>
<tr>
<th>Table B2 Design basis of wave load analysis for fatigue strength</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wave environment</strong></td>
</tr>
<tr>
<td>Probability of exceedance</td>
</tr>
<tr>
<td>Wave spectrum</td>
</tr>
<tr>
<td>Wave heading profile</td>
</tr>
<tr>
<td>Wave spreading</td>
</tr>
</tbody>
</table>

1) Recommended value (approximately daily return period)
2) Cos² is to be used, unless otherwise documented.

506 Non-linear correction factor shall be used for the wave bending moments and shear forces delivered from linear wave load analysis. Typical non-linear correction factors are given in Table B3, unless otherwise documented.
C. Working Stress Design, WSD

C 100 General
101 The WSD principles and the acceptance criteria for the different combinations are applicable to hull and
topside structure for direct calculations when the structural requirements are not covered by DNV Rules for
Classification of Ships Pt.3 Ch.1, or if direct calculations are used to replace the structural requirements in the
Rules for Classification of Ships Pt.3 Ch.1.

C 200 Load combinations
201 Each structural member shall be designed for the most unfavourable of the loading conditions given in
Table C1.

<table>
<thead>
<tr>
<th>Combination</th>
<th>Description</th>
<th>Basic usage factor, $\eta_0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>static loads</td>
<td>0.60</td>
</tr>
<tr>
<td>b)</td>
<td>maximum combined static and dynamic loads</td>
<td>0.80</td>
</tr>
<tr>
<td>c)</td>
<td>accidental loads and associated static loads</td>
<td>1.00</td>
</tr>
<tr>
<td>d)</td>
<td>maximum combined operational static loads and dynamic loads from extreme environmental situations, e.g. hurricane or typhoon</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Notes:
b) Represent maximum operational conditions with the following:
   — Well service or drilling unit: North Atlantic with a 20 year return period or site specific with a 100 year return period
   — FPSO: site specific with a 100 year return period.

c) Represent accidental conditions with low probability of occurrence such as explosions, fire, dropped objects etc.
d) Represent for units intended to stay on location during extreme weather condition, e.g. permanently moored, with a 100 year return period. For units intended to escape during extreme weather condition, e.g. not permanently moored or with disconnectable mooring system, this load combination can be omitted.

C 300 Permissible usage factor
301 The permissible usage factors depend on load combination, failure mode and importance of strength member.

302 The usage factor is defined as the ratio between the calculated nominal stress and the corresponding
minimum specified yield stress of the material used. The calculated usage factor based on the von Mises
equivalent membrane stress at centre of a plane element (shell or membrane) shall not exceed the permissible
usage factors defined in 303.

303 The permissible usage factor, $\eta_p$, is calculated by:

$$\eta_p = \beta \eta_0$$

where:

$\eta_0$ = basic usage factor, see Table C1
$\beta$ = for material yield and buckling checks in general
       = for specific type of structure, see Sec.6

The basic usage factor $\eta_0$ accounts for:

— possible unfavourable deviations of specified or expected loads
— uncertainties in the model and analysis used for determination of load effects
— possible unfavourable deviations in the resistance of materials
— possible reduced resistance of the materials in the structure, as a whole, as compared to the values deduced from test specimens
— deviation from calculated strength resistance due to fabrication.
Guidance note:
The von Mises equivalent stress is defined as follows:

$$\sigma_{eq} = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3\tau^2}$$

Where $\sigma_x$ and $\sigma_y$ are element membrane stresses in x- and y-direction respectively, $\tau$ is element shear stress in the x-y plane, i.e. local bending stresses in plate thickness not included.

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

C 400 Usage factor for peak stress

401 The peak usage factor is defined as the ratio between the calculated peak stress and the corresponding minimum specified yield stress of the material used.

402 Local peak stress by fine mesh Finite Element (FE) analysis in areas with pronounced geometrical changes, such as moonpool corners, frame corners etc., may exceed the permissible usage factor in C203 provided plastic mechanisms are not developed in the adjacent structural parts.

403 Local peak stress criteria are based on the element mesh size of either 50 × 50 mm or 100 × 100 mm or 200 × 200 mm depending on the actual thickness and geometrical complexity of local details to be checked. The calculated usage factor based on the von Mises equivalent membrane stress at centre of a plane element (shell or membrane) shall not exceed the permissible peak usage factors given in Sec.5 Table E1.

404 For fatigue critical connections local peaks are not accepted, ref. Sec.5 F.
SECTION 4
DESIGN LOADS

A. Introduction

A 100 General

101 The requirements in this section define and specify load components to be considered in the overall strength analysis as well as design pressures applicable for local scantling design.

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

— drilling, production, workover and combinations thereof
— consumable re-supply procedures and frequency
— maintenance procedures and frequency
— possible load changes in most severe environmental conditions.

B. Static Loads

B 100 General

101 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.
— mooring forces
— mud, brine and drill water.

105 The variable functional loads utilised in structural design shall 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.

B 200 Still water hull girder loads

201 All relevant still water load conditions shall be defined and permissible limit curves for hull girder bending moments and shear forces shall be established for transit and operating condition separately.

202 The permissible limits for hull girder still water bending moments and hull girder still water shear forces shall be given at least at each transverse bulkhead position and be included in the loading manual. Separate limits will normally be given for sagging and hogging bending moments, and positive and negative shear forces.

203 Actual still water shear forces shall be corrected for structural arrangement according to the procedures given in the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.5 D.

204 The shape of the limit curves for the still water bending moments and shear forces are defined in the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.5. The permissible limit curve is to envelop the main class minimum values and actual still water bending moments and shear forces calculated for transit and operating conditions. The permissible limit curve shall be applied to all relevant load combinations.
C. Environmental Loads

C 100 General

101 Environmental loads are loads caused by environmental phenomena. Environmental loads which may contribute to structural damages shall be considered. Consideration should be given to responses resulting from the following listed environmental loads:

— wave induced loads
— wind loads
— current loads
— snow and ice loads, when relevant
— green sea on deck
— sloshing in tanks
— 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).

C 200 Wave induced loads

201 If wave induced loads are not based on the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.4 and Sec.5, the wave induced loads shall be calculated by the hydrodynamic wave load analysis using three dimensional sink source (diffraction) formulation.

202 The wave loads shall be determined for the site specific environment in which the unit is intended to operate, see DNV-RP-C205 for environmental data.

203 The following wave induced responses shall be calculated:

— motions in six degrees of freedom
— vertical wave induced 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
— accelerations
— axial forces
— external sea pressure distribution.

204 The wave induced bending moments and shear forces may be calculated considering the weather vaning characteristics of the unit, see Sec.3 B500.

205 Torsional moments may normally be disregarded, unless found relevant.

C 300 Wind loads

301 Wind loads shall be accounted for in the design of topside structures subject to significant wind exposure, e.g. flare tower, derrick, modules, etc. The reference mean wind load is often given as 1 hour period at 10m above sea level, but for the calculations the mean wind speed over 1 minute period at actual position above the sea level shall be used.

302 The calculation procedure of wind loads may be found in DNV-RP-C205. The pressure acting on vertical external bulkheads exposed to wind shall not be less than 2.5 kN/m², unless otherwise documented.

303 For slender structures, 3s duration shall be used. See DNV-RP-C205 for details.

304 The wind velocity for transit and operation should normally be not less than the following, unless otherwise documented:

— Transit condition: 36 m/s (1 hour period at 10m above sea level)
— Operating condition (at site specific): specified value.

Guidance note:
Some typical 1 hour mean wind speeds with a return period of 100 year at different locations:

<table>
<thead>
<tr>
<th>Location</th>
<th>Mean Wind Speed (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norwegian sea</td>
<td>Haltenbanken</td>
</tr>
<tr>
<td>North Sea</td>
<td>Troll field</td>
</tr>
<tr>
<td></td>
<td>Greater Ekofisk area</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>Libya</td>
</tr>
<tr>
<td></td>
<td>Egypt</td>
</tr>
<tr>
<td>Gulf of Mexico</td>
<td>Hurricane</td>
</tr>
<tr>
<td></td>
<td>Winter storm</td>
</tr>
</tbody>
</table>
Additional information can be found in ISO19901.1 and API RP95F.
1 minute mean wind speed is approximately $= 1.25 \times 1$ hour mean wind speed

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

### C 400  Green sea

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

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

403 Structural members exposed to green sea shall be designed to withstand the induced loads. Green sea loads are considered as local loads.

404 When lacking more exact information, e.g. from model testing, green sea loads specified in unit specific provisions Sec.11 and Sec.12 shall be used.

405 Shadow effects from either green water protection panel or other structure may be accounted for.

### C 500  Sloshing loads in tanks

501 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.

502 The pressures generated by sloshing of the cargo or ballast liquid and the acceptance criteria shall comply with the requirements given in the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.4 C300.

### C 600  Bottom slamming

601 When lacking more exact information, e.g. from model testing, relevant requirements to strengthening against bottom slamming in the bow region are given in the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.6 H.

602 The bottom aft of the unit shall be strengthened against stern slamming according to DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.7 E200.

### C 700  Bow impact

701 The bow region 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. The design of the bow structure exposed to impact loads shall be carried out according to DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.7 E.

702 The speed $V$ in knots used in the formulas shall not be less than 8.0.
SECTION 5
HULL STRENGTH

A. Introduction

A 100 General

101 This section gives the requirements and guidance to the design of hull structure.

102 Operating mode for offshore ship shaped units such as well service/drilling units and FPSOs are normally different and depends on units characteristics both for transit and operating conditions. Detailed design basis and environmental loads are specified in unit specific provisions Sec.11 and Sec.12.

103 Hull structures affected by topside facilities are to be checked with additional requirements given in Sec.7.

104 The design criteria for other hull structures where not addressed in this standard are to conform to recognized practices acceptable to DNV.

105 Overview of design principles for hull is given in Table A1, A2 and A3 respectively.

<table>
<thead>
<tr>
<th>Table A1 General design basis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design conditions</strong></td>
</tr>
<tr>
<td><strong>Transit</strong></td>
</tr>
<tr>
<td>Ship Rules</td>
</tr>
<tr>
<td>Direct calculation</td>
</tr>
<tr>
<td><strong>Operation</strong></td>
</tr>
<tr>
<td>Ship Rules</td>
</tr>
<tr>
<td>Direct calculation</td>
</tr>
<tr>
<td><strong>Extreme</strong></td>
</tr>
<tr>
<td>Direct calculation</td>
</tr>
<tr>
<td><strong>Design basis and</strong></td>
</tr>
<tr>
<td>environmental load level</td>
</tr>
<tr>
<td>Unit specific provisions Sec.11 and Sec.12</td>
</tr>
<tr>
<td><strong>Local scantlings of hull</strong></td>
</tr>
<tr>
<td>(plates, stiffeners,</td>
</tr>
<tr>
<td>girders, beams in</td>
</tr>
<tr>
<td>general)</td>
</tr>
<tr>
<td>Ship Rules Pt.3 Ch.1 and unit specific provisions Sec.11 and Sec.12</td>
</tr>
<tr>
<td><strong>Direct strength</strong></td>
</tr>
<tr>
<td>calculation</td>
</tr>
<tr>
<td>Ship Rules Pt.3 Ch.1 Sec.12</td>
</tr>
<tr>
<td>Part C, D &amp; E + Sec.11 and</td>
</tr>
<tr>
<td>Sec.12</td>
</tr>
<tr>
<td>Ship Rules Pt.3 Ch.1 Sec.12</td>
</tr>
<tr>
<td>Part C, D &amp; E + Sec.11 and</td>
</tr>
<tr>
<td>Sec.12</td>
</tr>
<tr>
<td>Part C, D &amp; E + Sec.11 and</td>
</tr>
<tr>
<td>Sec.12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table A2 Design loads</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design conditions</strong></td>
</tr>
<tr>
<td><strong>Transit</strong></td>
</tr>
<tr>
<td>Ship Rules</td>
</tr>
<tr>
<td>Direct calculation</td>
</tr>
<tr>
<td><strong>Operation</strong></td>
</tr>
<tr>
<td>Ship Rules</td>
</tr>
<tr>
<td>Direct calculation</td>
</tr>
<tr>
<td><strong>Extreme</strong></td>
</tr>
<tr>
<td>Direct calculation</td>
</tr>
<tr>
<td><strong>Still water bending</strong></td>
</tr>
<tr>
<td>moments and shear forces</td>
</tr>
<tr>
<td>Sec.4, limit curves</td>
</tr>
<tr>
<td>Sec.4, limit curves</td>
</tr>
<tr>
<td>Sec.4, limit curves</td>
</tr>
<tr>
<td><strong>Green sea</strong></td>
</tr>
<tr>
<td>Sec.4, Sec.11 and Sec.12</td>
</tr>
<tr>
<td><strong>Design accelerations</strong></td>
</tr>
<tr>
<td>Ship Rules Pt.3 Ch.1 Sec.4</td>
</tr>
<tr>
<td>Sec.3, wave load analysis</td>
</tr>
<tr>
<td>(North Atlantic)</td>
</tr>
<tr>
<td>Ship Rules Pt.3 Ch.1 Sec.4</td>
</tr>
<tr>
<td>Sec.3, wave load analysis</td>
</tr>
<tr>
<td>with specified seastate</td>
</tr>
<tr>
<td>Ship Rules Pt.3 Ch.1 Sec.5</td>
</tr>
<tr>
<td>Sec.3, wave load analysis</td>
</tr>
<tr>
<td>with specified seastate</td>
</tr>
<tr>
<td><strong>External sea pressure</strong></td>
</tr>
<tr>
<td>Ship Rules Pt.3 Ch.1 Sec.4</td>
</tr>
<tr>
<td><strong>Wave bending moments</strong></td>
</tr>
<tr>
<td>and shear forces</td>
</tr>
<tr>
<td>Ship Rules Pt.3 Ch.1 Sec.5</td>
</tr>
<tr>
<td><strong>Sec.5</strong></td>
</tr>
<tr>
<td>Ship Rules Pt.3 Ch.1 Sec.5</td>
</tr>
</tbody>
</table>

