DNV·GL

OFFSHORE STANDARD

DNVGL-OS-C106 Edition July 2015

Structural design of deep draught floating units - LRFD method

DNV GL AS

FOREWORD

DNV GL offshore standards contain technical requirements, principles and acceptance criteria related to classification of offshore units.

Any comments may be sent by e-mail to *rules@dnvgl.com*

CHANGES – CURRENT

General

This document supersedes DNV-OS-C106, July 2014.

Text affected by the main changes in this edition is highlighted in red colour. However, if the changes involve a whole chapter, section or sub-section, normally only the title will be in red colour.

On 12 September 2013, DNV and GL merged to form DNV GL Group. On 25 November 2013 Det Norske Veritas AS became the 100% shareholder of Germanischer Lloyd SE, the parent company of the GL Group, and on 27 November 2013 Det Norske Veritas AS, company registration number 945 748 931, changed its name to DNV GL AS. For further information, see www.dnvgl.com. Any reference in this document to "Det Norske Veritas AS", "Det Norske Veritas", "DNV", "GL", "Germanischer Lloyd SE", "GL Group" or any other legal entity name or trading name presently owned by the DNV GL Group shall therefore also be considered a reference to "DNV GL AS".

Main changes July 2014

- General

The revision of this document is part of the DNV GL merger, updating the previous DNV standard into a DNV GL format including updated nomenclature and document reference numbering, e.g.:

— Main class identification **1A1** becomes **1A**.
— DNV replaced by DNV GL.
— DNV-RP-A201 to DNVGL-CG-0168. A complete listing with updated reference numbers can be found on DNV GL's homepage on internet.

To complete your understanding, observe that the entire DNV GL update process will be implemented sequentially. Hence, for some of the references, still the legacy DNV documents apply and are explicitly indicated as such, e.g.: Rules for Ships has become DNV Rules for Ships.

Editorial corrections

In addition to the above stated main changes, editorial corrections may have been made.

CONTENTS

CHAPTER 1 INTRODUCTION

SECTION 1 INTRODUCTION

1 General

1.1 Introduction

1.1.1 This document provides requirements for the structural design of deep draught floater (DDF) units, fabricated in steel, in accordance with the provisions of DNVGL-OS-C101 utilizing the LRFD design method. For WSD methodology, reference is made to DNVGL-OS-C201.

1.1.2 A DDF platform is categorised as having a relatively large draught when compared to ship shaped, semi-submersible or TLP type units. This large draught is mainly introduced to obtain sufficiently high "Eigen period" in heave and reduced wave excitation in heave such that resonant responses in heave can be omitted or minimised.

1.1.3 A DDF can include a Spar, deep draught semi (DDS) or other deep draught floating units. Spar can consist of multi-vertical columns, single column with or without moonpool (e.g. classic, truss and cell spar). A DDS can consist of multi-vertical columns with ring pontoon with or without a heave damping structure.

1.1.4 The unit is usually kept in position by a passive mooring system. The mooring system may also be activated in case of horizontal movements above wells (drilling riser placed vertically above well), or other needed operational adjustments (e.g. reduction in VIM responses).

1.1.5 The deck or topside solution may be modular, or integrated type.

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

1.2 Objectives

The objectives of the standard are to:

— provide an internationally acceptable standard for structural design of DDF's
— serve as a contractual reference document for suppliers, yards and owners
— serve as guidance for designers, suppliers, owners and regulators
— specify procedures and requirements for units and installations subject to DNV GL verification and classification services.

1.3 Scope and application

1.3.1 The DDF unit may be applied for drilling, production, export and storage.

1.3.2 A DDF unit may be designed to function in different modes, typically operational (inclusive horizontal movement above wells) and survival. Limiting design criteria when going from one mode of operation to another shall be established.

1.3.3 The DDF unit should also be designed for transit relocation, if relevant.

1.3.4 For novel designs, or unproven applications of designs where limited, or no direct experience exists, relevant analyses and model testing shall be performed which clearly demonstrate that an acceptable level of safety can be obtained, i.e. safety level is not inferior to that obtained when applying this standard to traditional designs.

1.3.5 Requirements concerning mooring are given in DNVGL-OS-E301 and riser systems are given in DNV-OS-F201.

1.3.6 Requirements related to floating stability are given in DNVGL-OS-C301.

1.3.7 For application of this standard for classification, see Ch.3.

1.3.8 For application of this standard under non-operational phases see [5].

2 Normative references

The offshore standards given in Table 1 are referred to in this standard.

Table 1 DNV GL offshore standards

Reference	*Title*
DNVGL-OS-A101	Safety principles and arrangement
DNVGL-OS-B101	Metallic materials
DNVGL-OS-C101	Design of offshore steel structures, general - LRFD method
DNVGL-OS-C103	Structural design of column stabilised units - LRFD method
DNVGL-OS-C301	Stability and watertight integrity
DNVGL-OS-C401	Fabrication and testing of offshore structures
DNVGL-OS-E301	Position mooring
DNVGL-OS-E401	Helicopter decks
DNV-OS-F201	Dynamic Risers
DNV-OS-H101	Marine Operations General

3 Informative references

The documents listed in Table 2 include acceptable methods for fulfilling the requirements in the standard and may be used as a source of supplementary information.

Table 2 DNV GL and DNV recommended practices, classification notes and other references

Reference	*Title*
DNVGL-RP-C201	Buckling strength of plated structures
DNV-RP-C202	Buckling Strength of Shells
DNVGL-RP-C203	Fatigue strength analysis of offshore steel structures
DNV Classification Notes 30.1	Buckling Strength Analysis of Bars an Frames, and Spherical Shells
DNV-RP-C205	Environmental Conditions and Environmental Loads
DNV Classification Notes 30.6	Structural Reliability Analysis of Marine Structures
DNV-RP-F205	Global Performance Analysis of Deepwater Floating Structures
SNAME 5-5A	Site Specific Assessment of Mobile Jack-Up Units
API RP 2T	Planning, Designing and Constructing Tension Leg Platforms
API RP 2FPS	Recommended Practice for Planning, Designing and Constructing Floating Production Systems
API RP 2SK	Design and Analysis of Station keeping Systems for Floating Structures
API RP 2A	Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms—Working Stress Design
API BUL 2TD	Guidelines for Tie-downs on Offshore Production Facilities for Hurricane Season
ISO 19904-1	Petroleum and natural gas industries – Floating Offshore Structures Part 1: Monohulls, Semi-submersibles and Spars
N-004	NORSOK - Design of Steel Structures

4 Definitions

4.1 Verbal forms

Table 3 Verbal forms

Term	*Definition*
shall	verbal form used to indicate requirements strictly to be followed in order to conform to the document
should	verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required
may	verbal form used to indicate a course of action permissible within the limits of the document
can	can-requirements are conditional and indicate a possibility to the user of the standard

4.2 Terms

Table 4 Terms

Term	*Definition*
cell spar	a classic spar with main column composed of several cylinders (cells)
classic spar	a deep draft floater (DDF) with shell type cylindrical hull structure
collision ring	inner bulkhead in the splash zone area with the purpose of providing a second barrier in case of damage or rupture to outer hull skin
damping plates	horizontal decks or plates introduced in the truss area of e.g. a truss spar with the purpose of creating additional heave damping and increased added mass in heave
dynamic up-ending	a process where seawater is filled or flooded into the bottom section of a horizontally floating DDF/Spar hull and creating a trim condition and subsequent water filling of hull or moonpool and dynamic upending to bring the hull in vertical position
hard tank area	usually upper part of the hull providing sufficient buoyancy for a DDF/Spar unit
heave damping structure	structure to increase added mass in heave and reduce the vertical motions of the deep draught semi units (DDS)
heave plates	horizontal stiffened plates in the truss area to increase added mass in heave and reduce the vertical motions of the spar
high frequency (HF) response	response at frequency higher than the wave frequency
launching	similar to a traditional launching of a jacket Applicable for a truss or classic spar.
low frequency (LF) responses	defined as DDF/Spar rigid body motions at, or near system “Eigen periods” which are normally well below the dominant wave frequency
pre-upending	the phase prior to dynamic upending
P-delta effect	global bending or shear effects in DDF/Spar units due to relatively high roll or pitch angles in harsh environment
riser frame	framed steel structures installed at different vertical elevations along the hull or moonpool in order to separate the different risers
roll, pitch, yaw	rotational modes around surge, sway and heave axes, respectively
skirt area	stiffened single shell area below hard tank for a classic spar
soft tank area	bottom section of a spar concept Flooded during upending and used as storage of potential fixed ballast.
spar	a deep draught floater consisting of a single column type structure which may be either classic, truss, or cell spar
strake	usually helical triangular shaped section plated structures welded to outer hull with the purpose of reducing the VIM motion of DDF/Spar hull due to current (mainly) Also the term VIV suppression strake is used sometimes.
surge, sway, heave	translatory displacements of DDF/Spar in horizontal planes (surge, sway) and vertical plane (heave)

