



OFFSHORE STANDARD

DNV-OS-J301

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# Rules for Classification of Wind Turbine Installation Units

APRIL 2013

*The electronic pdf version of this document found through <http://www.dnv.com> is the officially binding version*

## FOREWORD

DNV is a global provider of knowledge for managing risk. Today, safe and responsible business conduct is both a license to operate and a competitive advantage. Our core competence is to identify, assess, and advise on risk management. From our leading position in certification, classification, verification, and training, we develop and apply standards and best practices. This helps our customers safely and responsibly improve their business performance. DNV is an independent organisation with dedicated risk professionals in more than 100 countries, with the purpose of safeguarding life, property and the environment.

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- *Service Specifications*. Procedural requirements.
- *Standards*. Technical requirements.
- *Recommended Practices*. Guidance.

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
- U) Unconventional Oil & Gas

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Any comments may be sent by e-mail to [rules@dnv.com](mailto:rules@dnv.com)

## CHANGES

### General

This document supersedes DNV-OS-J301, April 2011.

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.

### Main changes in April 2013

- **General**

- The document has changed numbering system.
- References to other DNV rules have been updated.
- In general, guidance notes have been updated.

- **Sec.1 Introduction**

- **Table 1-1**: Reference to DNV-OS-C107 has been replaced by DNV-OS-C102.
- **Table 1-1**: Rule reference for crane pedestals has been included.

- **Sec. 2 Self-elevating Units**

- **[2]**: Rule requirements to allow for use of ship rules for material selection, welding and inspection have been revised.
- **[2.2]**: Guidance for jetting system has been included.
- **[3.4.4]**: Requirement to include leg to hull friction during jacking condition has been included.
- **[3.5.1]**: A new sub-section element which clarifies requirements to wave bending moment during harbour condition has been included.
- **[5.1]**: Requirements for a leg stuck condition have been rewritten.

### Editorial Corrections

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

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## SECTION 1 INTRODUCTION

### 1 General

#### 1.1 Introduction

**1.1.1** This standard provides principles, technical requirements and guidance for the design and construction of units built to satisfy the service notation “**Wind Turbine Installation Unit**”.

**1.1.2** The notation may be combined with other DNV notations if found relevant:

Examples may be:

-“**SELF ELEVATING WIND TURBINE INSTALLATION UNIT**”

-“**WIND TURBINE INSTALLATION and CRANE UNIT**”.

**1.1.3** The standard has been written for column stabilised or self-elevating units intended for repeated installations/maintenance of wind turbine equipment, including foundations, nacelles, towers, blades, etc., in weather restricted operations.

**1.1.4** Design and construction requirements for assignment of service notation Wind Turbine Installation Vessel are provided in DNV Rules for Classification of Ships Pt.5 Ch.7 Sec.22. This is applicable if the vessel is not self-elevating or column-stabilized.

**1.1.5** Coastal State and Statutory regulations may include requirements in excess of the provisions of this standard depending on size, type, location and intended service of the offshore unit/vessel.

#### 1.2 Organisation of this Standard

**1.2.1** The standard is organised with a general section containing common requirements and sections containing specific requirement for different types of offshore units listed in [1.4.1]. In case of deviating requirements between general sections and the object specific sections, requirements of the object specific sections shall apply.

#### 1.3 Objectives

**1.3.1** The objectives of this standard are to:

- Provide an internationally acceptable standard of safety for units were parts of the operational scope include transport, installation and maintenance of wind turbine equipment, by defining minimum requirements for the structural design, materials and construction.
- Serve as a technical reference document in contractual matters between purchaser and manufacturer
- Serve as a guideline for designers, purchasers, contractors and regulators.
- Specify procedures and requirements for units and installations subject to DNV verification and classification services.

#### 1.4 Scope and application

**1.4.1** This standard is in principle applicable to all types of wind turbine installation units including, but not limited to, the following variants:

- Self elevating units
- Column stabilised units.

**1.4.2** 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.

**1.4.3** For novel designs, or unproven applications of designs where limited or no direct experience exists, the designer shall clarify with DNV the type of and extent of technical documentation including relevant analyses and model testing, which should be performed to demonstrate that an acceptable level of safety is obtained.