DET NORSKE VERITAS
Design principles for foundations and supporting structures of hull equipment and machinery are given in Table A4.

**Table A3 Longitudinal strength requirements**

<table>
<thead>
<tr>
<th>Main longitudinal members of hull</th>
<th>Design conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Transit</strong></td>
</tr>
<tr>
<td></td>
<td>Ship Rules</td>
</tr>
<tr>
<td>Yield capacity</td>
<td>Ship Rules Pt.3 Ch.1 Sec.5&amp;12</td>
</tr>
<tr>
<td>Buckling capacity</td>
<td>Ship Rules Pt.3 Ch.1 Sec.5&amp;13</td>
</tr>
<tr>
<td>Shear strength 1)</td>
<td>Ship Rules Pt.3 Ch.1 Sec.5</td>
</tr>
</tbody>
</table>

1) Main shear members as side shell and longitudinal bulkheads

**Table A4 Design principles for foundations and supporting structures of hull equipment and machinery**

<table>
<thead>
<tr>
<th>Supporting structures of thruster</th>
<th>Ship Rules Pt.3 Ch.3 Sec.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rudders, nozzle and steering gears</td>
<td>Ship Rules Pt.3 Ch.3 Sec.2</td>
</tr>
<tr>
<td>Supporting structures of helicopter deck and substructure</td>
<td>DNV-OS-E401</td>
</tr>
<tr>
<td>Foundations and supporting structures of temporary mooring equipment (e.g. chain stoppers, windlasses or winches, bollards, chocks, etc)</td>
<td>Ship Rules Pt.3 Ch.3 Sec.5</td>
</tr>
<tr>
<td>Supporting structures of position mooring equipment (e.g. turret, etc)</td>
<td>Sec.12</td>
</tr>
<tr>
<td>Crane pedestal and supporting structures</td>
<td>DNV-RP-C102</td>
</tr>
<tr>
<td>Davits and supporting structures of launching appliances (e.g. life boat, raft, etc)</td>
<td>Ship Rules Pt.3 Ch.3 Sec.5</td>
</tr>
</tbody>
</table>

**A 200 Corrosion addition**

Corrosion addition $t_k$ for tanks containing liquids used for offshore service is given in Table A6. These additions shall be considered in scantlings calculations.

**Table A5 Corrosion addition $t_k$ in mm**

<table>
<thead>
<tr>
<th>Internal members and plate boundary between spaces of the given category.</th>
<th>Tank/hold region</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Tank/hold region</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Within 1.5 m below weather deck or hold top</strong></td>
</tr>
<tr>
<td>Mud tanks/Brine tanks/Produced water tanks</td>
<td>3.0</td>
</tr>
<tr>
<td>Methanol tanks/MEG tanks/Condensate tanks</td>
<td>2.0</td>
</tr>
<tr>
<td>Plate boundary between given space category</td>
<td>Tank/hold region</td>
</tr>
<tr>
<td></td>
<td><strong>Within 1.5 m below weather deck or hold top</strong></td>
</tr>
<tr>
<td>Ballast/Mud/Brine/Produced water tanks towards cargo oil/condensate/MEG/methanol tanks</td>
<td>2.5</td>
</tr>
<tr>
<td>Ballast/Mud/Brine/Produced water tanks towards other category space 1)</td>
<td>2.0</td>
</tr>
<tr>
<td>Cargo oil/condensate/MEG/methanol tanks towards other category space 1)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

1) Other category space denotes the hull exterior and all spaces other than water ballast, cargo oil tanks and tanks mentioned above.

2) The figure in brackets refers to non-horizontal surfaces.

**B. Compliance with Main Class Requirement, 1A1**

**B 100 Local scantling requirement**

DNV Rules for Classification of Ships Pt.3 Ch.1 shall be basis for the general hull structures such as:

— plates, stiffeners and simple girders in general
— bulkheads in general
— deck houses and superstructure
— fore- and aft ship structure.

C. Hull Girder Longitudinal Strength

C 100 Application

101 This section describes the requirements to the hull girder longitudinal strength for both operational and transit conditions in case it is based on direct calculations (hydrodynamic wave load analysis) according to the principles defined in unit specific provisions Sec.11 and Sec.12.

102 The hull girder longitudinal strength calculation is intended to verify ultimate strength of main longitudinal members of the hull such as:
— continuous decks, bottom and inner bottom
— side, inner side and longitudinal bulkheads
— longitudinal stringers and longitudinal girders.

103 If using the direct calculation method to check the main hull girder longitudinal members according to the requirement given in C500 and C600, the DNV Rule checks for longitudinal strength (Pt.3 Ch.1 Sec.5, 12 and 13) may be omitted.

Guidance note:
In DNV Rules for Classification of Ships Pt.3 Ch.1, the longitudinal strength is based on sailing (transit) condition with maximum wave response of $10^{-8}$ probability of exceedance (20 year return period) in the North Atlantic.

C 200 General

201 Hull girder longitudinal strength shall be evaluated by FE analysis or using the DNV NAUTICUS Hull program for ultimate strength calculation. The probability of exceedance shall be consistent when global and local loads are combined.

202 Horizontal wave bending moments are generally disregarded in the assessment of the hull girder longitudinal strength.

203 The wave axial force determined by the hydrodynamic wave load analysis shall be considered.

204 The shear correction factor for the longitudinal bulkheads is to be calculated. The factor is defined as the ratio between the corrected still water shear force and actual still water shear force at the relevant section. Ref. DNV Classification Note No.31.3 Sec.4

205 Any phase angles between accelerations and bending moments are normally disregarded and it is assumed that maximum acceleration and design bending moments occurs at the same time.

206 Gross scantlings may be used for the calculation of the hull girder longitudinal strength.

C 300 Analysis model

301 The part ship model(s) or the whole ship model shall be used for the FE analysis depending on the structural arrangements of the unit. The purpose of the FE analysis is either to fully satisfy the structural requirements given in C500 and C600, or only to calculate the transverse stress and double bottom/side stress that shall be used as input to DNV NAUTICUS Hull program for ultimate strength check.

302 Longitudinal extent of the part ship model should be large enough that structural response is not significantly affected by the boundary conditions.

303 Main structural members of the hull are to be represented in FE model. These include inner and outer shell, floor and girder system in double bottom, transverse and vertical web frames, stringers, transverse and longitudinal bulkhead structures.

304 The topside loads shall be represented in FE model to account for the effect of topside interface with the hull structure.

305 Mesh boundaries in FE model are to simulate the stiffening systems on the actual structures as far as practical and are to represent the correct geometry of the panels between stiffeners. Element mesh size in the part ship model is normally based on the standard mesh size.

Guidance note:
Standard mesh size is defined as equal to or less than the representative spacing of longitudinal stiffeners.

306 Finer mesh less than the standard mesh size may be necessary for correct representation of structural details in local areas, e.g. moonpool corner, other large deck/bottom openings, etc. For element mesh size in
fine mesh areas, see E. Local Detailed Stress Analysis.

C 400  Design loading conditions

401  For still water hull girder loads, see Sec.4 B200.
402  Local static and dynamic loads from topside, tank pressure and sea pressure shall be considered.
403  Dynamic loads shall be determined from the wave load analysis according to the principles given in Sec.3 B500.
404  For the purpose of structural analysis, the loading conditions in the loading manual may need to be modified to satisfy the principles given in 401 and 402.
405  Detailed design loading conditions for the hull girder longitudinal strength are specified in unit specific provisions Sec.11 and Sec.12.

C 500  Hull girder yield check

501  The von Mises criteria should be used for the yield stress control according to the criteria given in Sec.3 C200
502  Where elements are smaller than the standard mesh size, the von Mises equivalent membrane stress may be obtained from the averaged stress over the elements within the standard mesh size.
503  Where the effect of openings is not considered in the FE model, the von Mises equivalent membrane stress in way of the opening is to be properly modified with adjusting shear stresses in proportion to the ratio of web height and opening height, ref. DNV Classification Note No.31.3 Ch.2.3.2
504  Local peak stresses by refined mesh density in local areas described in C306 shall comply with the requirement given in E. Local Detailed Stress Analysis

C 600  Hull girder buckling capacity check

601  The hull girder ultimate buckling capacity check of the main longitudinal members is performed by assessment of local stiffened panels subject to:
   — longitudinal nominal stress (in direction of primary stiffener for stiffened panel)
   — transverse nominal stress (in direction perpendicular to primary stiffener for stiffened panel)
   — nominal in-plane shear stress
   — local lateral pressure from sea or cargo.
602  For units with large opening such as moonpool, the distribution of the global longitudinal bending stress shall be considered with respect to global stress concentration.
603  For the hull girder ultimate buckling capacity check using DNV NAUTICUS Hull only, the transverse stresses determined from FE analysis due to bending of main primary members subject to local loads need to be considered. The local stress effects from bending of stiffeners and plates may be omitted. The average membrane stress is to be calculated from a group of elements representing one plate field between stiffeners.
604  The permissible still water bending moment and still water shear force curves (limit curves) defined based on the loading manual shall be used together with the characteristic wave bending moments and wave shear forces (limit curves) for the considered transverse section. Phase information between the wave bending moment and the wave shear force may be considered if available.
605  The ultimate buckling capacity control of local stiffened panels should be performed according to DNV-RP-C201 and shall comply with the permissible usage factor given in Sec.3 C200. The ultimate buckling capacity estimate of stiffened panels accepts local elastic buckling of plates between stiffeners.
606  The buckling usage factor is defined as the ratio between the applied loads and the corresponding ultimate capacity.
D. Transverse Strength

D 100 Application
101 Transverse strength refers to the strength of the main transverse girder system of the hull such as floors, transverse stringers, transverse bulkheads and transverse web frames which are not directly affected by the hull girder longitudinal loads.
102 The transverse strength should be evaluated by use of FE analysis and shall meet the requirement with respect to material yield and buckling capacity given in the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.12 and 13 respectively.

Guidance note:
In DNV Rules for Classification of Ships Pt.3 Ch.1, local dynamic loads and corresponding acceptance criteria for transverse strength are taken at a probability of exceedance of $10^{-4}$ (daily return period) in the North Atlantic. Transverse strength is carried out with net scantlings where corrosion addition is deducted.

103 Main longitudinal members of the hull shall also be checked in the transverse strength analysis for the cases when direct calculations for the hull girder longitudinal strength are not required in accordance with unit specific provisions Sec.11 and Sec.12.