Table 4 Terms (Continued)

Term	*Definition*
truss spar	spar with a truss structure below the hard tank and above the soft tank areas
VMO Standard	all the DNV offshore standards covering marine operation, i.e. DNV-OS-H101, DNV-OS-H102 and DNV-OS-H201 through DNV-OS-H206
vortex induced motions (VIM)	the rigid body global motion of the DDF/Spar due to vortex shedding
vortex induced vibrations (VIV))	the in-line and transverse (cross) oscillation of slender structures like risers, umbilicals, mooring lines, or other tubular structure in a current, induced by the periodic shedding of vortices
wave frequency (WF) response	DDF/Spar linear rigid body motions at the dominating wave periods

4.3 Abbreviations

The abbreviations given in Table 5 are used in this standard.

Table 5 Abbreviations

Abbreviation	*In full*
ALS	accidental limit states
DDF	deep draught floater
DDS	deep draught semi-submersible unit
DFF	design fatigue factors
FLS	fatigue limit states
GOM	Gulf of Mexico
HF	high frequency
OS	offshore standard
LF	low frequency
LRFD	load and resistance factor design
NDT	non-destructive testing
QTF	quadratic transfer function
RAO	response amplitude operator
ROV	remote operated vehicle
RP	recommended practice
SCR	steel catenary riser
TTR	top tensioned risers
ULS	ultimate limit states
VIM	vortex induced motions
VIV	vortex induced vibrations
VMO	Veritas marine operations
WF	wave frequency
WSD	working stress design

4.4 Symbols

4.4.1 The following Latin symbols are used:

x_D load effect
D number of years
$F_X(x)$ long-term peak distribution
H_s significant wave height
N_D total number of load effect maxima during D years
T_p wave period

4.4.2 The following Greek symbols are used:

$\gamma_{f,D}$ load factor for deformation loads
$\gamma_{f,E}$ load factor for environmental loads
$\gamma_{f,G,Q}$ load factor for permanent and functional loads
γ_m material factor

5 Non-operational phases

5.1 General

5.1.1 In general the unit shall be designed to resist relevant loads associated with conditions that may occur during all phases of the life-cycle of the unit. Such phases may include:

- fabrication
- load-out and sea fastening
- sea transportation (wet or dry)
- assembly of hull main sections including lifting
- installation (dynamic upending, launching, deck mating, jacking)
- relocation (drilling mode, new site)
- de-commissioning.

5.1.2 Structural design covering marine operations and construction sequences shall be undertaken in accordance with DNVGL-OS-C101 for LRFD method or DNVGL-OS-C201 for WSD method.

5.1.3 Marine operations may be undertaken in accordance with the requirements stated in the VMO standards (ref. [4]).

5.1.4 All marine operations shall, as far as practicable, be based upon well proven principles, techniques, systems and equipment and shall be undertaken by qualified, competent personnel possessing relevant experience.

5.1.5 Structural responses resulting from one temporary phase condition (e.g. construction or assembly, or transportation) that may influence design criteria in another phase shall be clearly documented and considered in all relevant design workings.

5.2 Fabrication

5.2.1 The planning of fabrication sequences and the methods of fabrication shall be performed. Loads occurring in fabrication phases shall be assessed and, when necessary, the structure and the structural support arrangement shall be evaluated for structural adequacy.

5.2.2 Major lifting operations shall be evaluated to ensure that deformations are within acceptable levels, and that relevant strength criteria are satisfied.

5.2.3 Fabrication residual; stresses due to welding and fitting must be within acceptable tolerance (see DNVGL-OS-C401) or otherwise accounted for in design analysis.

5.3 Mating

All relevant load effects incurred during mating operations shall be considered in the design process. Particular attention should be given to hydrostatic loads imposed during mating sequences.

5.4 Sea transportation

5.4.1 A detailed transportation assessment shall be undertaken which includes determination of the limiting environmental criteria, evaluation of intact and damage stability characteristics, motion response of the global system and the resulting, induced load effects. The occurrence of slamming loads on the structure and the effects of fatigue during transport phases shall be evaluated when relevant. Wind induced vortex shedding should be evaluated for truss and deck tubular members.

Guidance note:
Guidance on sea transportation is available in the DNV VMO standards.

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5.4.2 Satisfactory compartmentation and stability during all floating operations shall be ensured.

5.4.3 All aspects of the transportation, including planning and procedures, preparations, sea-fastenings and marine operations should comply with the requirements of the warranty authority.

5.5 Installation

5.5.1 Installation procedures of foundations (e.g. piles, suction anchor or gravity based structures) shall consider relevant static and dynamic loads, including consideration of the maximum environmental conditions expected for the operations.

5.5.2 For novel installation activities, relevant model testing should be considered.

5.5.3 The loads induced by the marine spread mooring involved in the operations, and the forces exerted on the structures utilised in positioning the unit, such as fairleads and pad-eyes, shall be considered for local strength checks.

Guidance note:
Guidance on offshore installation is available in the DNV VMO standards.

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5.6 Decommissioning

Abandonment of the unit shall be planned for in the design stage.

CHAPTER 2 TECHNICAL CONTENT

SECTION 1 STRUCTURAL CATEGORISATION, SELECTION OF MATERIAL AND EXTENT OF INSPECTION

1 Introduction

1.1 General

1.1.1 Selection of materials and inspection principles shall be based on a systematic categorisation of the structure according to the structural significance and the complexity of the joints or connections as given in DNVGL-OS-C101 Ch.2 Sec.3.

1.1.2 In addition to in-service operational phases, consideration shall be given to structural members and details utilised for temporary conditions, e.g. fabrication, lifting arrangements, towing and installation arrangements, etc.

1.1.3 The structural application categories are determined based on the structural significance, consequences of failure and the complexity of the joints. The structural application category set the selection of steel quality and the extent of inspection for the welds.

1.1.4 The steel grades selected for structural components are to be related to calculated stresses and requirements for toughness properties and are to be in compliance with the requirements given in the DNVGL-OS-B101.

1.1.5 Special consideration shall be given to ensure the appropriate inspection category for welds with high utilisation in fatigue if the coverage with standard local area allocation is insufficient.

1.1.6 Examples of typical structural categories applicable to DDF are stated in [2]. These examples provide minimum requirements and are not intended to restrict the designer in applying more stringent requirements should such requirements be desirable.

2 Structural categorisation

Application categories for structural components are defined in DNVGL-OS-C101 Ch.2 Sec.3. Structural members of a DDF unit are grouped as follows: However if a special design warrants redefining the categories, the same shall be discussed and agreed.

Special category

a) Portions of deck plating, heavy flanges, and bulkheads within the structure which receive major concentrated loads.
b) External shell structure (plating and stiffeners) in way of highly stressed connections (higher than 85% of the allowable i.e. at 0.85 usage factor) to the deck structure.
c) Major intersections of bracing members.
d) External brackets, portions of bulkheads, and frames which are designed to receive concentrated loads at intersections of major structural members.
e) Highly stressed elements of anchor line fairleads, crane pedestals, flare boom, etc. and their supporting structure.

For Spars, these special structural categories include the hard tank to deck leg and to truss leg connections, the truss to soft tank connections, the heave plate to truss leg connections, truss tubular joints, the fairlead and chain jack foundations, and the riser frame to hard tank connections.

For DDS units, these special structural categories include "through" material used at connections of vertical columns, upper platform decks and upper or lower hulls which are designed to provide alignment and adequate load transfer, i.e. the pontoon to column connection, column to deck connection, any brace to column connections and connection of heave damping structure to main hull structure.

