OFFSHORE STANDARD
DNV-OS-J301

STANDARD FOR CLASSIFICATION OF WIND TURBINE INSTALLATION UNITS

APRIL 2011

DET NORSKE VERITAS

FOREWORD

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— *Recommended Practices.* Guidance.

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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

Motives

This DNV Offshore Standard provides special technical requirements for units which are purpose built for installation/maintenance of Offshore Wind Turbine. The standard supports the special service notation "**Wind Turbine Installation Unit**" which was introduced through the DNV-OSS-101 in October 2009.

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CHANGES

- **General**

This document supersedes DNV-OS-J301, October 2010.

Main changes in April 2011

— *Non-self elevating Wind Turbine Installation Units*
Requirements for Non Self-elevating Vessel or Barge is taken out of this standard as it is covered by Rules for Classification of Ships Pt.5 Ch.7 Sec.22.

— *Hull structure categorization*
Requirement for self-elevating units is dependent on the governing mode of operation, either floating or elevated, ref. Sec.2 B200.

— *Load factors for crane pedestal*
A reference is included to applicable dynamic and load factors for design of crane pedestal, ref. Sec.2 C307.

— *Risk of collision with other vessel*
The risk of collision with other vessel is considered different if the installation unit works with or without support from other vessel(s), ref. Sec.2 E200.

— *Scouring*
Mitigation actions for severe scouring is specified, ref. Sec.2 E300.

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SECTION 1
INTRODUCTION

A. General

A 100 Introduction

101 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".

102 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**"

103 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.

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

105 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.

A 200 Organisation of this Standard

201 The standard is organised with a general section containing common requirements and sections containing specific requirement for different types of offshore units listed in 400. In case of deviating requirements between general sections and the object specific sections, requirements of the object specific sections shall apply.

A 300 Objectives

301 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.

A 400 Scope and application

401 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.

402 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.

403 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.

404 Structural design covering marine operation sequences is not covered in this standard and shall be undertaken in accordance with the requirements stated in "Rules for Planning and Execution of Marine Operations".

A 500 Classification

501 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".

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

503 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.

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

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

B. Assumptions and Applications

B 100 General

101 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.

102 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.

103 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.

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

105 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.

106 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.

B 200 Applicable DNV Rules and Standards

201 Table B1 and B2 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.

202 Section 2 of this standard gives additional detailed design requirements for self-elevating Wind Turbine Installation units.

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

204 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.

Table B1 Technical reference standards for self-elevating Wind Turbine Installation Units		
Area	*Reference standard*	*Guidance*
Hull and structure	DNV-OS-C107	The hull strength of ship shaped units and barges, may follow the requirements of DNV Rules for Classification of Ships Pt.3 Ch.1 & Ch.2 for all transit conditions as referred in DNV-OS-C107 Sec.1 A101.
	DNV-OS-C104 or DNV-OS-C201	To be followed for the hull strength of triangular shaped self-elevating units, and ship shaped 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	Same as DNV Rules for Classification of Ships Pt.4 Ch.8.
Instrumentation Systems	DNV-OS-D202	
Marine and Machinery systems	DNV-OS-D101	Requirements to marine and machinery systems for self- elevating units are given in DNV-OS-D101.
DP System	Rules for Classification of Ships Pt.6 Ch.7	
Stability and watertight integrity		Requirements for floating mode are given as follows:
	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 triangular shaped and barge shape 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.	Section 2 of DNV-OS-A101 is only relevant for elevated mode.
Fire Protection	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	See B205

Table B2 Technical reference standards for column-stabilised Wind Turbine Installation Units		
Area	*Reference standard*	*Guidance*
Hull and structure	DNV-OS-C103 or DNV-OS-C201	
Electrical systems	DNV-OS-D201	
Instrument systems	DNV-OS-D202	
Marine and Machinery systems	DNV-OS-D101	
DP systems	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	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	See B205

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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C. Definitions

C 100 Verbal forms

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

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

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

C 200 Terms

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

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

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

204 *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.

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

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

207 *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.

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

209 *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.

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

SECTION 2
SELF-ELEVATING UNITS

A. Scope and Application

A 100 General

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

102 The following defines the interpretation of the requirements given in the set of rules which are to be applied according to Sec.1 Table B1 for the class notation **Wind Turbine Installation Unit**.