D 200 General
201 Hull girder normal stresses and hull girder shear stresses should not be considered directly from the FE analysis unless special boundary conditions and loads are applied to represent the hull girder bending moments and shear forces correctly.
202 The effects of topside facilities and drilling equipment deck loads shall be included, where relevant.
203 Net scantlings are to be utilised in the calculation of the transverse strength according to Rules for Classification of Ships Pt.3 Ch.1 Sec.12.

D 300 Analysis model
301 Part ship model(s) used for the hull girder longitudinal strength as described in C300 may be used. Detailed considerations are given in unit specific provisions Sec.11 and Sec.12.

D 400 Design loading condition
401 All operating conditions specified in the loading manual should be checked for the selection of design loading condition and most onerous loading conditions with the unit resulting in maximum stress response of the main transverse girder system shall be selected.
402 Detailed considerations are given in unit specific provisions Sec.11 and Sec.12.

D 500 Material yield check
501 Nominal stress derived from FE analysis shall be checked according to the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.12 B400.
502 The final thickness of the considered structure is not to be less than the minimum thickness given in DNV Rules for Ships Pt.3 Ch.1 Sec.6 to Sec.10.

503 Local structural areas with local stress concentrations e.g. toe of girder bracket shall be evaluated by local detailed stress analysis.

D 600 Buckling capacity check

601 Buckling capacity of each individual plate panel between stiffeners shall comply with the requirements given in the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.13. 602 The buckling capacity check of unstiffened panels in the main transverse girder system of the hull may be performed according to DNV-RP-C201. Ideal elastic buckling strength without accepting any local redistribution of the loads shall be used as basis together with the acceptance criteria given in the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.13.

E. Local Detailed Stress Analysis

E 100 Application

101 Local detailed stress analyses are applicable to local areas of the hull where part ship FE model(s) used for the strength of the main girder system does not represent the local response sufficiently, e.g. toe of girder bracket, etc.

102 Areas to be checked are given in unit specific provisions Sec.11 and Sec.12.

E 200 General

201 Local structural details shall be evaluated by fine mesh FE analysis or equivalent methods to determine local stress distribution in the local areas which is difficult to achieve with coarse mesh.

202 The stress distribution in areas with global stress concentrations and discontinuities, e.g. moonpool openings, turret openings, etc. shall be derived from fine mesh FE analysis.

203 Net scantlings are to be utilised in the local strength analysis according to Rules for Classification of Ships Pt.3 Ch.1 Sec.12. Alternatively, gross scantlings may be utilised in case WSD design method defined in Sec.3 C is used for the evaluation.

E 300 Analysis model

301 Local models may be included directly in FE model used for the part ship analysis or by separate sub-models with prescribed boundary conditions, displacements and forces.

302 If sub-model is used, the extent of the local FE model is to be such that the calculated stresses at the areas of interest are not significantly affected by the imposed boundary conditions and application of loads. The boundary of the FE model should be coincided with primary support members, such as girders, stringers and floors, in the part ship model.

303 Local details at the areas of interest should be generally modelled with element mesh size of either $50 \times 50$ mm or $100 \times 100$ mm or $200 \times 200$ mm depending on the actual thickness and geometrical complexity of local details to be checked. Proper attention should be paid to transition of mesh density. Abrupt changes of mesh density should be avoided and transition area should be well off the stress concentration.

E 400 Design loading condition

401 The most onerous loading condition among those relevant for the hull girder longitudinal strength analysis or transverse strength analysis shall be applied for the local areas to be assessed.

402 If the local fine mesh analysis is run as a sub-model, prescribed boundary deformations or forces taken from the hull girder longitudinal strength analysis or the transverse strength analysis shall be applied. Local loads acting on the structure shall be applied to the model.

E 500 Acceptance criteria

501 Permissible peak usage factors given in Table E1 are defined according to the structural components, design method, load combination and applied mesh size.

502 The calculated usage factor based on the von Mises equivalent membrane stress at centre of a plane element (shell or membrane) shall not exceed the permissible peak usage factor given in Table E1.

$$\sigma_{\text{Peak}} = \eta_{\text{Peak}} \cdot \sigma_{\text{Material\_yield\_stress}}$$
Fatigue strength should be evaluated based on fine element mesh models made for the critical stress concentration details for hull and topside supporting structures which are not sufficiently covered by stress concentration factor given in DNV Classification Notes No.30.7 or DNV-RP-C203.

The correlation between different loads such as global wave bending, external and internal dynamic pressure and acceleration of the topside should be considered in the fatigue assessment.

Areas to be checked are given in unit specific provisions Sec.11 and Sec.12.

Low cycle fatigue due to the repetitive effects of loading and unloading for structure with oil storage shall be checked according to principles given in DNV-RP-C206.

The size of the model should be of such extent that the calculated stresses in the hot spots are not significantly affected by the assumptions made for the boundary conditions.

Element size for stress concentration analyses is to be in the order of the plate thickness. Normally, shell elements may be used for the analysis.

Design loading conditions to be applied for fatigue analysis are given in unit specific provisions Sec.11 and Sec.12.

Design criteria are given in Sec.8.

### Table E1 Permissible peak usage factor ($\eta_{Peak}$) for fine mesh FE analysis

<table>
<thead>
<tr>
<th>Structural component 1)</th>
<th>Design method</th>
<th>Load combination</th>
<th>Mesh size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull in general</td>
<td>Ship Rules</td>
<td>Static+Dyn. (10^-4 level) 2)</td>
<td>50 x 50 mm</td>
</tr>
<tr>
<td>Hull and topside interface structures</td>
<td>WSD method</td>
<td>Static</td>
<td>100 x 100 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Static+Dyn. (10^-8 or 10^-8.7 level) 2)</td>
<td>200 x 200 mm</td>
</tr>
</tbody>
</table>

1) For details to be checked, see unit specific provisions Sec.11 and Sec.12
2) See Sec.1 C212 for definition.

**Note:**

a) Load level is to be consistent according to the applied design method and load combination
SECTION 6
STRENGTH OF TOPSIDE STRUCTURES

A. Introduction

A100 General

101 The requirement in this section is applicable for:

— local strength of plate and stiffener
— simple girders
— calculation of complex girder systems.

102 This section gives provisions for checking of ultimate strength for typical topside structures such as:

— drill-floor and substructure
— modules
— gantry structure
— flare tower
— riser balcony
— deck houses which carry loads from risers, mud, brine etc.

Guidance note:
For derrick structure, see DNV-OS-E101

103 The topside structures shall be designed to withstand the relevant loading conditions according to the transit and operating conditions.

104 In the operating conditions the topside loads are normally different from the transit conditions, and direct calculations of the accelerations and hull girder loads may be carried out.

105 Topside structures of truss work type of structure as the primary load-bearing elements and where the plates are not included in assessment of the global strength, the plates with stiffeners should normally comply only with the local requirements.

106 When the plates with stiffeners are part of the primary load-bearing structure, both local and global requirements shall be complied with.

107 The deformations due to hull girder bending and stiffness variations of the supporting structure shall be accounted for in the structural analyses.

108 Deck houses, accommodation or superstructure, which is not part of the load-bearing structure for typical offshore element loads, shall comply with the requirements given in unit specific provisions Sec.11 and Sec.12.

109 The local requirements to end connections of stiffeners and design of brackets are given in DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.3 C.

110 For slender structures, e.g. flare tower, the response due to vortex shedding shall be considered. Ref. DNV-RP-C205.

111 Overview of the design principles are given in Table A1.
### Table A1 Design principles for topside and topside supporting structures

<table>
<thead>
<tr>
<th>Items</th>
<th>Transit</th>
<th>Operation</th>
<th>Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ship Rules</td>
<td>Direct calculation</td>
<td>Ship Rules</td>
</tr>
<tr>
<td>Local requirements to topside structure (plates / stiffeners / girders / beams)</td>
<td>Part B, C and D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Still water bending moments and shear forces</td>
<td>Sec.4, limit curves</td>
<td>Sec.4, limit curves</td>
<td>Sec.4, limit curves</td>
</tr>
<tr>
<td>Design accelerations</td>
<td>Ship Rules Pt.3 Ch.1 Sec.4</td>
<td>Sec.5, wave load analysis (North Atlantic)</td>
<td>Ship Rules Pt.3 Ch.1 Sec.4</td>
</tr>
<tr>
<td>Wave bending moments</td>
<td>Ship Rules Pt.3 Ch.1 Sec.5</td>
<td>Ship Rules Pt.3 Ch.1 Sec.5</td>
<td>Ship Rules Pt.3 Ch.1 Sec.5</td>
</tr>
<tr>
<td>Wind loads</td>
<td>Sec.4</td>
<td>Sec.4</td>
<td>Sec.4</td>
</tr>
<tr>
<td>Hull deformation</td>
<td>Part I and Sec7</td>
<td>Part I and Sec7</td>
<td>Part I and Sec7</td>
</tr>
<tr>
<td>Green sea</td>
<td>Sec.4, Sec.11 and Sec.12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### A 200 Definition of load point

#### 201 Symbols:

\[ p = \text{design pressure in kN/m}^2 \]

#### 202 The load point for which the design pressure shall be calculated is defined for various strength members as follows:

a) For plates:
- midpoint of horizontally stiffened plate field. Half of the stiffener spacing above the lower support of vertically stiffened plate field, or at lower edge of plate when the thickness is changed within the plate field.

b) For stiffeners:
- midpoint of span.
  - When the pressure is not varied linearly over the span the design pressure shall be taken as the greater of:
  \[ P_m \quad \text{and} \quad \frac{P_a + P_b}{2} \]
  - \( P_m \), \( P_a \), and \( P_b \) are calculated pressure at the midpoint and at each end respectively.

c) For girders:
- midpoint of load area.

### B. Local Static Loads

#### B 100 Local loads on topside structures

101 The local static loads for decks and bulkheads in topside facilities, which are not part of a tank, are given in Table B1. For areas not specifically mentioned in Table B1, relevant values in the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.9 may be applied.
Table B1 Local static loads

<table>
<thead>
<tr>
<th>Decks</th>
<th>Plates and stiffeners</th>
<th>Girders (kN/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Evenly distributed load (kN/m²)</td>
<td>Point load (kN)</td>
</tr>
<tr>
<td>Storage areas in modules ¹)</td>
<td>q</td>
<td>1.5 q</td>
</tr>
<tr>
<td>Lay down areas ¹)</td>
<td>q</td>
<td>1.5 q</td>
</tr>
<tr>
<td>Lifeboat platforms</td>
<td>9.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Area between equipment</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Walkways, staircases and platforms, crew spaces</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Walkways and staircases for inspection only</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Minimum values for areas not given above ²)</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

¹) The distributed loads, q, to be evaluated for each case. Lay down areas should not be designed less than 15 kN/m². ²) The minimum values shall be determined considering the weights of the equipment and bulks, which may be located on the area. The minimum values shall not be less than 2.5 kN/m².

Notes:
- Wheel loads to be added to distributed loads where relevant. (Wheel loads can normally be considered acting on an area of 300 × 300 mm.)
- Point load may be applied on an area 100 × 100 mm, and at the most severe position, but not added to wheel loads or distributed loads.
- The factor f may be taken as

\[
f = \min \left\{ 1.0; \left( 0.5 + \frac{3}{\sqrt{A}} \right) \right\}
\]

Where, A is the loaded area in m².

C. Local Requirements to Plates and Stiffeners

101 The plate thickness shall not to be less than:

\[
t = \frac{5}{\sqrt{f_1}} + t_k (\text{mm})
\]

- \(f_1\) = see DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.2
- \(t_k\) = corrosion addition according to the Ship Rules, Pt.3 Ch.1 Sec.2 Table D1
- \(t_k = 0\) for elements which are not part of a tank

102 The thickness of plating subjected to lateral pressure shall not be less than:

\[
t = 15.8 \frac{k_s \sqrt{p}}{\eta_p f_y} + t_k (\text{mm})
\]

- \(k_s\) = correction factor for aspect ratio of plate field, (1.1 - 0.25 s/l)²
- Maximum 1.0 for s/l = 0.4
- Minimum 0.72 for s/l = 1.0
- \(s\) = stiffener spacing in m
- \(l\) = stiffener span in m
- \(p\) = local design load in B
- \(\eta_p\) = permissible utilisation factors as given in I
- \(f_y\) = specified minimum yield stress of the material in N/mm²
C 200 Stiffeners

201 The section modulus for longitudinals, beams, frames and other stiffeners subjected to lateral load shall not be less than:

\[ Z_t = \frac{l^3 s p}{k_m \eta_p f_y} \times 10^3 \text{ (cm}^3) \]

1) stiffener span in m
s = stiffener spacing in m
p = local design load in B
\[ k_m = \text{bending moment factor, see DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.3 Table B1} \]
\[ \eta_p = \text{permissible usage factors as given in I} \]

202 The requirement in 201 applies to an axis parallel to the plating. For stiffeners at an oblique angle with the plating, the required section modulus shall be multiplied by:

\[ \frac{1}{\cos \phi} \]

\[ \phi = \text{angle in degrees} \] 1) between the stiffener web plane and the plane perpendicular to the plating
1) \( \phi \) is to be taken as 90 degrees if the angle is greater or equal to 75 degrees.