Primary category

a) Deck plating, heavy flanges, transverse frames, stringers, and bulkhead structure that do not receive major concentrated loads (not categorized as special).
b) Moonpool shell.
c) External shell structure of vertical columns, lower and upper hulls, and diagonal and horizontal braces.
d) Bulkheads, decks, stiffeners and girders that provide local reinforcement or continuity of structure in way of intersections, except areas where the structure is considered special application.
e) Main support structure of heavy substructures and equipment, e.g. anchor line fairleads, cranes, drill floor substructure, lifeboat platform, thruster well and helicopter deck.

For Spars, primary structures include hull shell, top spar deck and bottom deck structures, hull ring frames, longitudinal stringers and web frames, all radial bulkheads, truss chords and brace members, heave plate and soft tank structures.

For DDS units, the heave damping structure is considered primary structure.

Secondary category

a) Upper platform decks, or decks of upper hulls except areas where the structure is considered primary or special application.
b) Bulkheads, stiffeners, flats or decks and girders, diagonal and horizontal bracing, which are not considered as primary or special application.
c) Non-watertight bulkheads internal outfitting structure in general, and other non-load bearing components.
d) Deckhouses.

For Spars, secondary structures include; e.g., all internal hull flats, soft tank shell and internal bulkheads with no pressure differential, and hull and heave plate stiffeners and soft tank stiffeners.

3 Material selection

3.1 General

3.1.1 Material specifications shall be established for all structural materials utilised in a DDF unit. Such materials shall be suitable for their intended purpose and have adequate properties in all relevant design conditions. Material selection shall be undertaken in accordance with the principles given in DNVGL-OS-C101.

3.1.2 When considering criteria appropriate to material grade selection, adequate consideration shall be given to all relevant phases in the life cycle of the unit. In this connection there may be conditions and criteria, other than those from the in-service, operational phase, that may govern the design requirements with respect to the selection of material. (Such criteria may, for example, be design temperature and/or stress levels during marine operations.)

3.1.3 In structural cross-joints essential for the overall structural integrity where high tensile stresses are acting normal to the plane of the plate, the plate material shall be tested to prove the ability to resist lamellar tearing (Z-quality).

3.1.4 Material designations are defined in DNVGL-OS-C101.

3.2 Design temperature

3.2.1 External structures above the inspection waterline are to be designed for service temperatures down to the lowest mean daily temperature for the area(s) where the unit is to operate.

3.2.2 External structures below the inspection waterline need normally not be designed for service temperatures lower than 0°C.

3.2.3 Internal structures are assumed to have the same service temperature as the adjacent external structure if not otherwise documented.

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

4 Inspection categories

4.1 General

4.1.1 Welding, and the extent of non-destructive examination during fabrication, shall be in accordance with the requirements stipulated for the structural categorisation designation as defined in DNVGL-OS-C101 Ch.2 Sec.3.

4.1.2 Inspection categories determined in accordance with DNVGL-OS-C101 provide requirements for the minimum extent of required inspection. When considering the economic consequence that repair during in-service operation may entail, for example, in way of complex connections with limited or difficult access, it may be considered prudent engineering practice to require more demanding requirements for inspection than the required minimum.

4.1.3 When determining the extent of inspection and the locations of required NDT, in additional to evaluating design parameters (for example fatigue utilisation), consideration should be given to relevant fabrication parameters including:

— location of block (section) joints
— manual versus automatic welding
— start and stop of weld etc.

5 Guidance to minimum requirements

Figure 1 to Figure 5 illustrate minimum requirements for selection of the structural category for one example of structural configurations of a DDF unit. The indicated structural categorisation should be regarded as guidance of how to apply the recommendations in DNVGL-OS-C101.

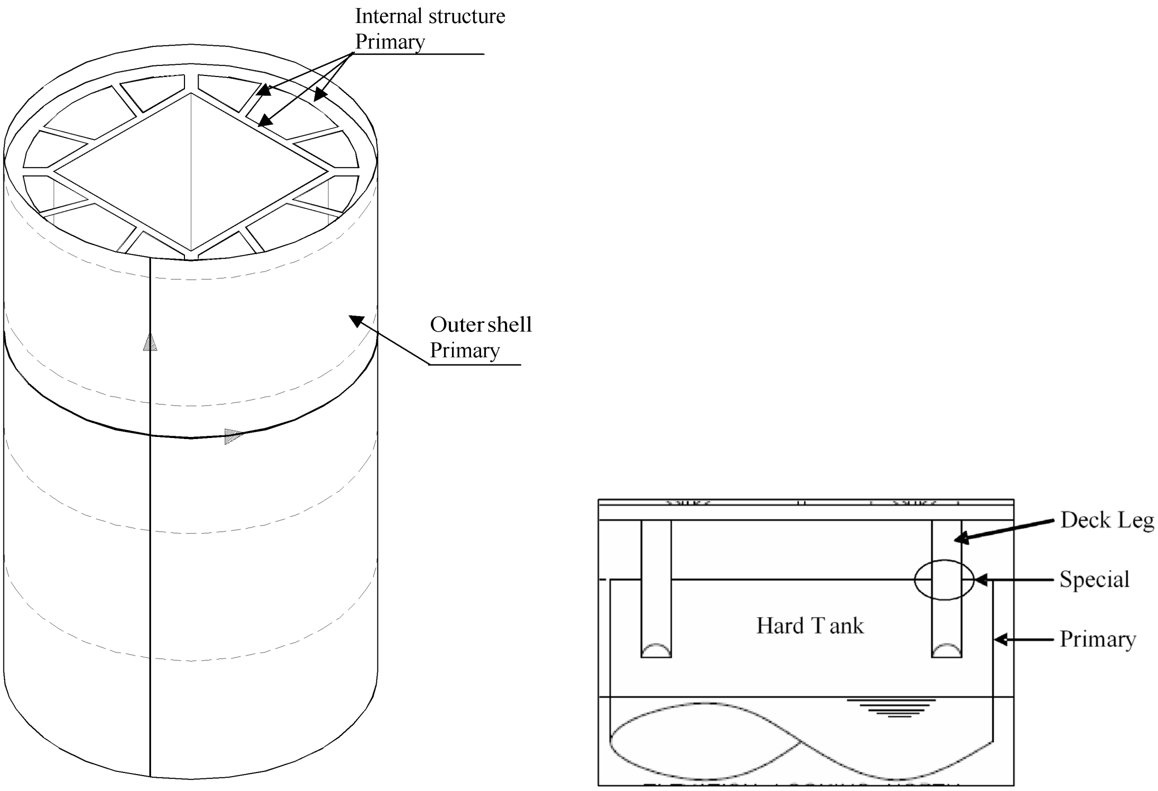


Figure 1 Example of structural categorisation (Special and Primary Steel) in the hard tank area of a typical Spar