**1.4.4** Structural design covering marine operation sequences is not covered in this standard and shall be undertaken in accordance with the requirements stated in DNV-OS-H101 “Marine Operations, General” and DNV-OS-H102 “Marine Operations, Design and Fabrication”.

#### 1.5 Classification

**1.5.1** Principles, procedures and applicable class notations for classification of offshore units are given in the DNV Offshore Service Specification DNV-OSS-101 “Rules for Classification of Drilling and Support Units”.

**1.5.2** Documentation for classification shall be in accordance with DNV-RP-A201.

**1.5.3** Detailed documentation requirements for specific vessel are dependent on the vessel's specific class and service notations. A detailed list of documentation requirements for each vessel can be provided by DNV through DNV Nauticus Production System.

**1.5.4** Technical requirements given in DNV-OS-C101, Sec.8, related to Serviceability Limit States, are not mandatory as part of classification.

**1.5.5** Technical requirements given in DNV-OS-C101 related to design for earthquakes are not mandatory as part of classification.

## **2 Assumptions and Applications**

### **2.1 General**

**2.1.1** The WTI units will in general be used to carry out repeated weather restricted operations, and therefore it has been established practice to allow for limited design conditions as an alternative to the design- and class requirements for vessels used for more continuous operations in the offshore oil and gas industry.

**2.1.2** Both design philosophies are applicable for Wind Turbine Installation units; "mobile units" are assumed to be designed for quick demobilisation and escape to protected waters; "stationary units" are assumed to be appropriately designed to sustain the expected extreme design conditions at location.

**2.1.3** When restricted environmental design conditions are used in the design of the vessel, it is emphasised that the design requirements need to be consistent in order to ensure a robust design that is capable to withstand the relevant design loads for all design/operational conditions. Special attention is paid to the ability to demobilise and escape. The design criteria shall be established by the designer and will be stated in the Class Certificate.

**2.1.4** To ensure sufficient redundancy of the system, the design principles given in DNV-OS-A101, Sec.2 B100 and B200 shall be followed.

**2.1.5** It is assumed that the units will comply with the requirement for retention of the Class as defined in DNV-OSS-101, Ch.1 Sec.5.

**2.1.6** Wind Turbine Installation Units which are equipped with a crane, and is specially intended for lifting purposes, shall in addition to service notation **Wind Turbine Installation Unit** be assigned the service notation **Crane Unit** and shall comply with the requirements of class notation **CRANE** as specified in DNV-OSS-101, Ch.2 Sec.6 H.

### **2.2 Applicable DNV Rules and Standards**

**2.2.1** [Table 1-1](#) and [Table 1-2](#) include references to either DNV Rules for Classification of Ships Pt.3 Ch.1 or Pt.3 Ch.2 or DNV-OS-C104 or DNV-OS-C201 which shall be followed for each type of installation unit listed in A400.

**2.2.2** Section 2 of this standard gives additional detailed design requirements for Self-elevating Wind Turbine Installation Units.

**2.2.3** For Non Self-elevating Vessel or Barge, reference is made to DNV-OSS-101, Ch.2 Sec.7 B200.

**2.2.4** The crane shall be delivered with Det Norske Veritas' certificate in compliance with the DNV Standard for Certification No. 2.22 "Lifting Appliances". In agreement with the society the crane may be certified based on other internationally recognised standards. Cranes certified by other societies may be accepted based on special consideration.