203 Stiffeners with sniped ends may be accepted where dynamic stresses are small and vibrations are considered to be of minor importance, provided that the plate thickness \( t \) supported by the stiffener is not less than:

\[ t = 1.25 \sqrt{\frac{(l-0.5s)p}{f_y}} \text{ (mm)} \]

In such cases the required section modulus in 201 shall be based on the following parameter values:

\[ k_m = 8 \]

Guidance note:
For typical snipped end details as described above, a stress range lower than 30 MPa can be considered as small dynamic stress.

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

C 300 Green sea loads

301 Topside members exposed to green sea loads shall be checked according to the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.9 with the design loads given in Sec.11 and Sec.12.

D. Local Requirements to Simple Girders

D 100 General

101 The requirements in this sub-section give minimum scantlings to simple girders with respect to yield. When boundary conditions for individual girders are not predictable due to dependence of adjacent structures, direct calculations shall be carried out.

102 The local requirements to end connections of girders and design of brackets are given in DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.3 C.

103 The requirements for section modulus and web area given in D500 apply to simple girders supporting stiffeners, or other girders, exposed to linearly distributed lateral load. It is assumed that the girder satisfies the basic assumptions of simple beam theory, and that the supported members are approximately evenly spaced and similarly supported at both ends. Other loads should be specially considered based on the same beam-theory.

104 The section modulus and web area of the girder shall be taken in accordance with particulars as given in D500. Structural modelling in connection with direct stress analysis shall be based on the same particulars when applicable.

105 Dimensions and further references with respect to buckling capacity are given in sub-section G.

D 200 Minimum thickness

201 The thickness of web and flange of girders shall not be less than:
— for longitudinal girders located lower than 4.0 m above the upper continuous deck of the hull or up to the first deck in modules or topside deck houses: \( t = 5 + 0.01 \times L \) (mm), maximum 8 mm
— for longitudinal girders at higher locations or transverse girders: \( t = 4 + 0.01 \times L \) (mm), maximum 7 mm, minimum 5 mm.

**D 300 Effective flange of girders**

301 The effective flange of girders is determined according to DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.3 C400.

**D 400 Effective web of girders**

401 The effective web of girders is determined according to DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.3 C500.

**D 500 Strength requirement of simple girders**

501 Simple girders subjected to lateral loads and which are not taking part in the overall strength of the unit, shall comply with the following:

502 Minimum section modulus Section modulus \( Z_g \):

\[
Z_g = \frac{S_g^2 \times b \times p}{k_\mu \eta_p \times f_y} \times 10^3 \text{ (cm}^3\text{)}
\]

503 Minimum web area after deduction of cut-outs:

\[
A_w = \frac{k_c \times S_g \times b \times p - N_s \times p_p}{\tau_p} \times 10 \text{ (cm}^2\text{)}
\]

The web area at the middle of the span is not to be less than 0.5 \( A_W \)

\( S_g \) = girder span in m. see DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.3.
\( b \) = breadth of load area in m (plate flange), \( b \) may be determined as:
\( = 0.5 \times (l_1 + l_2) \) where \( l_1 \) and \( l_2 \) are the spans of the supported stiffeners on both sides of the girder, respectively, or distance between girders
\( p \) = local design load in sub-section B
\( k_m \) = bending moment factor, see DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.3 Table B1
\( k_c \) = shear force factor, see DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.3 Table B1
\( \eta_p \) = permissible usage factors as given in sub-section I
\( \tau_p \) = permissible shear stress in N/mm\(^2\)
\( f_y \) = specified minimum yield stress of the material in N/mm\(^2\)

**E. Global Static Loads**

**E 100 Global static loads in topside structure**

101 The static loads to be applied for the global analysis of the topside facilities or in the still water loading conditions of the unit are in principle determined by considering the permanent loads and realistic values for simultaneously acting variable loads.

102 The total static load of a module, excluding tank loads, is determined according to:

\[
q_s = F_s + \sum_{i=1}^{n} F_e_i + \sum_{i=1}^{n} K_{pi} P_{v_i} \times A
\]

Where

\( q_s \) = static global weight of module (kN)
\( F_s \) = total steel weight of decks (kN)
\( F_e \) = weight of equipment (kN)
\( N \) = total number of heavy equipment (>50kN)
K = global load reduction factor for the deck considered to account for simultaneous acting module loads
= 0.6
Pv = evenly distributed design load (kN/m²) for the deck considered, ref Table B1.
M = total number of decks
A = loaded area of deck considered (area covered by equipment may be excluded)

103 The tank loads within the module shall be included, if relevant.
104 The load used shall include all equipment over 50 kN plus the sum of all realistic deck loads accounting
for the joint probability of occurrence.

F. Global Dynamic Loads

F 100 Global dynamic loads in topside structure

101 The global dynamic loads to be combined with the global static loads are determined by multiplying the
masses with the design accelerations defined in F200.
102 Wind force shall be included for topside structures with large wind area as e.g. modules, flare tower,
derrick structure, etc.

F 200 Design accelerations

201 The design accelerations used for design of the topside structures are:

\[ a_v \] = vertical acceleration
\[ a_t \] = transverse acceleration
\[ a_l \] = longitudinal accelerations

The sign convention is according to the coordinate system below:

![Coordinate System](image)

F 300 Transit conditions

301 Design accelerations given in Table F1 may be based on the DNV Rules for Classification of Ships Pt.3 Ch.1
Sec.4, or alternatively by direct calculations using the basis given in Sec.3 Table B1 for the transit condition.
302 Load cases shall be generated for each of the maximum basic responses for the head sea, beam sea and
oblique sea as given in Table F1. For symmetrical structures about a longitudinal and transverse plane through
the centre of gravity of the topside structure, load combination 4 and 7 may be omitted.

<table>
<thead>
<tr>
<th>Table F1 Combination of dynamic responses in transit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heading</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Head Sea</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Beam Sea</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Oblique Sea</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

1) Design accelerations, \(a_v\), \(a_t\), \(a_l\) are based on a 20 year return period in the North Atlantic
2) For wind force, \(F_{w}\), see Sec.4.
Where:

<table>
<thead>
<tr>
<th>Values for L &gt; 200 m</th>
<th>Values for L &lt; 100 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>C = -0.003 L + 0.7</td>
<td>0.1</td>
</tr>
<tr>
<td>J = -0.002 L + 0.4</td>
<td>0</td>
</tr>
<tr>
<td>M = -0.004 L + 1.1</td>
<td>0.3</td>
</tr>
<tr>
<td>R = -0.004 L + 1.4</td>
<td>0.6</td>
</tr>
</tbody>
</table>

L = Length of unit (m), shall not be taken higher than 200 nor less than 100

**F 400 Operating conditions**

401 The design accelerations given in Table F2 should be determined based on the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.4, or alternatively by direct calculations using the basis given in Sec.3 Table B1 for the relevant operation condition.

**Table F2 Combination of dynamic responses in operating conditions**

<table>
<thead>
<tr>
<th>Load case</th>
<th>Maximum response</th>
<th>Combination with fraction of responses</th>
<th>Fw</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a_t</td>
<td>-b</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>a_t</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>a_t</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

1) Accelerations need to be calculated for each relevant design condition.
2) Other factor may be accepted, if documented.

**G. Hull Deformation**

**G 100 General**

101 Large topside structures that have significant impact on the total stiffness of the hull girder interface, e.g. derrick structure and main support stools for topside process structure, shall be included in longitudinal hull girder FE model.

102 Minor topside modules may be analysed separately from the hull provided they have less importance for the total hull girder behaviour. Alternatively the longitudinal deformation in deck may be estimated by the simplified formula below:

\[
\delta = \frac{M}{ZE} \cdot \frac{l_1}{l_2}
\]

\(\delta\) = longitudinal deformation between sections 1 and 2
\(M\) = design vertical bending moment at sections 1 and 2
\(Z\) = section modulus at the deck at the interface with topside structure
\(E\) = Young’s modulus of elasticity
\(l_1\) = distance between sections 1 and 2
1) = The design bending moment \( M \) consists of static and dynamic part and shall be considered for the load combination a), b) and d) as specified in Sec.3 Table C1.

\[
\delta = \left( \frac{0.5(M_1 + M_2)}{Ze} \right) I_i
\]

H. Complex Girder Systems

H 100 General

101 For girders that are parts of a complex 2- or 3-dimensional structural system, a complete structural analysis shall be carried out to demonstrate that the stresses are acceptable with respect to material yield and buckling.

102 The method used in the analysis shall be capable of describing the physical behaviour of the structure when exposed to the local and global loads.

103 For girder systems consisting of slender girders, the assessment for all load combination in Sec.3 Table C1 may be based on elastic beam theory. Due attention should be given to:

— shear area variation, e.g. due to cut-outs
— moment of inertia variation
— effective flange
— local buckling of girder flanges.

H 200 Design loads

201 Both local and global loads as defined in sub-section B, E and F shall be considered. The relevant load combinations given in Sec.3 Table C1 shall be addressed.

202 Green sea loads need not to be considered for the global check of a girder system.

H 300 Impact from surrounding structure

301 The impact of structures connected to the part covered by the capacity model shall be included in the assessment of the girders.

I. Acceptance Criteria

I 100 Material yield check

101 The maximum permissible usage factor, \( \eta_p \), is calculated by:

\[ \eta_p = \beta \eta_0 \]

\( \eta_0 \) = basic usage factor in Sec.3 Table C1
\( \beta \) = coefficient depending on type of structure

<table>
<thead>
<tr>
<th>Items</th>
<th>Load combination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a)</td>
</tr>
<tr>
<td>Basic usage factor, ( \eta_0 )</td>
<td>0.6</td>
</tr>
<tr>
<td>Coefficient depending on type of structure, ( \beta )</td>
<td>1.14</td>
</tr>
<tr>
<td>Local requirements to plates and stiffeners</td>
<td>1.14</td>
</tr>
</tbody>
</table>
I 200 Local liquid tanks

201 The local strength requirements to plates, stiffeners and simple girders in tanks shall comply with the requirements in DNV Rules for Classification of Ships Pt.3 Ch.1. The allowable stress for longitudinal members need not be less than 160f₁ MPa.

For material factor f₁, see Rules for Classification of Ships Pt.3 Ch.1 Sec.2.

J. Buckling Stability

J 100 Bars, beams, columns and frames

101 It shall be ensured that there is conformity between the initial imperfections in the buckling resistance formulas and the tolerances in the applied fabrication standard.

**Guidance note:**

If buckling resistance is calculated in accordance with Classification Note 30.1 for bars and frames, the tolerance requirements given in DNV-OS-C401 should not be exceeded.

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

J 200 Flat plated structures and stiffened panels

201 The buckling stability of plated structures may be checked according to DNV-RP-C201.

J 300 Tubulars

301 Tubular members may be checked according to DNV Classification Note 30.1 or API RP 2A - WSD. For interaction between local shell buckling and column buckling, and effect of external pressure, DNV-RP-C202 may be considered.

302 Cross sections of tubular member are divided into different types dependent of their ability to develop plastic hinges and resist local buckling. Effect of local buckling of slender cross sections shall be considered.

**Guidance note:**

a) Effect of local buckling of tubular members without external pressure, i.e. subject to axial force and/or bending moment) given in section 3.8 of DNV-RP-C202 may be used.

b) Effect of local buckling of tubular members with external pressure need not be considered for the following diameter

Dm to thickness t ratio:

where

\[ E = \text{modulus of elasticity} \]

\[ f_y = \text{minimum yield strength} \]

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

303 Tubular members with external pressure, tubular joints and conical transitions may be checked according to API RP 2A-WSD.