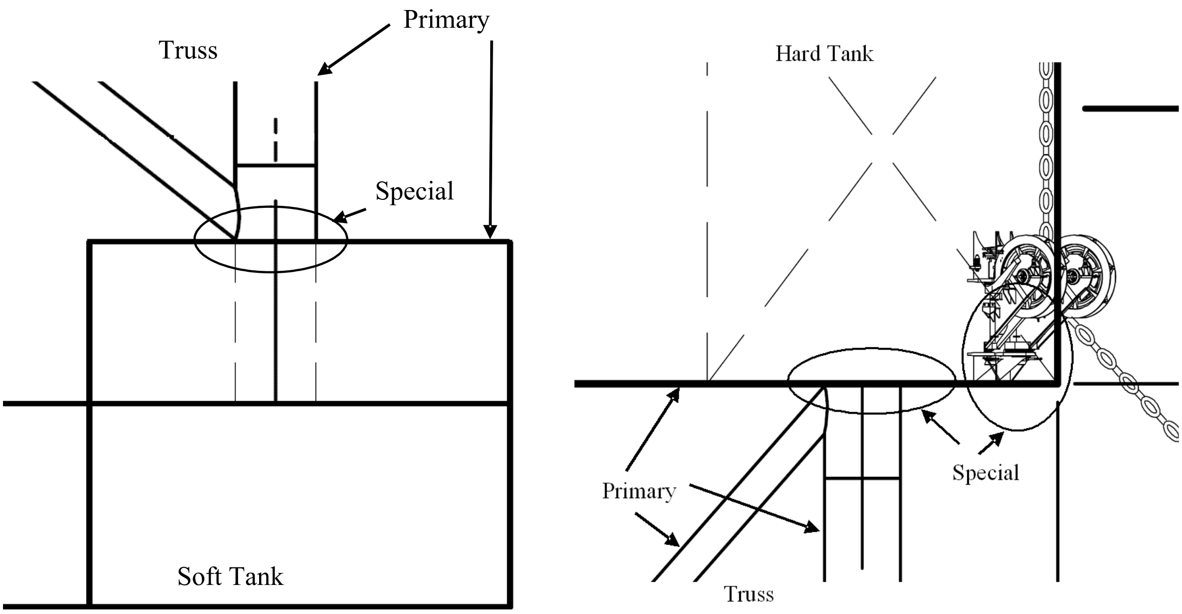
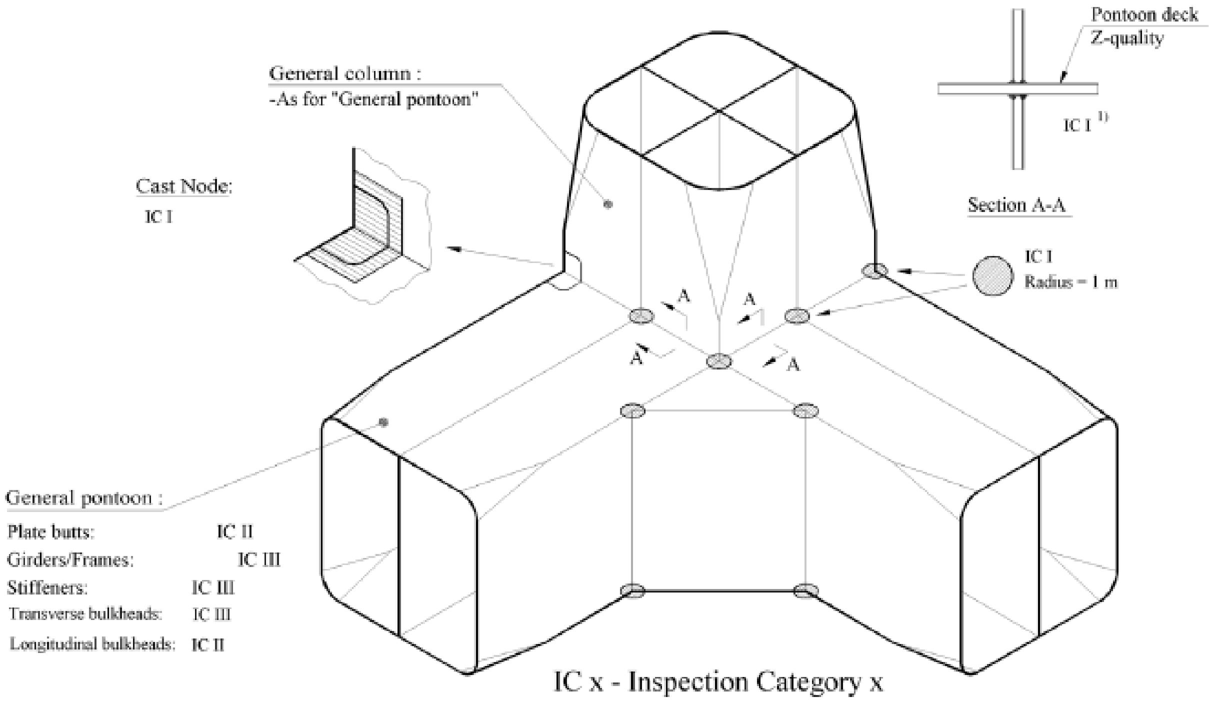
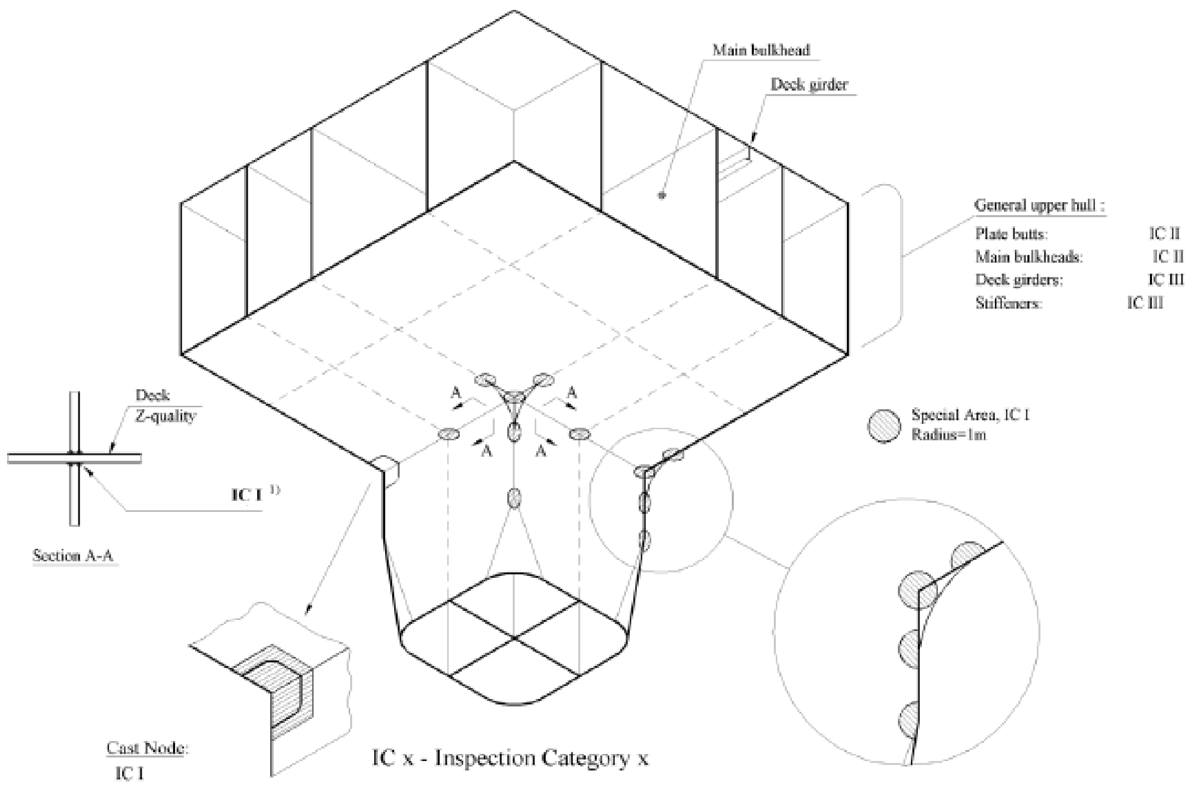


Figure 2 Example of structural categorisation (Special and Primary Steel) in the soft tank/hard tank and Truss interface of a typical Spar



1) This detail is normally fatigue critical within primary area and hence the inspection category is increased from II to I.

Figure 3 Example of structural categorisation of a column and pontoon connection of a typical Deep Draught Semi



1) This detail is normally fatigue critical, and hence the inspection category is increased from II to I.

Figure 4 Example of structural categorisation of deck and column connection of a typical Deep Draught Semi

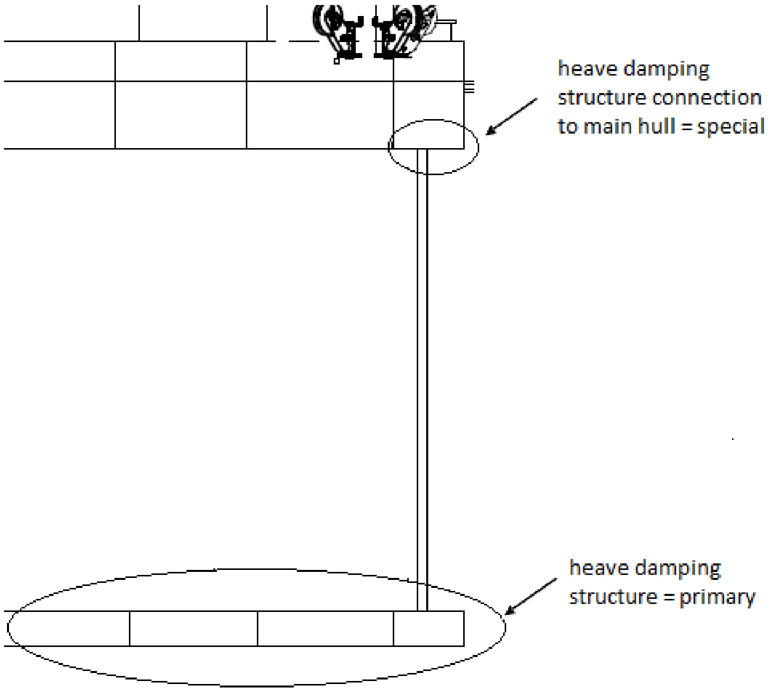


Figure 5 Example of structural categorisation of heave damping structure of a typical DDF

SECTION 2 DESIGN LOADS

1 General

1.1 Objective

The objective of this section is to provide additional load provisions to DDF units not covered within DNVGL-OS-C101.