<i>Area</i>	<i>Reference standard</i>	<i>Guidance</i>
Hull and Structure	DNV-OS-C102	The hull strength of ship shaped units and barges, may follow the requirements of DNV Rules for Classification of Ships Pt.3 Ch.1 and Ch.2 for all transit conditions as referred in DNV-OS-C102
	DNV-OS-C104 or DNV-OS-C201	To be followed for the hull strength of units and barges in the elevated condition.
Jack-up specific structural items such as, legs, jack case, jacking gear, guides, steel categorisation, etc.	DNV-OS-C104 DNV-OS-C201	
Electrical Systems	DNV-OS-D201	Equivalent to DNV Rules for Classification of Ships Pt.4 Ch.8.
Instrumentation	DNV-OS-D202	
Marine and Machinery systems	DNV-OS-D101	
DP System	DNV Rules for Classification of Ships Pt.6 Ch.7	
Stability and Watertight Integrity		Requirements for floating mode are given as follows:
	DNV Rules for Classification of Ships Pt.3 Ch.3 Sec.9	Self propelled units that are designed for unsupported sailing shall comply with DNV Rules for Classification of Ships Pt.3 Ch.3 Sec.9.
	DNV-OS-C301	Self-elevated units, which may be self-propelled but need towing support for longer field moves or ocean transits, shall follow DNV-OS-C301.
Safety Principles and Arrangements	DNV-OS-A101 Sec.1, 2, 3 and 6.	Sec.2 of DNV-OS-A101 is only relevant for elevated mode.
Fire Protection	DNV Rules for Classification of Ships Pt.4 Ch.10	DNV-OS-D101 can be used for units which shall have a MODU Code Certificate.
Crane(s)	DNV-OSS-101 Ch.2 Sec.5	
Crane Pedestals	DNV-OS-C102 DNV-OS-C104 DNV-OS-C201 DNV Standard for Certification No. 2.22 “Lifting Appliances”.	Crane pedestals installed on self-propelled units that are designed for unsupported sailing shall comply with DNV-OS-C102.

<i>Area</i>	<i>Reference standard</i>	<i>Guidance</i>
Hull and Structure	DNV-OS-C103 or DNV-OS-C201	
Electrical Systems	DNV-OS-D201	
Instrumentation	DNV-OS-D202	
Marine and Machinery systems	DNV-OS-D101	
DP Systems	DNV Rules for Classification of Ships Pt.6 Ch.7	
Stability and Watertight Integrity	DNV-OS-C301	
Safety Principles and Arrangements	DNV-OS-A101 Sec.1, 2, 3 and 6.	
Fire Protection	DNV Rules for Classification of Ships Pt.4 Ch.10	DNV-OS-D101 can be used for units which shall have a MODU Code Certificate.
Crane(s)	DNV-OSS-101 Ch.2 Sec.5	

**Guidance note:**

The safety/stability criteria to be used for self-elevating WTI units depend largely on how the units are planned to operate. Self-propelled units which sail regularly in transit to port are normally expected to hold SOLAS certificates covering for the vessel in the sailing mode. Additional compliance with MODU code is expected for the elevated mode. Units which primarily work as offshore support/installation units could formally be certified solely based on the MODU-Code. It will be up to the flag state to decide which certificates and statutory requirements should be applied for the unit.

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### 3 Definitions

#### 3.1 Verbal forms

**3.1.1 *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.

**3.1.2 *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.

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

#### 3.2 Terms

**3.2.1 *Installation condition*:** A condition during which a unit is lowering the legs and elevating the hull.

**3.2.2 *Moulded baseline*:** A horizontal line extending through the upper surface of hull bottom shell.

**3.2.3 *Operating conditions*:** Conditions where a unit is on location for purposes of wind turbine equipment installation or other similar operations, and combined environmental and operational loadings are within the appropriate design limits established for such operations. For self-elevating units, the legs are supported on the seabed and the hull is normally jacked out of water to avoid contact with sea.

**3.2.4 *Retrieval conditions*:** Conditions during which a unit is lowering the hull and elevating the legs.

**3.2.5 *Self-elevating unit/jack-up*:** A mobile unit having hull with sufficient buoyancy to sail on own keel to the desired location, and that is bottom founded in its operation mode. The unit reaches its operation mode by lowering the legs to the seabed and jacking the hull out of water to reach the required hull elevation above sea surface. Total number of legs is normally 3, 4 or 6.

**3.2.6 *Ship-shaped*:** Monohull ship or barge having displacement hull with or without propulsion machinery.

**3.2.7 *Survival conditions*:** Conditions wherein a unit is on location subjected to the most severe environmental loadings for which the unit is designed. Drilling or similar operations may have been discontinued due to the severity of the environmental loadings. Self-elevating units, are jacked up with sufficient air gap for the hull to avoid contact with sea.