J 400 Capacity checks according to other codes

401 Stiffeners and girders may be checked according to provisions for beams in recognised standards such as AISC-ASD.

**Guidance note:**

The principles and effects of cross section types are included in the AISC-ASD.

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

K. Fatigue strength

K 100 General

101 Fatigue of topside structures shall be documented according to the principles and requirements given in Sec.8
The worst dynamic stress amplitude using the combinations in Table F1 and Table F2 may be applied for a simplified fatigue calculation in transit and operation.
SECTION 7
TOPSIDE INTERFACE TO HULL STRUCTURE

A. Introduction

A 100 General

101 The overall principles for assessment of topside interface to hull are given in Sec.6, both for an integrated hull-topside analysis and for separate capacity models for the topside structures. This section gives provisions for checking of ultimate strength for typical topside interface to hull structure and foundations and supporting structures of heavy equipment attached to deck and hull.

102 The principles for topside structures also apply to the load carrying part of the topside supporting structures.

103 Topside support structure is the structural elements of which the strength and fatigue capacities may be affected by the presence of the topside structure. This includes elements like support stools for topside modules, and the parts of the hull structure where the additional stresses from the topside structure is of such a magnitude that the yield, buckling and fatigue capacities need to be assessed.

B. Strength Assessment

B 100 Application

101 The structural strength of the topside supporting structures and foundations and supporting structures of heavy equipment attached to deck and hull shall be documented by means of FE analyses or equivalent methods, see also Sec.6 G Hull deformation.

102 Typical topside supporting structures to be analysed are given in unit specific provisions Sec.11 and Sec.12.

B 200 Requirements to the FE model

201 The extent of the model shall be based on requirements to determine the stress distribution from:

— hull girder bending moments and shear forces
— local loads from equipment
— lateral pressures in tanks and sea pressure, where relevant

202 The boundary conditions applied to the model should not introduce significant errors in the structural response.

203 In case of separate local models for hull and topside structures, part of the topside structure may be required to be included in the hull model to ensure that the reaction forces from the topside model will be applied to the hull model at a location which will have negligible impact on the stress distribution in the hull model.

204 The element mesh size in FE models should be sufficient to determine the stress distribution in relation to the acceptance criteria given in Sec.5.

205 When local peak stress criterion is applied in the assessment, the element mesh size should be determined as defined in Sec.5 E such that the area which exceeds the yield stress of the material is determined to such a degree that it is possible to evaluate the impact on adjacent elements.

B 300 Design load

301 Hull girder bending moments in the sagging and hogging conditions shall be applied. The still water bending moment and shear force values shall not be smaller than the permissible limit values. The design wave bending moments are specified in Sec.5.

302 Maximum reaction forces from the topside facilities may be applied simultaneously. Those forces are applied to the contacted area by point loads or pressure load equal to that of the reaction force.

303 Tank pressure and sea pressure shall be included provided the response from these loads will increase the stresses in the topside supporting structures.

B 400 Load combination

401 The load combination between hull girder loads and topside loads shall account for joint probability of occurrence. Unless direct analyses are carried out to determine the phases between the dynamic responses, the loads may be combined according to Table C1 and C2.
B 500 Acceptance criteria

501 The material yield and buckling capacity for the topside supporting structures shall comply with the requirements of Sec.5 taking applied design method, load combination and the element mesh size into account.

C. Combination of Loads

C 100 General

101 The loads to be combined for the assessment of the topside supporting structures are:

- $F_X$ = maximum longitudinal reaction force from topside structure in kN
- $F_Y$ = maximum transverse reaction force from topside structure in kN
- $F_Z$ = maximum vertical reaction force from topside structure in kN
- $M_S$ = still water bending moment (limit value at transit or operating condition) in kNm
- $M_WV$ = vertical wave bending moment (limit value at transit or operating condition) in kNm

1) Using a direct calculation method, the values of $M_S$ and $M_WV$ for the actual loading conditions may be considered.

102 For units with double side, the horizontal bending moment may be disregarded for design of topside structures.

103 The vertical hull girder shear force may be disregarded, unless the vertical relative shear deformation of the support stools of the module are significant.

104 If direct calculations are carried out the heading profiles specified in Sec3 B500 shall be used, unless otherwise documented.

C 200 Transit conditions

201 The load cases and load combination in the transit condition resulting in maximum stress response are given in Table C1.

<table>
<thead>
<tr>
<th>Heading</th>
<th>Load cases</th>
<th>Hull girder load (global)</th>
<th>Topside load (local)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$F_X$</td>
<td>$F_Y$</td>
</tr>
<tr>
<td>Head sea</td>
<td>1</td>
<td>$M_S + M_WV$ (sag)</td>
<td>(-)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>$M_S + M_WV$ (hog)</td>
<td>(+)</td>
</tr>
<tr>
<td>Beam sea</td>
<td>3</td>
<td>$M_S + a M_WV$ (hog)</td>
<td>(+)</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>$M_S + a M_WV$ (hog)</td>
<td>(-)</td>
</tr>
<tr>
<td>Oblique sea</td>
<td>5</td>
<td>$M_S + h M_WV$ (hog)</td>
<td>(+)</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>$M_S + k M_WV$ (sag)</td>
<td>(+)</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>$M_S + k M_WV$ (sag)</td>
<td>(+)</td>
</tr>
</tbody>
</table>

- Global and local loads are based on same probability level of, see unit specific provision in Sec.11 and Sec.12
- Topside load $F_X$, $F_Y$ and $F_Z$ are calculated according to Sec.6 Table F1
- $F_X$ (+): forward direction
- $F_Y$ (+): port side direction
- $F_Z$ (+): upward direction 4. Hold or tank is assumed empty and the effect of sea pressure may be disregarded

Values for $L > 200$ m | Values for $L < 100$ m
---|---
$a$ = -0.004 $L + 1.3$ | 0.5 | 0.9
$h$ = 0.002 $L + 0.5$ | 0.9 | 0.7
$k$ = -0.003 $L + 0.7$ | 0.1 | 0.4
$L$ = Length of unit (m), shall not be taken higher than 200 nor less than 100.
C 300 Operating conditions

301 Load case and load combination resulting in maximum stress response in the operating conditions is given in Table C2.

### Table C2 Load case and load combination for operating condition

<table>
<thead>
<tr>
<th>Load cases</th>
<th>Hull girder load (global)</th>
<th>Topside load (local)</th>
<th>Local loads</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fx</td>
<td>Fy</td>
</tr>
<tr>
<td>1</td>
<td>Ms + M_{wv} (hog)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>2</td>
<td>Ms + M_{wv} (hog)</td>
<td>(+)</td>
<td>(-)</td>
</tr>
<tr>
<td>3</td>
<td>Ms + M_{wv} (hog)</td>
<td>(-)</td>
<td>(+)</td>
</tr>
<tr>
<td>4</td>
<td>Ms + M_{wv} (hog)</td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>5</td>
<td>Ms + M_{wv} (sag)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>6</td>
<td>Ms + M_{wv} (sag)</td>
<td>(+)</td>
<td>(-)</td>
</tr>
<tr>
<td>7</td>
<td>Ms + M_{wv} (sag)</td>
<td>(-)</td>
<td>(+)</td>
</tr>
<tr>
<td>8</td>
<td>Ms + M_{wv} (sag)</td>
<td>(-)</td>
<td>(-)</td>
</tr>
</tbody>
</table>

Global and local loads shall be based on same probability level of load. See unit specific provision in Sec.11 and Sec.12. Topside load Fx, Fy and Fz are calculated according to Sec.6 Table F2. Hold or tank shall consider full or empty condition. Sea pressure is based on the maximum operating draught.

D. Fatigue Assessment

D 100 General

101 The fatigue life of the topside supporting structure shall be documented according to the principles and requirements given in Sec.8.

102 The worst dynamic stress amplitude using the combinations in Table C1 and Table C2 may be applied for a simplified fatigue calculation in transit and operation.
SECTION 8
FATIGUE CAPACITY ASSESSMENT

A. Introduction

A 100 General
101 This section gives provisions for assessment of fatigue capacity of the structural details in the unit. The assessment shall account for all significant loads contributing to fatigue damage.
102 In the assessment of fatigue life, consideration shall be given to the stress concentration factors from fabrication imperfections which exceed the values included in the S-N curves.
103 Hull vibration is not covered by this standard, but should be included if relevant.

B. Principles and Methodology

B 100 Assessment principles
101 The dynamic response for all relevant variable loading conditions shall be considered in the fatigue calculation.
102 The accumulated fatigue damage from both transit and operating conditions shall be calculated according to the operational characteristics of the unit. Appropriate fraction of time in each condition and wave headings shall be considered.
103 The fatigue life shall be calculated considering the combined effects of global and local structural response.
104 The resistance against fatigue is normally given as S-N curves, i.e. stress range (S) versus number of cycles to failure (N) based on fatigue tests. Fatigue failure is defined as when the crack has grown through the thickness.
105 Gross scantling may be utilized in the fatigue calculation.

B 200 Methods for fatigue capacity
201 The fatigue analysis should be based on S-N data, determined by fatigue testing of the considered welded detail, and the linear damage hypothesis. When appropriate, the fatigue analysis may alternatively be based on fracture mechanics.
202 Acceptable analysis methods for calculation of the accumulated damage are given in DNV Classification Note 30.7 (CN 30.7) and DNV-RP-C203. Analysis methods, e.g. simplified or spectral methodology, should be specified in the structural design brief.
203 When a wave load analysis is used for a spectral fatigue analysis, the design basis for transit and operating condition as specified in Sec.3 Table B1 and B2 shall be applied.
204 For detailed consideration on design loading conditions and mean stress effect, see unit specific provisions Sec.11 and Sec.12.

C. Structural Details and Stress Concentration Factor (SCF)

C 100 General
101 Fatigue sensitive details in the hull and topside supporting structures shall be documented to have sufficient fatigue strength. Areas to be checked are given in unit specific provision Sec.11 and Sec.12.
102 Stress concentration factors of local details may be determined according to CN 30.7. For details not covered by CN 30.7, or documented in other recognised publications, detailed FE analysis shall be carried out for determination of SCFs, according to the procedure given in CN 30.7.

D. Design Loads and Calculation of Stress Ranges

D 100 Wave environment
101 The wave date in transit and operating conditions shall be determined according to unit specific provisions Sec.11 and Sec.12.
D 200  Wind and current
201  The effect of wind may be omitted except for special structures subject to significant wind exposure, e.g. flare tower, derrick, etc.

D 300  Local and global loads
301  Typical local load effects to be considered are:
   — vortex shedding
   — external sea pressure
   — tank pressure
   — variation of filling level in cargo tanks (low cycle).

302  Typical global loads to be considered are:
   — wave bending moments and shear forces
   — horizontal and vertical hull deformations/deflections
   — wave induced accelerations (inertia loads).

303  The global and local load effects shall be combined according to the procedures given in CN 30.7.

E. Design Fatigue Factor (DFF)

E 100  General
101  DFF is required for different structural elements based on the consequences of failure and accessibility for in service inspection and repair.

102  The required service life of new units shall be minimum 20 years assuming that the unit complies with the DNV requirements for dry-docking inspection.

103  For additional consideration on DFF, see unit specific provisions Sec.11 and Sec.12.

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

   Guidance note:
   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 affects 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.

---End of Guidance Note---
SECTION 9
ACCIDENTAL CONDITIONS

A. Introduction

A 100 General

101 Accidental loads are loads related to abnormal operation or technical failure. Attention should be given to layout and arrangements of facilities and equipment in order to minimise the adverse effects of accidental events.

102 Safety assessment shall be carried out according to the principles given in DNV-OS-A101 for relevant accidental scenarios.

103 The overall objective for design with respect to accidental conditions is that unit's main safety functions shall not be impaired by accidental events. Satisfactory protection against accidental damage may be achieved by two barriers:

— reduction of damage probability
— reduction of damage consequences.

104 The design against accidental loads may be done by direct calculation of the effects imposed by the loads on the structure, or indirectly, by design of the structure as tolerable to accidents.

B. Design Criteria

B 100 General

101 Structures shall be checked for accidental loads in two steps, according to the loading conditions presented in Sec.3 Table C1:

— resistance of the structure against design accidental loads, i.e. loading condition c)
— post accident resistance of the structure against environmental loads after accidental damage, i.e. loading conditions d).