1.2 Application

Load descriptions are intended to cover operational as well as non-operational phases for the three limit states (ULS, FLS and ALS).

2 Permanent loads

The type and use of permanent ballast (e.g. within soft tank of DDF units) for stability reasons must be carefully evaluated with respect to long term effects related to corrosion, wash out etc.

3 Variable functional loads

3.1 Hydrostatic pressures

3.1.1 *For Spars*, all relevant combinations of tank filling in the hard tank for the installation and operational phases shall be taken into account in design.

3.1.2 *For Deep Draught Semis*, all relevant combinations of tank filling in the columns, pontoons and/or heave damping structure in the installation and operational phases shall be taken into account in design.

3.1.3 Hydrostatic or hydrodynamic differential pressures acting on the hull or buoyancy tanks during launch and upending sequences, mating, ballasting sequences, whichever is relevant, shall be analysed or determined and taken into account in design of the hull.

3.2 Differential pressures

All relevant combinations of differential pressures due to filling of ballast tanks, produced fluids, compressed air etc. shall be taken into account in design.

4 Environmental loads

4.1 Environmental conditions

4.1.1 If sufficient environmental data is available, environmental joint probability models may be developed and applied in the design of DDF units. This is especially important in regions with e.g. high loop current and frequently occurring hurricanes.

4.1.2 In geographical areas with hurricane activity, special considerations have to be made with respect to the selection of relevant sea states to be applied in design of the unit. (E.g. new Meteocean criteria (API BUL.INT 2/- MET) with updated GOM criteria published in May 2007).

4.1.3 Due to the geometry (deep draught and large volume) of DDF units the current loading may be of high importance for design of mooring or riser systems in relation to vortex induced vibrations (VIV) for e.g. hull and risers. Hence attention must be given to the description of magnitude and direction of current with depth.

4.2 Determination of characteristic loads

4.2.1 Calculation of characteristic hydrodynamic loads may be carried out according to DNV-RP-C205.

4.2.2 Hydrodynamic model tests should be carried out to:

— confirm that no important hydrodynamic features have been overlooked (for new type of units, environmental conditions, adjacent structures, Mathieu instability etc.)
— support theoretical calculations when available analytical methods are susceptible to large uncertainties (e.g. in evaluating the need for VIM suppression strakes, on DDF hull)
— verify theoretical methods or models on a general basis.

4.2.3 Wind tunnel tests should be performed when:

— wind loads are significant for overall stability, motions or structural response
— there is a danger of dynamic instability.

4.2.4 Models applied in model tests shall be sufficient (reasonable scale and controllable scaling effects) to represent the actual unit. The test set-up and registration system shall provide a sound basis for reliable and repeatable interpretations.

4.2.5 A correlation report (tests and calculations) shall be prepared for validation purposes (design documentation).

4.3 Hydrodynamic loads

4.3.1 Resonant excitation (e.g. internal moonpool resonance, sloshing and roll/pitch resonance) shall be carefully evaluated. Wave on deck via moonpool has to be considered for DDF concepts with relatively short distances between moonpool and the outer wave active zone.

4.3.2 If hydrodynamic analyses of a DDF are performed with the moonpool 'sealed' at the keel level it must be validated that the results are equivalent to 'open' DDF hydrodynamic analyses. Special focus should be placed on the heave motion prediction (important for riser system) by using consistent added mass, total damping and excitation forces such that the Eigen period and response in heave can be determined correctly.

4.3.3 In case of a DDF with damping and added mass heave plates and where it is possible that resonant, or near resonant heave motion may occur, the theoretical predictions should be validated against model test results.

4.3.4 If VIM suppression devices (e.g. spiral strakes) are attached to the hull, the increased loads (drag, inertia) must be taken into account. This applies to the operational as well as non-operational phases.

4.3.5 Air gap and green water (Wave-on-Deck) are to be considered. (See DNVGL-OS-C101 or DNVGL-OS-C201).

4.3.6 Air gap is measured to the bottom of the deck structure.

4.3.7 Simulation of loads and responses on risers in the moonpool area shall be carried out according to a recognised code.

Guidance note:
DNV-OS-F201 may be applied for this purpose.

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4.4 Combination of environmental loads

4.4.1 In areas with high current (e.g. loop current, or high subsurface current) special attention must be given to the joint occurrence of wind, waves and current. Joint probability models (loads and load effects) are recommended.

4.4.2 If more accurate data are not available, the combination of environmental loads may be taken according to DNVGL-OS-C101 Ch.2 Sec.2.

SECTION 3 LOAD EFFECTS

1 General

1.1 Objective

The objective of this section is to provide additional load effect provisions to DDF units not covered within DNVGL-OS-C101.

1.2 Application

Load effect descriptions are intended to cover operational as well as non-operational phases for the three limit states (ULS, FLS and ALS).

2 Load effect analysis in the operational phase

2.1 General

2.1.1 Global dynamic motion response analysis taking into account loads from wind (static and gust), waves (wave frequency and low frequency) and current shall be performed. Time domain analysis is the preferred option as opposed to frequency domain type analysis. However, frequency domain analysis may be acceptable if proper justification is demonstrated. Reference is made to DNV-RP-F205 for detailed description of global performance analysis procedures.

2.1.2 Coupled analyses may be performed for DDF units in order to determine the coupling effects due to the presence of mooring and risers. These coupled analyses mainly provide viscous damping estimates for slowly varying motions (all six degrees of freedom). When utilising viscous damping estimates from coupled analyses the actual riser installation program must be taken into consideration.

2.1.3 The simulation length for determination of the different load effects must be sufficient such that reliable extreme response statistics can be obtained.

Guidance note:
Combined loading.

Common practice to determine extreme responses has been to expose the dynamic system to multiple stationary design environmental conditions. Each design condition is then described in terms of a limited number of environmental parameters (e.g. H_s, T_p) and a given seastate duration (3 to 6 hours). Different combinations of wind, wave and current with nearly the same return period for the combined environmental condition are typically applied.

The main problem related to design criteria based on environmental statistics is that the return period for the characteristic load effect is unknown for non-linear dynamic systems. This will in general lead to an inconsistent safety level for different design concepts and failure modes.

A more consistent approach is to apply design based on response statistics. Consistent assessment of the D-year load effect will require a probabilistic response description due to the long-term environmental loads on the system. The load effect with a return period of D-year, denoted x_D, can formally be found from the long-term load effect distribution as:

$F_X(x_D)$ = $1 - 1/N_D$

N_D = total number of load effect maxima during *D* years

$F_X(x)$ = long-term peak distribution of the (generalised) load effect

The main challenge related to this approach is to establish the long-term load effect distribution due to the non-linear behaviour. Design based on response statistics is in general the recommended procedure and should be considered whenever practicable for consistent assessment of characteristic load effects. Further details may be found in Appendices to DNV-OS-F201.

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2.2 Global bending effects

2.2.1 Global bending and shear forces along the length of the structure due to environmental load effects shall be determined. This applies to first order wave effects, as well as P-delta effects due to platform heel or tilt.

2.2.2 Global bending and shear forces in the hull will be influenced by the non-linear restoring effect from the mooring system. This additional load effect shall be analysed and taken into account in design of the hull structure.

3 Load effect analysis in the non operational phases

3.1 General

3.1.1 All temporary phases shall be carefully evaluated and sufficient level and amount of analyses shall be performed according to this standard. Further details regarding non-operational conditions may be found in DNV's VMO standards.