**3.2.8 *Transportation or transit conditions*:** All unit movements from one geographical location to another.

**3.2.9 *Unit*:** Term used for hull which is built according DNV Offshore Standards.

**3.2.10 *Vessel*:** Term used by DNV for hull which is built according DNV Rules for Classification of Ships.

## SECTION 2 SELF-ELEVATING UNITS

### 1 Scope and Application

#### 1.1 General

**1.1.1** This section contains specific requirements and guidance applicable for ship shaped self-elevating units. The requirements come in addition to those of Sec.1.

**1.1.2** The following defines the interpretation of the requirements given in the set of rules which are to be applied according to [Table 1-1](#) for the class notation **Wind Turbine Installation Unit**.

### 2 Structural Categorization, Material Selection and Inspection Principles

#### 2.1 Jacking system

**2.1.1** It is recommended that assignment of primary and special categories are verified against an overall risk assessment of possible failures of the different components of the jacking systems. Failure in one structural element may result in excessive utilization of other parts of the structure or in the system, leading to an unacceptable load scenario. All phases (transit, jacking up / down and elevated) should be considered.

**2.1.2** A Failure Mode, Effect and Criticality Assessment (FMECA) shall be carried out to define the control of the jacking system and shall form the basis for the risk assessment described above.

**2.1.3** Elements with a low utilisation factor imply that the likelihood of failure is reduced. This can be taken into account during the FMECA and in the selection of the grade of material.

#### 2.2 Jetting system

**2.2.1** A critical condition for the vessel is during installation or retrieval operations when legs are to be set or retrieved from the sea bed. Analysis requirements for these temporary conditions are covered by [\[3.4\]](#) of this document.

**Guidance note:**

An effective mean to avoid a stuck leg may be to install a jetting system to flush water, breaking the suction between spudcan and soil and reducing the friction at the leg soil interface. Use of a jetting system will minimize the extraction forces when lifting the leg and reduce the probability of damage to the vessel.

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#### 2.3 Hull structure categorization

**2.3.1** The material grade shall in principle be selected according to DNV-OS-C104 Sec.2 or DNV-OS-C201 Sec.12.

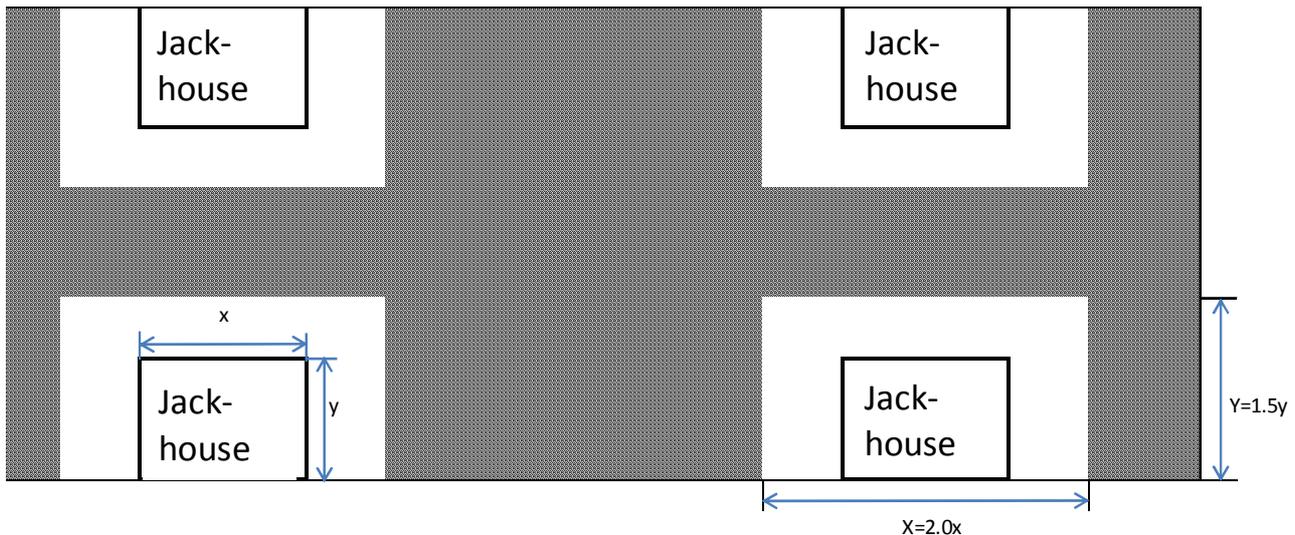
**2.3.2** For ship shaped units, where the design temperature is equal or above -10°C based on lowest mean daily average temperature, the material grade in the grey shaded area in Figure 1 may be selected according to Table B2 of DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.2.