The unit shall be designed for environmental condition corresponding to 1 year return period after accidental damage.

102 Generic values of accidental loads are given in DNV-OS-A101.

103 The different types of accidental loads require different methods and analyses to assess the structural resistance. Local exceedance of the structural capacity is acceptable provided redistribution of forces due to yielding, buckling and fracture is accounted for.

104 The inherent uncertainty of the frequency and magnitude of the accidental loads, as well as the approximate nature of the methods for determination of accidental load effects, shall be recognised. It is therefore essential to apply sound engineering judgement and pragmatic evaluations in the design.

105 If non-linear, dynamic FE analysis is applied for design, it shall be verified that all local failure modes (e.g. strain rate, local buckling, joint overloading, and joint fracture) are accounted for implicitly by the modelling adopted, or else subjected to explicit evaluation.

B 200 Dropped objects

201 Critical areas for dropped objects shall be determined on the basis of the actual movement of potential dropped objects, e.g. crane or other lifting operation mass, relative to the structure of the unit itself. Where a dropped object is a relevant accidental event, the impact energy shall be established and the structural consequences of the impact assessed.

202 Critical areas for dropped objects should be determined assuming a minimum drop direction within an angle of 10° with the vertical direction.

203 Setback area shall be designed to satisfy the dropped object scenario in accordance with DNV-OS-E101.

Guidance note:

The dropped object is calculated according to DNV-RP-C204.

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

B 300 Fires

301 The structure that is subjected to a fire shall maintain sufficient structural strength before evacuation has occurred. The following fire scenarios shall be considered:
— jet fires
— fire inside or on the hull
— fire on the sea surface.

Assessment of fire may be omitted provided fire protection requirements made in DNV-OS-D301 are met.

**B 400  Explosions**

**401** One or more of the following main design philosophies will be relevant:

— 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 overpressure.
— Locate hazardous areas in enclosed locations and install pressure relief mechanisms (e.g. blast panels) and design for the resulting overpressure.

**402** As far as practicable, structural design accounting for large plate field rupture resulting from explosion actions should be avoided due to the uncertainties of the actions and the consequences of the rupture itself.

**403** Structural support of blast walls and the transmission of the blast action into main structural members shall be evaluated when relevant. Effectiveness of connections and the possible outcome from blast, such as flying debris, shall be considered.

**B 500  Unintended flooding**

**501** The structural design of the hull against unintended flooding shall be based on the deepest equilibrium waterline in damaged condition obtained from damage stability calculations.

**502** The permissible stresses for local scantling, e.g. plating, stiffener and girder, in a flooded condition may be taken as 220f₁ for normal stresses and 120 f₁ for shear stresses in accordance with DNV Rules for Classification of Ships Pt.3 Ch.1.

**503** Heeling condition after damage flooding shall be checked using the actual heeling angle from a damage stability calculation considering the required damage extent of hull according to DNV-OS-C301. Alternatively 17° heeling angle may be used if no actual heeling angle is available. The heeling condition is considered to be a static condition without combining any environmental loads. Normally the heeling condition is not dimensioning for the topside or topside support structure as the inertia loads from operation and transit condition will be governing.

**B 600  Collision**

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

**B 700  Extreme whether condition**

**701** Units designed not to disconnect and escape from the extreme environmental loading condition, as a hurricane or typhoon, shall be designed using the 100-years return period for the actual loading as an accidental case, ref. Sec.3 B400.
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 DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.11.

102 Full penetration welds shall be used if weld improvements (e.g. grinding) is needed to achieve required design fatigue life, unless the fatigue life at the weld root is documented.

103 Deep penetration welds are acceptable in areas where the design load is primarily static or shear. If the static compression stress constitutes more than 35% of the yield stress, deep penetration welds may be used with a root face of t/3. See Figure 1.

![Weld root face](image)

Figure 1
Weld root face

B. Size of Welds

B 100 Double continuous fillet welds

101 Double continuous fillet welds shall be dimensioned according to principles given in DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.11. The Table B1 has been extended to include C factors for typical offshore members.

<table>
<thead>
<tr>
<th>Item</th>
<th>60% of span</th>
<th>At ends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local buckling stiffeners</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>Stiffeners, frames, beams or longitudinals to shell, deck, oil tight or water tight girders or bulkhead plating, except in after peaks.</td>
<td>0.16</td>
<td>0.26</td>
</tr>
<tr>
<td>Secondary stiffeners in topside structures.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary stiffeners in turret</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Web plates of non-watertight girders except in after peak.</td>
<td>0.20</td>
<td>0.32</td>
</tr>
<tr>
<td>Girder webs and floors in double bottom.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stiffeners and girders in after peaks.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main girder system and decks in turret</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal stringers on transverse bulkheads.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watertight centre line girder to bottom and inner bottom plating.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boundary connection of ballast and liquid cargo bulkhead:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>— longitudinal bulkheads</td>
<td></td>
<td></td>
</tr>
<tr>
<td>— transverse bulkheads.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hatch coamings at corners and transverse hatch end brackets to deck.</td>
<td></td>
<td>0.52</td>
</tr>
<tr>
<td>Top horizontal profile to coaming.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength deck plating to shell scuppers and discharges to deck.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main girder system in topside structures of framework design type.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fillet welds subject to compressive stresses only.</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>All other welds not specified above.</td>
<td>0.43</td>
<td></td>
</tr>
</tbody>
</table>
B 200  Fillet welds and deep penetration welds subject to high tensile stresses

201  Fillet welds and deep penetration welds subject to high tensile stresses shall be dimensioned according to the principles given in DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.11.

B 300  Full penetration welds

301  In addition to the full penetration welds required for joints specified by the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.11, full penetration welds shall be used for the following connections:

— crane pedestal to deck plating
— topside support stools to main deck 1)
— flare to hull structure
— drill floor support structure to main deck 1).

1)  Ref. Section 2 for details.

B 400  End connection of stiffeners

401  The connection area at supports of stiffeners shall comply with the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.11 C400.

B 500  Direct calculations

501  The distribution of forces in a welded connection may be calculated on the assumption of either elastic or plastic behaviour.

502  Residual stresses and stresses not participating in the transfer of load need not be included when checking the resistance of a weld. This applies specifically to the normal stress parallel to the axis of a weld.

503  Welded connections shall be designed to have adequate deformation capacity.

504  In joints where plastic hinges may form, the welds shall be designed to provide at least the same design resistance as the weakest of the connected parts.

505  In other joints where deformation capacity for joint rotation is required due to the possibility of excessive straining, the welds require sufficient strength not to rupture before general yielding in the adjacent parent material.

Guidance note:

In general this will be satisfied if the design resistance of the weld is not less than 80% of the design resistance of the weakest of the connected parts.

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

506  The design resistance of fillet welds is adequate if, at every point in its length, the resultant of all the forces per unit length transmitted by the weld does not exceed its design resistance.

507  The design resistance of the fillet weld will be sufficient if both the following conditions are satisfied:

$$\sqrt{\sigma_\perp^2 + 3(r_\perp^2 + r_\parallel^2)} \leq \frac{f_u}{\beta_w} \eta_0$$

and

$$\sigma_\perp \leq f_u \eta_0$$

$\sigma_\perp$  =  normal stress perpendicular to the throat

$r_\perp$  =  shear stress (in plane of the throat) perpendicular to the axis of the weld

$r_\parallel$  =  shear stress (in plane of the throat) parallel to the axis of the weld, see Table B1

$f_u$  =  nominal lowest ultimate tensile strength of the weaker part joined

$\beta_w$  =  appropriate correlation factor, see Table B1

$\eta_0$  =  basic usage factor, see Sec.3 C400
Figure 2
Stress components in a fillet weld

<table>
<thead>
<tr>
<th>Steel grade</th>
<th>Lowest ultimate tensile strength $f_u$</th>
<th>Correlation factor $\beta_w$</th>
</tr>
</thead>
<tbody>
<tr>
<td>NV NS</td>
<td>400</td>
<td>0.83</td>
</tr>
<tr>
<td>NV 27</td>
<td>400</td>
<td>0.83</td>
</tr>
<tr>
<td>NV 32</td>
<td>440</td>
<td>0.86</td>
</tr>
<tr>
<td>NV 36</td>
<td>490</td>
<td>0.89</td>
</tr>
<tr>
<td>NV 40</td>
<td>510</td>
<td>0.9</td>
</tr>
<tr>
<td>NV 420</td>
<td>530</td>
<td>1.0</td>
</tr>
<tr>
<td>NV 460</td>
<td>570</td>
<td>1.0</td>
</tr>
</tbody>
</table>
SECTION 11
ADDITIONAL PROVISIONS FOR WELL SERVICE AND DRILLING UNITS

A. Introduction

A 100 Scope and application

101 This additional provision contains specific requirements and guidance applicable for well service and drilling unit which are intended to operate on a specific location.

B. Design Principles

B 100 General

101 The limiting operating condition which the unit is intended to operate shall be specified and used as a basis for the design operating conditions. The condition shall be specified with:

— significant wave height and zero crossing period
— wind speed.

102 The design principles for transit, operating and extreme conditions are given in Table B1.

Table B1 Design principles for well service and drilling units

<table>
<thead>
<tr>
<th>Design condition</th>
<th>Design basis and environmental load level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit condition</td>
<td>DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.5. Alternatively see Sec.3 B500</td>
</tr>
<tr>
<td>(World Wide)</td>
<td></td>
</tr>
<tr>
<td>Operating condition</td>
<td>DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.5 1) Alternatively direct calculations based on the specified sea state or site specific scatter diagram(s) with a 100 year return period, ref Sec.3 B500</td>
</tr>
<tr>
<td>Extreme condition</td>
<td>Direct calculations based on the specified sea state or site specific scatter diagram(s) with a 100 year return period, ref Sec.3 B500</td>
</tr>
</tbody>
</table>

1) Using Ship Rules values Pt.3 Ch.1 Sec.5 for the longitudinal strength in operation is allowed provided that

\[ M_{W_{Rule-20\ year}} > M_{W_{Site-100\ year}} \]

Where:

- \( M_{W_{Rule-20\ year}} \) : Rule wave bending moment based on a 20 year return period in the North Atlantic
- \( M_{W_{Site-100\ year}} \) : Direct wave bending moment based on a 100 year return period at the specified site

Guidance note:

When the unit is intended to operate in areas where the 100 years significant wave height (Hs) in operation is less than 8.5 m (Hs ≤ 8.5m), the Ship Rules Pt.3 Ch.1 Sec.5 may be used for the longitudinal strength check. The significant wave height in the extreme storm can be estimated using 2-parameter Weibull parameters (\( \alpha_s, \beta_s \)) for different scatter diagram as present in DNV-RP-C205 Appendix C Table C-1 together with the formula:

\[ H_s = \alpha_s (\ln(N))^{\frac{1}{\beta_s}} \]

where “N” is the number of maxima for the sea state in a time period “t”, N = t/τ and “τ” is the duration of each short-term variation (normally taken as 3 hours). E.g. for a time period of 100 year the value N is then N=100*365*24/3 = 292000.

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

C. Design Loads

C 100 Green sea

101 In lack of more exact information, for example from model testing, relevant requirements to strengthening against green sea are given in the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.8 and 10 respectively.

D. Hull Girder Longitudinal Strength

D 100 General

101 The hull girder longitudinal strength shall be in accordance with the design basis and environmental load level given in Table B1.
D 200 Design loading conditions

201 The design loading conditions for operation for the hull girder longitudinal strength are given in Table D1. Additional load cases may be considered and agreed depending on the structural arrangements such as moonpool, setback area, etc.

<table>
<thead>
<tr>
<th>Load case</th>
<th>Draught</th>
<th>Global load</th>
<th>Local load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bending moment</td>
<td>Shear force</td>
</tr>
<tr>
<td>LC1</td>
<td>Maximum draught</td>
<td>Max. sagging</td>
<td>Max. sagging</td>
</tr>
<tr>
<td>LC2</td>
<td>Minimum draught</td>
<td>Max. hogging</td>
<td>Max. hogging</td>
</tr>
</tbody>
</table>

1) All dynamic loads are to be determined based on the design principles given in Table B1.
2) For internal dynamic pressure, the vertical acceleration at the centre of hold/cargo tank induced by the heave and pitch motion is to be applied. The height of air pipe should normally not be taken less than 0.76 m. The specific gravity of each cargo tank and water ballast tank is to be 1.025 t/m³.
3) Turret is normally not installed for well service and drilling vessels but the loads shall be included if relevant.