3.1.2 Relevant model testing should be considered for novel installation procedures.

3.1.3 Stability check and ballast capacity design shall include assessment of relevant load conditions during transport and installation.

3.2 Load-out and transportation

3.2.1 Hull/deck stresses during load-out are to be evaluated and accounted for in the design. Possible skid beam foundation settlement should be minimized or avoided. Local sea fastening stresses are to be kept within acceptable design limits.

3.2.2 In case of wet tow in harsh environment (e.g. overseas), model tests shall be performed as a supplement to motion response analyses. Non-linear effects (e.g. slamming, global bending or shear, green seas) shall be taken into account.

3.2.3 Motion response analyses shall be performed for dry transports on e.g. heavy lift vessel, or barge. Special attention shall be made to:

— roll motions (roll angles, accelerations, viscous roll damping)
— slamming pressures and areas and structural responses due to slamming
— global strength (vessel, DDF/Spar unit)
— strength of sea-fastening
— wind VIV of slender truss members.
— stability, overhang.

3.3 Launching

Launching may be an alternative way of installation or upending a Spar (e.g. truss spar). Model testing of the launch process may be required if there is limited or no experience with such operations for similar concepts.

3.4 Deck mating

3.4.1 Offshore installation of deck structure and modules will require refined analyses in order to determine the governing responses. This applies to lifting operations as well as float-over operations with barge. Important factors are limiting environmental criteria, impact responses and floating stability requirements.

3.4.2 Floating concepts ("jack-up") utilising jacking of legs to desired draught and subsequent deballasting to obtain sufficient air-gap, shall be carefully evaluated or analysed with respect to limiting environmental criteria.

3.5 Upending

3.5.1 Pre-upending phases shall be analysed with respect to global bending moments and shear forces in the hull. In case that wave load effects in this pre-upending phase may be relevant, this shall be analysed and taken into account.

3.5.2 In case of dynamic upending, analyses shall be performed in order to determine global and local load effects in the DDF/Spar unit and its appurtenances.

3.5.3 Hydrostatic or hydrodynamic differential (outside/inside) pressures during dynamic upending shall be determined and further used in design of the hull structure.

3.5.4 Model testing of the dynamic upending may be avoided if the applied simulation software has been validated against similar or relevant operations demonstrating good correlation.

3.5.5 In case of lift assisted upending offshore, the limiting environmental criteria must be carefully selected. Dynamic analyses of the system (i.e. lift vessel, lifting gear, Spar unit) will be required in order to determine responses in lifting gear and DDF/Spar unit.

SECTION 4 ULTIMATE LIMIT STATES (ULS)

1 General

1.1 Objective

1.1.1 General considerations in respect to methods of analysis and capacity checks of structural elements are given in DNVGL-OS-C101 for LRFD and DNVGL-OS-C201 for WSD.

1.1.2 This section applies for the hull and deck or modules and operational as well as non-operational phases.

1.1.3 The LRFD format shall be used when the ULS capacity of the structure is checked. Two combinations shall be checked, a) and b). The load factors are defined in DNVGL-OS-C101 Ch.2 Sec.1 [4.4] and values are given in Table 1.

Table 1 Load factors – ULS

Combination of design loads	*Load categories*		
	Permanent and variable functional loads, $\gamma_{f,G,Q}$	*Environmental loads,* $\gamma_{f,F}$	*Deformation loads,* $\gamma_{f,D}$
a)	1.3 [1)]	0.7	1.0
b)	1.0	1.3	1.0

1) If the load is well defined e.g. masses or functional loads with great confidence, no possible overfilling of tanks etc. the coefficient may be reduced to 1.2.

1.1.4 The loads shall be combined in the most unfavourable way, provided that the combination is physically feasible and permitted according to the load specifications. For permanent loads, a load factor of 1.0 in load combination a) shall be used where this gives the most unfavourable response. Other considerations for the partial coefficients and design loads are given in DNVGL-OS-C101 Ch.2 Sec 1 and 2, respectively.

1.1.5 The material factor γ_m for ULS yield check should be 1.15 for steel. The material factor γ_m for ULS buckling check is given in DNVGL-OS-C101 Ch.2 Sec.4.

1.2 Methodology and acceptance criteria

The LRFD methodology and the acceptance criteria for the ULS check are given in DNVGL-OS-C101.

2 Hull

2.1 Operational phase

2.1.1 For global structural analysis, a complete three-dimensional structural model of the unit is required. This may be a complete shell type model, or a combined shell or space-frame model.

2.1.2 Additional detailed finite element analyses may be required for complex joints and other complicated structural parts especially at interfaces and connections to determine the local stress distribution more accurately. Typical examples being: hull interface with mooring system, hard tank area, column and brace connections, strake terminations or interactions, deck and hull connections, hull interface with riser system, pontoon to column connection, brace to column connection, column to deck connection.

Guidance note:

For Spars, in order to be able to assess the effect of all possible tank filling configurations, a local finite element model covering the hard tank area may be utilised. Only those tanks used in the normal operation of the platform should as a minimum be modelled. The stresses from a local finite element model should be superimposed to global stresses.

For DDS units, reference is made to DNVGL-OS-C103.

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2.1.3 The additional global bending and shear due to P-delta and mooring restoring effects are to be combined with first order wave effects in a consistent way.

2.1.4 The same applies to combining the loads from the risers on riser frames in the moonpool and transfer into the hull structure. Horizontal forces as well as vertical (friction from riser system) shall be taken into account.

2.1.5 If VIV suppression devices (e.g. strakes) are installed, both local (direct wave or current loads) and global bending effects should be considered in design of the suppression devices.

2.2 Non-operational phases

2.2.1 Finite element analyses are to be performed for long international water wet tow and dry tow in harsh environment.

2.2.2 For dry tow this implies that the complete structural system (hull sections, sea-fastening, transport vessel) shall be modelled such that reliable stress-distributions can be obtained.

2.2.3 For wet tow in harsh environment special emphasis must be put on the simulation or modelling of the hydrodynamic wave pressures or accelerations acting on the wet hull structure. Further, the non-linear hogging and sagging bending or shear effects due to the shape of the hull should be properly simulated or accounted for in the design.

2.2.4 *For Spars*, the level or amount of finite element analyses for the upending process needs to be evaluated. As a minimum, the following considerations shall be made:

a) Operational Global bending moments and shear forces are to be compared (location and level) with those for pre-upending and dynamic upending.
b) Possibilities for local and global buckling (e.g. skirt area for a classic spar) due to global load effects and lateral differential pressures needs to be assessed/analysed.

2.2.5 *For DDS units*, the finite element analysis shall cover all critical transient phases during installation.

3 Deck or topside

3.1 Operation phase

3.1.1 Structural analysis of deck structure shall, in general, follow the same principles as outlined for the hull.

3.1.2 Horizontal accelerations at deck level due to wave loading will be high for some DDF units in harsh environment. Detailed finite element analyses of the deck and hull connections shall be performed in such instances.

3.2 Non-operational phases

Typical non-operational phases as fabrication, transportation and installation of deck and topside modules shall be assessed and analysed to a sufficient level such that the actual stress level can be determined and used in the design checks.

4 Minimum scantlings

Minimum scantlings for plate, stiffeners and girders are given in DNVGL-OS-C101 Ch.2 Sec.4.

SECTION 5 FATIGUE LIMIT STATES (FLS)

1 General

1.1 General

1.1.1 The objective of this section is to provide supplemental guidance related to FLS design as outlined in DNVGL-OS-C101 Ch.2, Sec.5.

1.1.2 This section applies for the hull and deck or modules and major structural interfaces for operational as well as non-operational phases.

1.1.3 In general, all significant stress fluctuations (operational and temporary phases) which contribute to fatigue damage in parts of the unit shall be taken into account for the FLS condition.

1.1.4 Criteria related to DFF's are given in DNVGL-OS-C101 Ch.2 Sec.5.

1.1.5 DNVGL-RP-C203 presents recommendations in relation to fatigue analyses based on fatigue tests and fracture mechanics.

2 Hull

2.1 Operation phase

2.1.1 First order wave loads will usually be the dominating fatigue component for the hull. The long term distribution of wave induced stress fluctuations need to be determined with basis in the same type of load effect and finite element analyses as for ULS.