**2.3.3** For ship shaped units, where the design temperature is lower than -10°C based on lowest mean daily average temperature, the material grade in the grey shaded area in Figure 1 may be selected according to Table B1 of DNV Rules for Classification of Ships Pt.5 Ch.1 Sec.7.

#### 2.4 Inspection category

**2.4.1** The extent of non-destructive testing and inspection during fabrication of the hull shall in principle be in accordance with DNV-OS-C104 Sec.2 or DNV-OS-C201 Sec.12. Detailed requirements to extent of testing are found in and DNV-OS-C401 Sec.3.

**2.4.2** The extent of non-destructive testing and inspection during fabrication of the hull may be in accordance with DNV Rules for Classification of Ships Pt.2 Ch.3 Sec.7 for the grey shaded area in Figure 2-1.



**Figure 2-1**  
**Extent of non-destructive testing and inspection**

## 2.5 Weld connections

**2.5.1** The requirements for weld connections shall in principle be in accordance with DNV-OS-C101 Sec.9 or DNV-OS-C201 Sec.9.

**2.5.2** For ship shaped units, the welding may follow DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.11 for the grey shaded areas indicated in Figure 2-1.

## 3 Ultimate Limit States (ULS) – Design

### 3.1 Compliance with basic 1A1 requirements

**3.1.1** During floating/transit condition the hull shall comply with the **1A1** main class requirements. The hull strength may be assessed according to DNV Rules for Classification of Ships Pt.3 Ch.1 for all transit and operational conditions. For ships with restricted service, a Service Area Notation **R** can be applied as given in the DNV Rules for Classification of Ships, Pt.3 Ch.1 Sec.5.

**Guidance note:**

It may be relevant to design the global strength of the vessel for unrestricted transit since the vessel may need to sail long distances; e.g. from construction site to home port. The vessel may also sail longer distances in relation to transit to new geographical areas or in cases where the distance between load-out port for equipment and wind farm is substantial. However, it may be necessary to consider the transit condition as a weather restricted operation as barge shaped units may be exposed to green sea and thruster ventilation.

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**3.1.2** Journeys with wind turbine components onboard the unit may be planned with weather restrictions, in accordance with DNV-OS-H101 “Marine Operations, General”, due to limitations of the sea fastening capacity or due to the components susceptibility to excessive motions or accelerations. The planning and execution of such operations, related to cargo and sea-fastening should, however, be considered as a marine operation which is not covered by the classification scope.

**3.1.3** If the unit is designed for unrestricted transit, the extreme values for motions and accelerations (i.e. probability level =  $10^{-8}$ ), may be based on the DNV Rules for Classification of Ships or a direct global motion analysis, and applied for the calculation of the maximum reactions in the legs, crane pedestal, accommodation, etc.

**Guidance note:**

For vessels with high metacentric height, motions established in accordance with the DNV Rules for Classification of Ships may be overestimated.

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**3.1.4** Structural design of sea fastening is not included in the classification scope. Sea fastening which is developed for repeated use to secure larger wind turbine components during sea transport may be certified by DNV.

## 3.2 Global capacity

**3.2.1** Corrosion allowance is not required provided a corrosion protection system in accordance with DNV-OS-C101 Sec.10 is installed and maintained

**3.2.2** Given a corrosion protection is implemented, gross scantlings may be utilised in the calculation of hull structural strength.

**Guidance note:**

Under the condition that [3.2.1] is applied, it will be stated in the Appendix to Class Certificate that “The vessel is built in compliance with DNV-OS-C101 with respect to corrosion allowances & corrosion protection system. Inspection and follow up in service is to be based on DNV-OSS-101, Ch.3 Sec.4 D207”, or equivalent.