Table D1 Design loading conditions for hull girder longitudinal strength

E. Transverse Strength

E 100 General

101 Transverse girder system shall be designed with a direct strength analysis according to the principles specified in Sec.5.

E 200 Design loading conditions

201 The tank/hold arrangement for well service and drilling units may be significantly deviated compared to those for conventional tankers, but the design loading principles for FE analysis given in DNV Classification Notes No.31.3 may be used as reference.

202 The selection of the design loading conditions should be documented in the structural design brief taking the structural arrangements of the unit into account.

F. Local Detail Stress Analysis

F 100 General

101 Typical hull and topside supporting structures to be analysed are given in Table F1, but not limited to:

Table F1 Areas to be checked

<table>
<thead>
<tr>
<th>Hull</th>
<th>Hull-topside interface structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>— toe of girder bracket at typical transverse web frame</td>
<td>— drill floor substructure and supporting structures</td>
</tr>
<tr>
<td>— toe and heel of horizontal stringer in way of transverse bulkhead</td>
<td>— topside stool and support structures</td>
</tr>
<tr>
<td>— local stiffener in way of transverse bulkhead subject to relative deformation</td>
<td>— crane pedestal foundation and supporting structures</td>
</tr>
<tr>
<td>— opening on main deck, bottom and inner bottom, e.g. moonpool corner</td>
<td>— foundation and supporting structures for rail of gantry crane</td>
</tr>
</tbody>
</table>

G. Fatigue Strength

G 100 Design loading conditions

101 Transit and operating conditions defined in the loading manual shall be selected. The fraction of the total design life spent for the transit and operating conditions shall be specified in the structural design brief and considered in the calculation.

102 For wave loads, see Sec.3 Table B2.
Guidance note:
The fraction of the total design life using 80% in operation and 20% in Transit may be used if no other information is available.

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

**G 200 Mean stress effect**

201 Mean stress effect can be used according to Table G1.

<table>
<thead>
<tr>
<th>Table G1 Mean stress effect for well service and drilling vessels</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base material</strong></td>
</tr>
<tr>
<td>DNV-RP-C203 or DNV Classification Notes No.30.7</td>
</tr>
</tbody>
</table>

**G 300 Design fatigue factor**

301 A design fatigue factor (DFF) of 1.0 is acceptable for all structural elements which are accessible for inspection and repair. For structural elements which are not accessible for inspection and repair, a DFF of 2.0 is to be used as minimum.

**G 400 Areas to be checked**

401 Fatigue sensitive details in the hull and topside supporting structures shall be documented to have sufficient fatigue strength. Particular attention should be given to the following details in Table G2, but not limited to:

<table>
<thead>
<tr>
<th>Table G2 Areas to be checked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull</td>
</tr>
<tr>
<td>— openings on main deck, bottom and inner bottom structure including deck penetrations</td>
</tr>
<tr>
<td>— longitudinal stiffener end connections to transverse web frame and bulkhead</td>
</tr>
<tr>
<td>— shell plate connection to longitudinal stiffener and transverse frames with special consideration in the splash zone.</td>
</tr>
<tr>
<td>— hopper knuckles and other relevant discontinuities</td>
</tr>
<tr>
<td>— attachments, foundations, supports etc. to main deck and bottom structure openings and penetrations in longitudinal members.</td>
</tr>
</tbody>
</table>

**H. Inspection Principles**

**H 100 Hull structure**

101 The extent of non-destructive testing during fabrication of the hull shall be in accordance with DNV Rules for Classification of Ships Pt.2 Ch.3 Sec.7.

**I. Corrosion Control**

**I 100 Hull and topside structure**

101 The corrosion protection of the hull and its structural members shall comply with the requirements in DNV Rules for Classification of Ships Pt.3 Ch.1

102 Steel surfaces in topside structure except tanks shall be protected by a suitable coating system proven for marine atmospheres.

103 Tanks for fresh water shall have a suitable coating system. Special requirements will apply for coating systems to be used for potable water tanks.

104 Tanks for liquids in the topsides shall have a corrosion protection system according to DNV Rules for Classification of Ships Pt.3 Ch.1.
SECTION 12
ADDITIONAL PROVISIONS FOR FLOATING PRODUCTION,
STORAGE AND OFFLOADING UNITS

A. Introduction

A 100  Scope and application

101  This additional provision contains specific requirements and guidance applicable for floating production,
storage and offloading unit which are intended to operate on a specific location.

A 200  Definition

201  The operating site is defined based on the environmental conditions in the area(s) of the intended
operation as given in Table A1.

<table>
<thead>
<tr>
<th>Table A1 Definition of operating site</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benign waters</strong></td>
</tr>
<tr>
<td>Hs ≤ 8.5m</td>
</tr>
</tbody>
</table>

Hs = significant wave height at site specific with a 100 year return period

202  If the unit is defined for “benign waters operation”, the “main class requirements” to the midship section
modulus are by definition more stringent than the design principles based on the direct calculations applied to
“benign waters”. If hull structures comply with the minimum midship section modulus and moment of inertia
given in the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.5, no direct calculations of wave bending
moments and shear forces are required in such cases.

203  When the hull is designed according to the direct calculations, the wave loads for the operation and
extreme condition shall be derived from a direct calculation using the actual sea state or site specific scatter
diagram(s) with a 100 year return period.

Guidance note:
The significant wave height in the extreme storm can be estimated using 2-parameter Weibull parameters \( \alpha_s, \beta_s \) for
different scatter diagram as present in DNV-RP-C205 Appendix C Table C-1 together with the formula:
\[
H_s = \alpha_s \left[ \ln(N) \right]^{1/\beta_s},
\]
where “N” is the number of maxima for the sea state in a time period “t”, N = t/τ and “τ” is the duration of each short-term variation (normally taken as 3 hours). E.g. for a time period of 100 year the value N is
then N=100*365*24/3= 292000.

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

B. Design Principles

B 100  General

101  The design principles for transit, operating and extreme conditions are given in Table B1.

<table>
<thead>
<tr>
<th>Table B1 Design principles for floating production and storage units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design condition</strong></td>
</tr>
<tr>
<td>Transit</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Operating condition</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Extreme condition</td>
</tr>
</tbody>
</table>
C. Design Loads

C 100  Mooring loads

1) 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.

C 200  Green sea

2) In lack of more exact information, for example model testing, the following design pressure given in Table C1 shall be used for weather deck, topside supports and deckhouses.

<table>
<thead>
<tr>
<th>Area</th>
<th>Benign waters Hs &lt; 8.5 m</th>
<th>Harsh Environment Hs &gt; 8.5 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather deck</td>
<td>Pt.3 Ch.1 Sec.8 B100</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unprotected front bulkheads</td>
<td>Pt.3 Ch.1 Sec.10 C100</td>
<td></td>
</tr>
<tr>
<td>Unprotected bulkheads elsewhere and topside supports</td>
<td>Pt.3 Ch.1 Sec.10 C100</td>
<td>Pt.3 Ch.1 Sec.10 C100</td>
</tr>
</tbody>
</table>

1) Linear interpolation shall be used for intermediate locations between the unit’s side and the centre line.

2) Speed V = 8 knots is to be used as minimum for moored or dynamically positioned units to ensure sufficient minimum pressure.

202 The required local scantlings shall be according to the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.10 using the design pressure as given in 201.

203 Glass thickness of windows in unprotected front bulkheads according to DNV Rules for Classification Pt.3 Ch.3 Sec.6 L, as well as the design of the fastening arrangement to the bulkheads shall be considered using the design pressures given in Table C1.

204 Topside members located in the midship or aft area of the unit shall be based on p₄ in Table C1 of the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.10.

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.

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

D. Hull Girder Longitudinal Strength

D 100  General

1) The hull girder longitudinal strength for operation and extreme conditions shall be in accordance with the design basis and environmental load level given in Table B1.
D 200 Design loading conditions

201 The design loading conditions for the hull girder longitudinal strength are given in Table D1.

<table>
<thead>
<tr>
<th>Load case</th>
<th>Draught</th>
<th>Global load</th>
<th>Local load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bending moment</td>
<td>External pressure</td>
</tr>
<tr>
<td>LC1</td>
<td>Full load draft</td>
<td>Max. sagging (limit value)</td>
<td>Static − dynamic</td>
</tr>
<tr>
<td>LC2</td>
<td>Ballast draft</td>
<td>Max. hogging (limit value)</td>
<td>Static + dynamic</td>
</tr>
</tbody>
</table>

1) All dynamic loads are to be determined based on a 100 year return period, ref. Sec.3 B500
2) For internal dynamic pressure, the vertical acceleration at the centre of hold/cargo tank induced by the heave and pitch motion is to be applied. The height of air pipe should normally not be taken less than 0.76m. The specific gravity of each cargo tank and water ballast tank is to be 1.025 t/m³
3) Turret load is to be added, if applicable.

E. Transverse Strength

E 100 General

101 Transverse girder system shall be designed with a direct strength analysis according to the principles specified in Sec.5.

102 Design loading conditions which arise for maintenance and inspection purposes offshore shall be taken into account.

E 200 Design loading conditions

201 The design loading conditions for FE analysis are generally given in DNV Classification Notes No.31.3. The selection of the design loading conditions should be specified in the structural design brief taking structural arrangements of unit into account.

Guidance note:
DNV Classification Note No.31.3 is normally used for a cargo hold FE analysis for 3 standard types of tanker. Harbour conditions need normally not to be considered.

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

F. Local Detail Stress Analysis

F 100 General

101 Typical hull and topside supporting structures to be analysed are given in Table F1, but not limited to:

<table>
<thead>
<tr>
<th>Hull</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>— toe of girder bracket at typical transverse web frame</td>
</tr>
<tr>
<td></td>
<td>— toe and heel of horizontal stringer in way of transverse bulkhead</td>
</tr>
<tr>
<td></td>
<td>— local stiffener in way of transverse bulkhead subject to relative deformation</td>
</tr>
<tr>
<td></td>
<td>— opening on main deck, bottom and inner bottom, e.g. moonpool corner.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hull-topside interface structure</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>— topside stools and support structures</td>
</tr>
<tr>
<td></td>
<td>— turret and supporting structures</td>
</tr>
<tr>
<td></td>
<td>— riser interfaces</td>
</tr>
<tr>
<td></td>
<td>— crane pedestal foundation and supporting structures</td>
</tr>
<tr>
<td></td>
<td>— gantry foundation and supporting structures</td>
</tr>
<tr>
<td></td>
<td>— flare tower foundation and supporting structures</td>
</tr>
<tr>
<td></td>
<td>— fairlead support.</td>
</tr>
</tbody>
</table>

F 200 Turret and moonpool structure

201 Moonpool opening should be designed such that additional stress occurring due to global stress concentration is minimised. See Figure 1 for details. The structure around the moonpool is to be checked both for excessive yielding and buckling.
202 Turret interface structure should be calculated by FE calculations considering the relevant loads. The combination of loads from mooring, internal tank filling and hull girder loads should be taken as unfavourable for the design of the turret/moonpool area and the adjoining hull structure.

203 The extent of the FE calculations should be appropriate to evaluate the effect of loads on the hull girder, transverse girders and local plate and stiffeners. For guidance of extent of FE model, see Figures 2 and 3.

Guidance note:

For guidance of the extent of modelling, see Figure 2 and 3.

For yield and buckling shall be checked with acceptance criteria given in Sec.5.
G. Fatigue Strength

G 100 Design loading conditions

101 The operating conditions in the loading manual shall be selected.

Guidance note:
Normally 50% in full load and 50% in ballast may be used for the operation, unless otherwise documented. Partial filling may be considered depending on operational characteristics.

102 For wave loads, see Sec.3 Table B2.

103 The transit condition may be omitted, if the time in transit is below 5% of the total design life.

G 200 Mean stress effect

201 Mean stress effect can be used according to Table G1.

<table>
<thead>
<tr>
<th>Base material</th>
<th>Welded structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNV-RP-C203 or DNV Classification Notes No.30.7</td>
<td>Not allowed</td>
</tr>
</tbody>
</table>

Guidance note:
Mean stress effect for welded structures is normally allowed for sailing ships that are in dry dock each 5 year and can be easily repaired. For permanently installed ships where traditionally a rather high safety margin with respect to fatigue is required and repair of these structures on the field can be rather costly, use of mean stress effect for welded structures is thus normally not allowed.