Guidance note:
Early phase evaluation or analysis of fatigue may incorporate modelling the hull as a beam with associated mass distribution and simulation of wave loads according to Morison formulation, or preferably, performing a radiation or diffraction analysis.

Final documentation related to first order wave induced fatigue damage should incorporate a stochastic approach. This implies establishing stress transfer functions, which are combined with relevant wave spectra (scatter diagram) in order to obtain long-term distribution of stresses. The stress transfer functions should be obtained from finite element analyses with appropriate simulation of wave loads (radiation/diffraction analysis). The P-delta effect due to platform roll and pitch shall be taken into account.

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2.1.2 As for ULS, the P-delta effect due to platform roll or pitch shall be taken into account. This implies that both first order and second order, slowly varying roll or pitch motions need to be considered and taken into account if contributing to fatigue damage in the hull.

2.1.3 For special fatigue sensitive areas, local stress concentrations shall be determined by detailed finite element analyses.

2.1.4 Typical fatigue sensitive areas for DDF units include:

— hull and deck connections
— collision ring area
— hull and deck and stiffener connections at location of peak wave induced global bending moments
— hull and mooring system interface
— hard tank area
— column and brace connections
— strake and hull connections and strake terminations
— riser frame/support and hull connections
— openings in main hull
— flare tower
— mooring and export/import SCR connections
— hard tank and truss connections
— tubular joints

— column to deck connections
— column to pontoon connections
— tensioner support structure.

2.1.5 Fatigue analyses shall be performed to check that the hull strakes have sufficient fatigue lives. Relative motions between the hull and disturbed wave kinematics around strakes must be properly taken into account. Hydrodynamic pressures from a radiation/diffraction analysis in combination with a Morison formulation (inertia and drag) will be sufficient to describe the environmental loads on the strakes.

2.1.6 VIM load effects from mooring system (global hull in-line and cross-flow motions) into the fairlead or hull areas shall be outlined and taken into account if significant. The same applies to VIV load effects from riser system into the riser frame or hull areas.

2.1.7 For mooring fairlead/riser porch analysis, the effect of disturbed wave field due to the presence of columns, etc. should also be taken into account.

2.1.8 Allowance for wear and tear shall be taken into account in areas exposed to for example friction and abrasion. For a DDF unit this will typically be interfaces between hull and risers (keel level, intermediate riser-frames, deck level). These relative motions are caused by movements of the unit and risers and subsequent pullout and push-up of the risers in the moonpool.

2.1.9 The fatigue analysis of riser / keel guide frames shall account for the interaction between risers and guide frames where relevant.

2.1.10 The design fatigue factors or fatigue life safety factors depend on the consequence of failure and the accessibility for inspection as given in Table 1.

Table 1 Design fatigue factors for hull and topside (DFF's) – FLS

Consequence of failure	*Accessibility for inspection*		
	In-accessible	*Underwater access*	*Accessible*
Unacceptable 1)	10	3	2
Acceptable	3	2	1
1) The acceptability of the consequence of failure involves the owner, the flag state authorities, as well as DNV GL. Refer to DNVGL-OS-C101 Ch.2 Sec.5 for further guidance.			

2.2 Non-operational phases

2.2.1 Wet, overseas transports in harsh environment will require quite detailed analyses to determine the fatigue damage during this temporary phase. Both global and local wave load effects shall be taken into account. Some level of monitoring of weather and load effects during towage will be required such that it is possible to recalculate the actual fatigue contribution during wet tow.

2.2.2 Dry, overseas transports will usually be less exposed to fatigue damages. It however, requires almost the same level of finite element analyses as for wet tow in order to determine the stress fluctuations in hull, sea-fastenings and transport vessel.

2.3 Splash zone

The definition of 'splash zone' as given DNVGL-OS-C101 Ch.2 Sec.9 [2.2], relates to a highest and lowest tidal reference. For DDF units, for the evaluation of the fatigue limit state, reference to the tidal datum should be substituted by reference to the draught that is intended to be utilised when condition monitoring is to be undertaken. The requirement that the extent of the splash zone is to extend 5 m above and 4 m below this draught may then be applied. The splash zone is to be considered in-accessible with respect to the required DFF (Table 1).

Guidance note:
If significant adjustment in draught is possible in order to provide for satisfactory accessibility in respect to inspection, maintenance and repair, a sufficient margin in respect to the minimum inspection draught should be considered when deciding upon the appropriate DFF's. As a minimum this margin is to be at least 1 m, however it is recommended that a larger value is considered especially in the early design stages where sufficient reserve should be allowed for to account for design changes (mass and centre of mass of the

unit). Consideration should further be given to operational requirements that may limit the possibility for ballasting and deballasting operations.

When considering utilisation of remotely operated vehicle (ROV) inspection, consideration should be given to the limitations imposed on such inspection by the action of water particle motion (e.g. waves). The practicality of such a consideration may be that effective underwater inspection by ROV, in normal sea conditions, may not be achievable unless the inspection depth is at least 10 m below the sea surface.

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3 Deck or topside

3.1 Operation phase

3.1.1 Wave induced horizontal accelerations and P-delta effects will usually be governing for FLS design of deck structure and topside modules and shall be duly taken into account.

3.1.2 A stochastic approach is the preferred option for determination of final fatigue damage for the deck or topside. See Guidance note to [2.1.1] for the hull. For Design Fatigue Factor (DFF) refer to Table 1 in Sec.5.

3.1.3 Deck and hull connections, joints in deck structure, module supports etc. will typically be fatigue sensitive areas. The amount or level of detailed finite element analyses for these joints needs to be considered. For the deck and hull connection some level or amount of detailed finite element analyses shall be performed, at least for units located in harsh environment.

3.2 Non-operational phases

Fatigue damage of deck structure and topside modules shall be documented if the stress fluctuations in the different phases are significant.

SECTION 6 ACCIDENTAL LIMIT STATES (ALS)

1 General

1.1 Objective

1.1.1 The objective of this section is to provide supplemental guidance related to ALS design as outlined in DNVGL-OS-A101 and in DNVGL-OS-C101 Ch.2 Sec.6.

1.1.2 This section applies for the hull and deck or modules and operational as well as non-operational phases.

1.1.3 General requirements concerning accidental events are given in DNVGL-OS-C101.

2 General requirements

Units shall be designed to be damage tolerant, i.e. credible accidental damages, or events, should not cause loss of global structural integrity or stability. The capability of the structure to redistribute loads should be considered when designing the structure. Hull compartmentation should not allow loss of unit with one or more compartments flooded (see DNVGL-OS-A101).

3 Fire

Deck area will be limited for some DDF/Spar concepts. Potential fire scenarios shall therefore be carefully considered and taken into account in design and layout planning.

4 Explosion

4.1 General

4.1.1 As for fire, the limiting deck space and protected moon-pool area (potential gas or oil leakage) for some DDF units require that explosions are carefully considered in the design process.

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

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

4.1.3 As far as practicable, structural design accounting for large plate field rupture resulting from explosion loads should normally be avoided due to the uncertainties of the loads and the consequence of the rupture itself.

4.1.4 Structural support of blast walls, and the transmission of the blast load 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.

5 Collision

5.1 General

5.1.1 Safety assessments will be the basis for determination of type and size of colliding vessel and impact speed.

5.1.2 Collision impact shall be considered for all elements of the unit, which may be impacted by supply vessel on sideways, bow or stern collision. The vertical extent of the collision zone shall be based on the depth and draught of attending vessels and the relative motion between the attending vessels and the unit.

5.1.3 Resistance to unit collisions may be accounted for by indirect means, such as, using redundant framing configurations, collision ring in splash zone and materials with sufficient toughness in affected areas.

5.1.4 Boat landings are to be designed to withstand probable impact loads depending on the design service vessels and the operational criteria. (see DNV-RP-C204).

6 Dropped objects

6.1 General

6.1.1 Critical areas for dropped objects shall be determined on the basis of the actual movement of potential dropped objects (e.g. crane actions) 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.

6.1.2 Generally, dropped object assessment will involve the following considerations:

a) Assessment of the risk and consequences of dropped objects impacting topside, wellhead, riser system in moon-pool and safety systems and equipment. The assessment shall identify the necessity of any local structural reinforcement or protections to such arrangements.
b) Assessments of the risk and consequences of dropped objects impacting externally on the hull structure (shell, or bracings) and hull attachments such as strakes, fairleads and pipes. The structural consequences are normally fully accounted for by the requirements for watertight compartmentation and damage stability and the requirement for structural redundancy of slender structural members.