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## 3.3 Elevated Condition

**3.3.1** The unit should be designed with sufficient ULS capacity for the maximum 100 years storm at location and this shall be checked according to DNV-OS-C104 or DNV-OS-C201. The elevated condition (ULS and SLS) and jacking conditions are normally governing for legs, jacking system and key parts of the hull/leg interface structure.

**3.3.2** As an alternative, the unit may be designed for restricted elevated weather condition, which implies that the unit will need to jack down and sail to protected waters in case of weather deterioration. In such case the weather exposure along the sailing route before reaching protected waters must also be considered.

**3.3.3** If the unit is designed for restricted elevated weather condition, the jacking system must be proven reliable, either by designing additional redundancy, additional safety margins or by including sufficient time to repair / replacement of spare parts.

**3.3.4** The environmental design criteria will define the operability limits for the vessel and will be included in the Class Certificate at delivery.

**Guidance note:**

For elevated conditions it is not required to base the design criteria with reference to a given extreme condition defined by a probability level, e.g. 20 years storm at a field. Due to the mobility of the unit, the design criteria may be chosen as a maximum environmental condition defined by assumptions with regard to the number of days that the unit will be able to work at a location during a year.

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**3.3.5** It is emphasised that the structural strength shall be documented for the maximum crane loading for all relevant crane positions in combination with the environmental loading and other functional loads as given in DNV-OS-C104, Sec.3 A100. The loads resulting from the crane should be in accordance with the DNV Standard for Certification No. 2.22 “Lifting Appliances”.

**3.3.6** For vessels where the crane foundation is built around one of the leg wells, special attention shall be paid to the combined effect of leg and crane loading at the interfacing structure. Detailed local models are required to document sufficient structural strength in accordance with DNV-OS-C104, Sec.3 A300 and D300. Dynamic factors and load factors shall be according to relevant parts of DNV Standard for Certification No. 2.22 “Lifting Appliances”.

## 3.4 Installation and retrieval

**3.4.1** Partially submerged hull position which is reached during installation and retrieval may represent a governing design condition for the legs. A simplified design check should be performed to assess the leg utilization during this condition. The results of the analysis (such as maximum leg bending moment and maximum vertical reactions) will define the directional limiting sea state for the installation phase. The analysis needs to take into account the dynamic effects of the environmental loads, added mass and hydrodynamic forces on the hull and legs.

**3.4.2** In case an operating mode of the unit is with the hull partially submerged, an analysis shall be performed, considering all operational loads including crane loads.

**3.4.3** For six legged units the hull shall be analysed for all relevant leg forces during a pulling operation.

**3.4.4** For units where sagging of the hull during elevated conditions may lead to friction forces between leg and guiding system, this effect shall be taken into account in the dimensioning of the jacking capacity.

## 3.5 Harbour condition Crane Operation

**3.5.1** During loading and unloading with the vessel moored to the quay the wave loading moment may be

reduced in accordance with DNV Rules for Classification of Ships Pt.5 Ch.7 Sec.21.

### 3.6 Deck cargo and heavy equipment

**3.6.1** All load effects caused by deck cargo and heavy equipment shall be accounted for in the design calculations for all operational phases.

**3.6.2** The deck shall be designed according to DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.4 C500 or DNV-OS-C104 Sec.4 D700 using accelerations according to the rules for classification of ships or direct calculations.

**3.6.3** Deck structures intended for operation of cargo handling vehicles and from cargo transporting vehicles shall be designed according requirements given in DNV Rules for Classification of Ships Pt.5 Ch.2 Sec.4 A.

## 4 Fatigue Limit States (FLS)

### 4.1 Leg fixity

**4.1.1** Fixity of legs towards the sea bottom is dependent on the soil conditions at the location where the vessel is going to operate and the geometry of the leg bottom. Appropriate assumptions shall be made with regard to leg fixation when calculating the fatigue capacity of the legs.

### 4.2 Principles and methodology

**4.2.1** The fatigue damage contributions from the operational phases shall be based on an assessment of the expected area of operation and the configuration of the operation with regards to time spent in the various phases (elevated, transit and jacking). The structure shall be designed for a minimum of 20 years fatigue life based on this assessment.