G 300 Design fatigue factors

301 The required fatigue life a new permanently installed unit (unit which is not intended to dry-dock) shall be minimum 20 years. Higher design fatigue factors (DFFs) should be used in case the structure is not accessible for inspection. The design fatigue factors are given in Table G2. See Figure 4 for the application for a typical shell structure.

<table>
<thead>
<tr>
<th>Table G2 Design fatigue factors (DFFs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>
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 worldwide operation.

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

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

G 400 Areas to be checked

401 Fatigue sensitive details in the hull and topside supporting structure shall be documented to have sufficient fatigue strength. Particular attention should be given to the following details as described in Table G3, but not limited to:

<table>
<thead>
<tr>
<th>Table G3 Areas to be checked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull</td>
</tr>
<tr>
<td>main deck, including deck penetrations, bottom structure and side shell</td>
</tr>
<tr>
<td>longitudinal stiffener end connections to transverse webframe and bulkhead</td>
</tr>
<tr>
<td>shell plate connection to longitudinal stiffener and transverse frames with special consideration in the splash zone.</td>
</tr>
<tr>
<td>hopper knuckles and other relevant discontinuities</td>
</tr>
<tr>
<td>openings and penetrations in longitudinal members</td>
</tr>
<tr>
<td>toe and heel of horizontal stringer in way of transverse bulkhead</td>
</tr>
<tr>
<td>bilge keels.</td>
</tr>
<tr>
<td>Hull-topside interface structure</td>
</tr>
<tr>
<td>attachments, foundations, supports etc. to main deck and hull</td>
</tr>
<tr>
<td>topside stools and supporting structures</td>
</tr>
<tr>
<td>caissons</td>
</tr>
<tr>
<td>turret and supporting structures</td>
</tr>
<tr>
<td>riser interfaces</td>
</tr>
<tr>
<td>crane pedestal foundation and supporting structures</td>
</tr>
<tr>
<td>flare tower foundation and supporting structures.</td>
</tr>
</tbody>
</table>
H. Special Consideration

H 100 Bilge keels
101 The requirements for design of bilge keels apply to turret moored units and to spread moored units. The bilge keel should normally be welded directly onto the shell plate without doubling plates. Adequate transverse supporting brackets, or an equivalent arrangement, are to be provided.

102 For bilge keels of a closed type design material yield, buckling and fatigue strength shall be documented. 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.

H 200 Support of mooring equipment, towing brackets etc
201 Structure supporting mooring equipment such as fairleads and winches, towing brackets etc. shall be designed for the loads and acceptance criteria specified in DNV-OS-E301.

H 300 Loading Instrument
301 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 DNV Rules for Classification of Ships Pt.3 Ch.3 Sec.9.

302 The limitations for the still water bending moments and shear forces shall be in accordance with maximum permissible still water bending moments and shear forces specified in the loading manual.

I. Inspection Principles

I 100 General
101 The extent of non-destructive testing during fabrication of the hull and topside structure shall be in accordance with DNV-OS-C401.

102 The inspection category shall be taken in accordance with Table I1. The relationship between the inspection category and material class is shown.

<table>
<thead>
<tr>
<th>Table I1 Inspection categories</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inspection category</strong></td>
</tr>
<tr>
<td>I</td>
</tr>
<tr>
<td>II</td>
</tr>
<tr>
<td>III</td>
</tr>
</tbody>
</table>

J. Corrosion Control

J 100 General
101 The corrosion protection of the hull, topside and its structural members shall comply with the requirements in DNV-OS-C201.
APPENDIX A
CONVERSION OF TANKER TO FLOATING OFFSHORE INSTALLATION

A. Introduction

A 100 General

101 This section provides specific requirements and guidance applicable for the conversion from tanker for oil to floating offshore production and/or offshore storage unit, ref. DNV-OSS-C102.

102 The basis of the vessel to be converted is a vessel with hull structures that comply with the structural requirements of 1A1 Tanker for Oil or equivalent from a vessel transferring into the DNV classification.

103 Prior to conversion it is to be evaluated for the followings:

— Steel wastages should be identified.
— Fatigue cracking and possible repair should be evaluated.

104 Any major change as lengthening of the unit, increased draft, increased static loads, etc, shall be evaluated.

105 For the new structures added to the converted vessel, material selection and inspection principles shall comply with the requirement given in Sec.2. The structural renewal including material should be replaced by steel of the same or higher grade according to the approved design scantling or greater.

106 Loading manual containing all operational modes shall be submitted for approval. The permissible limit curves for the hull girder still water bending moments and shear forces used for a trading vessel need to be checked for all operating conditions. New permissible limit curve for operation as an FPSO may need to be established, as found relevant.

B. Strength

B 100 General

101 Existing hull structure may be accepted “as is” provided that it comply with class requirements in force for 1A1 Tanker for Oil at the date of construction of the vessel. However, additional requirements with respect to longitudinal strength and fatigue capacity shall be complied with based on site specific environmental conditions.

102 New structures added to the converted vessel or existing structures affected by the new structures shall comply with the requirements of this standard. This will typically include but will not be limited to:

— installation of turret or mooring arrangement
— modification of super-structure
— installation of topside and modification to topside interface
— installation of helideck
— installation of lifeboat davits, cranes, etc.

B 200 Local scantling requirement

201 The plate and stiffener may be accepted with lower scantlings than original given that they comply with the local scantlings requirements in DNV Rules for Classification for Ships Pt.3 Ch.1.

B 300 Transverse strength

301 Transverse strength of the vessel due to tank filling arrangement may be accepted “as is” if the following conditions are satisfied with:

— Loading conditions in production and storage mode are not more severe than what the vessel has been basis for the trade as a tanker.
— Minimum scantlings are within the minimum thickness list provided as a tanker.

302 In case the vessel does not comply with 301, transverse strength in accordance with the principles in Sec.5 D shall be performed.

B 400 Longitudinal strength

401 If the unit is defined for “benign waters operation”, ref Sec.12 Table A1, hull structures shall comply with the requirements given in the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.5. No direct wave load analysis is required.
402 For operation in “harsh environment”, ref. Sec.12 Table A1, or if direct calculations are used as an alternative to the longitudinal strength requirements in the DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.5, hull girder longitudinal strength shall comply with the requirements given in Sec.5 C.

403 Reduced scantlings due to wastage of longitudinal members may be accepted given that the vessel complies with the longitudinal strength requirement based on direct calculations of site specific environment in Sec.5 C.

B 500 Topside and topside interface to hull structure
501 Topside structure shall be calculated according to Sec.6
502 Topside interface to hull structure shall be calculated according to Sec.7.

B 600 Minimum thickness list
601 The minimum list of “as is” plate and stiffener thickness shall be developed by the designer or owner in accordance with the principles in DNV-RP-C101.

C. Fatigue

C 100 General
101 The fatigue capacity for conversions shall be considered, and is a function of the following parameters:
   — results from survey and assessment of critical details
   — service history of the vessel
   — duration of the intended stay on a specific location and environmental conditions at the location.

C 200 Previous trade
201 Fatigue damage during the previous unrestricted trade should be evaluated for critical areas of the hull. Service history with actual trading route can be used in the assessment of fatigue damage.
202 Previous repair and damage history should be evaluated with the focus on critical areas and how to remove these potential failures in the operation phase as floating offshore installation.

C 300 Operation
301 The fatigue capacity shall be evaluated in accordance with Sec.8. Minimum 15 years fatigue life in the intended operational site shall be basis for the fatigue calculations. “As is” scantlings shall be used in the assessment.
302 S-N curves in air in the DNV Classification Notes No.30.7 (CN30.7) may be used for the specified design life of unit in case the corrosion protection system is maintained according to the principles in DNV-OS-C101/C201.

C 400 Areas to be checked
401 Fatigue sensitive details in the existing hull structure and newly installed structures shall be documented to validate sufficient fatigue strength. Particular attention should be given to the following details:
   — longitudinal stiffener end connections to transverse frames and bulkheads
   — shell plate below the draught in full load condition
   — new foundations and supports to main deck, side and bottom structure (e.g. topside, flare tower, riser balcony, turret, etc).
402 For units intend to stay on location without going to dry-dock every 5th year, the design fatigue factors as specified in Sec.12 G300 shall be followed.

C 500 Mean stress effect
501 Mean stress effect according to Table C1 shall be used.

<p>| Table C1 Mean stress effect for conversion of tankers to floating offshore installation |
|--------------------------------------|--------------------------------------|------------------|</p>
<table>
<thead>
<tr>
<th>Operating profile</th>
<th>Base material</th>
<th>Welded structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trading as tanker</td>
<td>DNV-RP-C203 or CN30.7</td>
<td>CN30.7</td>
</tr>
<tr>
<td>Operation at site</td>
<td>DNV-RP-C203 or CN30.7</td>
<td>Not allowed</td>
</tr>
</tbody>
</table>
D. Topside Interface to hull structure

D 100 General

101 When new topside structure is placed on the existing deck structure the following items need to be specially considered: Uplift of the topside structure may introduce high tensile stresses perpendicular to the plate of the deck plate and replacing existing plate with z-quality steel may be necessary. Due to fatigue, the existing fillet welds between transverse frame/bulkhead and deck plate may need to be replaced with full penetration welds when the topside support structure is placed above the deck plate.
APPENDIX B
LONGITUDINAL STRENGTH ACCORDING TO THE LRFD METHOD

A. Introduction

A100 General

101 This appendix explains the Load and Resistance Factor Design (LRFD) method. This method may be used for the longitudinal strength check instead of the Working Stress Method (WSD) as described in Sec.5 C.

102 Using the LRFD method will replace the a) and b) combinations given in Sec.3 Table C1 for the operation condition. Transit condition shall comply with the requirements to longitudinal strength (Pt.3 Ch.1 Sec.5) in Rules for Classification of Ships and the extreme condition will be similar to the WSD method as the load factor and material factor of 1.0 shall be used.

103 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, see Table B1.

104 The material factor to be used in the longitudinal strength assessment of the hull girder is 1.15.

105 The capacity assessment in the longitudinal strength condition shall include buckling and yield checks.

106 Buckling capacity checks shall be performed in accordance with Sec.5 C500.

B. Hull Girder Longitudinal Strength

B100 Hull girder bending and shear checks

101 The hull girder bending and shear capacity in the operating conditions shall be checked according to B200 and B300. The capacity checks are based on the two equations below:

\[ \gamma_{f,G,Q} Q_s + \gamma_{f,E} Q_w \leq Q_g / \gamma_m \]
\[ \gamma_{f,G,Q} M_s + \gamma_{f,E} M_w \leq M_g / \gamma_m \]

Where:

- \( M_g \): 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\(^{-2}\)
- \( \gamma_m \): material factor
- \( \gamma_{f,G,Q} \): partial load factor for still water loads (permanent + variable functional loads)
- \( \gamma_{f,E} \): partial load factor for environmental loads.

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.

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

102 The partial load coefficients for assessment of global capacity are given in Table B1.

<table>
<thead>
<tr>
<th>Table B1 Partial coefficients for the longitudinal strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combination</td>
</tr>
<tr>
<td>a)</td>
</tr>
<tr>
<td>b)</td>
</tr>
</tbody>
</table>

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

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

$$M_w \geq 0.44 M_s$$

**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---

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

Figure 1

Dimensioning combination

**B 200 Hull girder yield check**

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

$$\sigma_e \leq \frac{f_y}{\gamma_m}$$

for operating conditions (100 years return period for environmental loads)

- $\sigma_e$ = nominal equivalent stress
- $\gamma_m$ = material factor = 1.15
- $f_y$ = yield stress of the material

**B 300 Hull girder buckling capacity**

Hull girder buckling capacity shall be determined according to the principles given in Sec.5 C600 using a usage factor of:

$$\eta = \frac{1}{\gamma_n}$$

where $\gamma_n = 1.15$

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

The ultimate buckling capacity of each stiffened panel shall be determined according to DNV-RP-C201 Buckling Strength Analysis.