7 Unintended flooding

7.1 General

7.1.1 A procedure describing actions to be taken after relevant unintended flooding shall be prepared. Unintended filling of hard tanks, collision ring and bracings for a DDF will be the most relevant scenarios for the operation phase.

7.1.2 It must be ensured that counter-filling of tanks and righting up the unit can be performed safely and without delays.

7.1.3 Structural aspects related to the tilted condition and counter-flooding (if relevant) shall be investigated. This applies to the complete unit including risers and mooring system.

7.1.4 If the unit can not be brought back to the design draught and verticality by counter-ballasting and redistribution of ballast water, this must be taken into account in design of the unit.

7.1.5 The structure should be designed to withstand one compartment flooding under reduced environment (e.g. 10-yr return probability).

8 Riser damage

Provisions for accidental limit state design of risers, in general, are provided in DNV-OS-F201. Special considerations for risers on DDF/Spar include, but are not limited to:

— The structural and global performance design should account for one tensioner cylinder out of service.
— Loss of buoyancy, e.g. air cans for spar units.
— Loss of station keeping, e.g. mooring line failure, or tendon failure.
— Clashing between risers and/or umbilicals, and interaction between risers and surrounding structures.

9 Abnormal wave and wind events

9.1 General

9.1.1 Abnormal wave effects are partly related to air-gap and wave exposure of deck or topside structures as well as tensioner system. Consequences from such wave impacts shall be evaluated and taken into account in design of the relevant structural parts.

9.1.2 In hurricane environments the derrick tie down to the substructure and the top deck should be carefully designed. (see API Bulletin 2TD). The use of LRFD method for the design against uplift loads at the clamped footing connections is recommended.

9.1.3 In areas with hurricanes, special considerations have to be made with respect to effects of load hysteresis and high cycle fatigue especially for moorings and deck mounted tall structures (e.g., derricks).

9.1.4 Hurricane loading is considered abnormal only in cases where the occurrence probability is consistent with 10^{-4} annual level or if the unit is designed to be evacuated ahead of hurricanes and the damage is considered acceptable.

SECTION 7 SERVICEABILITY LIMIT STATES (SLS)

1 General

1.1 Objective

The objective of this section is to provide supplemental guidance related to SLS design as outlined in DNVGL-OS-C101 Ch.2 Sec.7. Since all partial load and material factors are equal to unity, the methodology as described is also a WSD design procedure.

1.2 Criteria

1.2.1 The SLS calculations should include expected values of permanent and variable loads and specific design environmental conditions and deformation extreme expected values.

1.2.2 The maximum allowable deflections or hull displacements or motions are to be assessed as given in DNVGL-OS-C101 Ch.2 Sec.7 and any additional relevant operational limitations for essential systems / equipment.

SECTION 8 WELD CONNECTIONS

1 General

1.1 Objective

1.1.1 The objective of this section is to provide supplemental guidance related to weld connections design as outlined in DNVGL-OS-C101 Ch.2 Sec.8 and DNVGL-OS-C201 Ch.2 Sec.8 for LRFD- or WSD-method, respectively.

1.1.2 The weld material factor γ_{Mw} shall be taken as 1.3 in the LRFD design method.

1.2 Special connections

1.2.1 Special DDF/Spar welded connections that should receive more detailed scrutiny include the TTR foundations in the centre well, the deck leg connections to the top of the spar deck, the hard tank bottom connection to the truss legs, the heave plates connections to the truss, the soft tank to truss connections, deck to column, column to pontoon and heave damping structure to main hull.

1.2.2 Special connections, for example, grouted connections shall be fully qualified. The process as presented in *DNV-RP-A203 Qualification of New Technology* can be used.

SECTION 9 CORROSION CONTROL

Design Requirements for Corrosion Protection and Control system are outlined in DNVGL-OS-C101 Ch.2 Sec.9 or DNVGL-OS-C201 Ch.2 Sec.9 for LRFD- or WSD-method, respectively. The two documents are equivalent in this regard.

SECTION 10 MOORING AND FOUNDATION DESIGN

Mooring design is detailed in DNVGL-OS-E301 and the foundations design requirements are outlined in DNVGL-OS-C101 Ch.2 Sec.10 or DNV's Classification Note 30.4. Approaches for LRFD and WSD design methods are provided in these documents. For DDF, in particular, the strength and fatigue damage of the mooring lines due to the vortex induced motions of the DDF itself, should be fully assessed.

SECTION 11 DYNAMIC RISER DESIGN AND GLOBAL PERFORMANCE

1 Dynamic riser design

1.1 General

1.1.1 Design of dynamic risers is detailed in DNV-OS-F201, with additional provisions in DNV-RP-F201 for titanium risers, DNV-RP-F202 for composite risers, DNV-RP-F203 for riser interference and DNV-RP-F204 for riser fatigue. Approaches for both LRFD and WSD design methods are provided in the above listed documents.

1.1.2 For DDS units, or other units where the risers are exposed to the dynamics of the wave splash zone, the effects of disturbed kinematics of the wave field due to the presence of the vessel should be fully assessed. This disturbance may be determined by the use of radiation/diffraction analysis. See DNV-RP-F205 for further details.

1.1.3 For vessels with moonpools, the kinematics of the water entrapped in the moonpool should be adequately addressed to ensure correct response of risers and/or tensioner buoys inside the moonpool. Kinematics of the entrapped water in the moonpool area can, in principle, be treated in the same way as the disturbed wave kinematics. See DNV-RP-F205 for further details.

1.1.4 For dry tree units, the riser tension system is a critical component and issues such as available stroke and tension variation due to stroke variation should be addressed.

1.1.5 Possible friction load effects due to keel guides should be accounted for in the riser design.

1.1.6 For DFFs and Spars, special attention should be paid to the influence of vortex induced motions of the DDF/Spar unit itself on the riser system.

2 Global performance

2.1 General

2.1.1 Global performance analyses are detailed in DNV-RP-F205. As the water depth increases, the interaction/coupling between the slender structures and the large volume floater becomes more important. In this case, a coupled analysis is required to capture the interaction between the two in order to accurately predict the individual responses of floater, risers and mooring.

2.1.2 For DDFs and Spars, special attention should be paid to the influence of vortex induced motions (VIM) on the global performance, and VIM induced fatigue on hull, mooring and risers.

2.1.3 Heave eigen period and cancellation period of DDS units tend to be close. Global performance is sensitive to viscous effects (both excitation and damping). Differences between model tests and analysis may be significant. Viscous effects at cancellation/resonance area should be carefully checked, so as not to take advantage from the cancellation effect.

CHAPTER 3 CLASSIFICATION AND CERTIFICATION

SECTION 1 CLASSIFICATION

1 General

1.1 Introduction

1.1.1 As well as representing DNV GL's recommendations on safe engineering practice for general use by the offshore industry, the offshore standards also provide the technical basis for DNV GL classification, certification and verification services.

1.1.2 This chapter identifies the specific documentation, certification and surveying requirements to be applied when using this standard for certification and classification purposes.

1.1.3 A complete description of principles, procedures, applicable class notations and technical basis for offshore classification is given by the applicable Rules for classification of offshore units as listed in Table 1.

Table 1 DNV GL Rules for classification - Offshore units

Reference	*Title*
DNVGL-RU-OU-0101	Offshore drilling and support units
DNVGL-RU-OU-0102	Floating production, storage and loading units
DNVGL-RU-OU-0103	Floating LNG/LPG production, storage and loading units

1.2 Application

1.2.1 It is assumed that the units will comply with the requirement for retention of the Class as defined in the above listed Rules.

1.2.2 Where codes and standards call for the extent of critical inspections and tests to be agreed between contractor or manufacturer and client, the resulting extent is to be agreed with DNV GL.

1.2.3 DNV GL may accept alternative solutions found to represent an overall safety level equivalent to that stated in the requirements of this standard.

1.2.4 Any deviations, exceptions and modifications to the design codes and standards given as recognised reference codes shall be approved by DNV GL.

1.3 Documentation

Documentation for classification shall be in accordance with the NPS DocReq (DNV GL Nauticus Production System for documentation requirements) and DNVGL-CG-0168.