**4.2.2** Because of the large number of repeated installation operations the vessels are expected to carry out, the legs and jacking system should be designed sufficiently robust to sustain a large number of jacking operations during the vessels design life. An appropriate assumption with regard to cargo weights should be included when fatigue loads are calculated for the jacking system.

**4.2.3** Fatigue documentation for the legs should account for all the relevant loading conditions, e.g.; transit, jacking and elevated. A sufficient number of load cycles for each condition should be assumed based on the planned operation of the vessel. The fatigue contributions shall be based on the same assumptions as described in item [4.2.1].

**4.2.4** Number of jacking operations used for fatigue documentation shall be stated in the Design Basis.

**4.2.5** A logging procedure should be established to register number of performed jacking operations. This will enable the operator to monitor the jacking history against design assumptions and provide input to the maintenance planning of the system.

#### Guidance note:

If not otherwise planned for it can be assumed that the vessel will perform a total of 150 jacking operations per year during its life time.

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## 5 Accidental Limit States (ALS)

### 5.1 Leg Stuck

**5.1.1** For the condition when a leg is stuck in the sea bottom, it may be required to partly submerge the hull in order to obtain sufficient lifting loads. This will lead to trim or heel of the vessel, which may overload the legs, jacking system or supporting structure. A leg stuck scenario shall not lead to uplift of other legs which may cause the vessel to rotate and cause damage to the stuck leg.

#### Guidance note:

An accidental condition may occur for special soil conditions with soft clay, when retrieval of the leg may become impeded by the leg/spudcan being stuck in the sea bed. The retrieval of a stuck leg may cause overloading of leg, but also the jacking system or hull beam may be critically loaded if the retrieval operation of the stuck leg is not carried out with caution. An effective means to avoid a stuck leg may be to install a jetting system to flush water, breaking the suction between spudcan and soil and reducing the friction at the leg soil interface. Use of a jetting system will minimize the extraction forces and reduce the probability of damage to the vessel.

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## 5.2 Collisions

**5.2.1** For vessels that operate primarily without support from other vessels it is considered that the risk of an impact from other vessels is low. If the operation is planned with support from other vessel, then the consequence of an impact should be considered both with regard to global and local integrity of the vessel.

## 5.3 Scouring

**5.3.1** The requirement of scour protection given in DNV-OS-C104, Sec.8 B106 is not applicable for time limited operations (less than 72 hours).

**5.3.2** If the vessel is to operate in an area where severe scouring is expected to happen, a system which is monitoring the extent of scouring shall be installed to prevent any sudden failures of the spud can support.

## 5.4 Operating manual

**5.4.1** The operating manual should include operational procedures related to releasing a stuck leg (For example limitations on max pull force and maximum heel and trim angles).

## 6 System Design

### 6.1 Jacking system

**6.1.1** The jacking machinery shall be designed and certified according to the requirements given in DNV-OS-D101.

**6.1.2** The certification of the structural and mechanical parts shall be carried out according to relevant parts of DNV-OS-D101, Ch.2 Sec.5 “Machinery and Mechanical Equipment”.

**6.1.3** Hydraulic Cylinders shall be certified according to Type Approval Programme No. 5-778.93 Hydraulic cylinders.

**6.1.4** The certification process shall be carried out in accordance with DNV-OS-D101, Ch.3 Sec.1 “Certification of Materials and Components”.

**6.1.5** Certification category for the jacking system is IA in accordance with DNV-OS-D101, Ch.3 Sec.1 Table C2.

**6.1.6** Due to number of cycles and pressure range, fatigue assessment of the system is required. The safety factors to be considered should be related to the criticality and inspect ability of the different parts of system. Guidance on DFF can be found in NORSOK N-004 Table 8-1.

### 6.2 Control system

**6.2.1** The control system is defined as an important system as defined in DNV-OS-D202, Ch.1 Sec.1 C209. System availability shall meet system category “repairable system” (R3), as defined in DNV-OS-D202, Ch.2 Sec.1 B102. Failure modes and effect analysis (FMEA) according to DNV-OS-D202, Ch.3 Sec.1 Table B2 is to be carried out.

#### Guidance note:

It is recommended that the operator ensure that necessary tools, spare parts and repair manuals are available to minimize the downtime in the event of possible failures to the jacking system.

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