B. Structural Categorization, Material Selection and Inspection Principles

B 100 Hydraulic jacking system

101 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 hydraulic jacking systems. Failure in one structural element may result in excessive utilization of other parts of the structure or in the hydraulic system, leading to an unacceptable load scenario. All phases (transit, jacking up / down and elevated) should be considered.

102 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.

103 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.

B 200 Hull structure categorization

201 Structural categorisation, selection of steel materials and inspection principles shall follow DNV-OS-C104 Sec.2.

202 Structural categorisation, selection of steel materials and inspection principles in areas of the hull which is not governed by the elevated mode may follow DNV Rules for Ships Pt.3 Ch.1 Sec.2.

B 300 Inspection category

301 Fabrication and testing of jacking and supporting system shall comply with the requirements in DNV-OS-C401. The requirements are based on the consideration of fatigue damage and assessment of general fabrication quality. The inspection categories are related to the structural categories.

302 The inspection category for elements of the jacking and supporting system should be considered separately from any downgrade of the structural category. The level of inspection should be based on the consequence of failure independent of the utilization of the system.

C. Ultimate Limit States (ULS) – Design

C 100 Compliance with basic 1A1 requirements

101 During floating/transit condition the hull shall comply with the 1A1 main class requirements. The rule reference for an offshore ship shaped hull is DNV-OS-C107 "Structural Design of Ship Shaped Drilling and Well Service Units", which state in Sec.1 A100 that the hull strength may be assessed according to DNV's 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 Rules for Classification of Ships, Pt.3 Ch.1 Sec.4.

Guidance note:

It is relevant to design the vessel for unrestricted operations 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.

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102 Journeys with wind turbine components onboard the unit may be planned with weather restrictions 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.

103 Alternatively vessel motions can be established by direct motion analysis.

104 If the unit is designed for unrestricted transit, the extreme values for motions and accelerations (i.e. probability level = 10^{-8}), should be based on the 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.

105 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.

C 200 Global capacity

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

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

Guidance note:

Under the condition that C200 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 (April 2010)", or equivalent.

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C 300 Elevated Condition

301 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. 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.

302 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.

303 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.

304 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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305 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 standard for certification No. 2.22 "Lifting Appliances".

306 For vessels where the crane foundation is built around one of the leg wells, special attention should 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.

307 Dynamic factors and load factors applied to crane pedestals and the supporting structure shall be according to relevant parts of DNV Standard for Certification No. 2.22 "Lifting Appliances".

C 400 Installation and retrieval

401 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.

402 In case that the operating mode of the unit is with the hull partially submerged, this analysis needs to be performed also considering all operational loads including crane loads, and this condition should also be included in the fatigue assessment.

403 The retrieval operation should be analysed similar to the pre-load condition in order to define the limiting sea state and conditions that this operation may be carried out unless this operation is demonstrated not to be critical.

C 500 Deck cargo and heavy equipment

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

502 The deck shall be designed according to DNV Rules for Ships (2010) Pt.3 Ch.1 Sec.4 D700 using accelerations according to the rules for classification of ships or direct calculations.

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

D. Fatigue Limit States (FLS)

D 100 Leg fixity

101 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.

D 200 Principles and methodology

201 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.

Guidance note:

If an estimation of the operational phase distribution is not made, the minimum requirement for hull fatigue calculations shall be made with the assumption that 50% of operational time is made in world wide unrestricted sailing. Fatigue effects to the hull resulting from repeated loading during elevated condition should also be considered and accounted for.

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202 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.

203 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 201.

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

205 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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E. Accidental Limit States (ALS)

E 100 Leg Stuck

101 Temporary operational modes such as retrieval of leg stuck (meaning an extreme leg retrieval that require a special procedure and applies elevated forces on the legs) needs to be carried out in order to define the limiting sea state and conditions when these operations may be carried out. The leg stuck condition can be considered as an accidental scenario if a site investigation to identify the likely leg penetration and extreme probability of leg stuck condition is carried out prior to operation.

E 200 Collisions

201 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.

E 300 Scouring

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

302 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.

E 400 Operating manual

401 The operating manual should include operational procedures related to releasing a stuck leg (For example limitations on max pull force).

F. System Design

F 100 Hydraulic jacking system

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

102 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".

103 Hydraulic Cylinders shall be certified according to TAP-778-93 Type Approval Programme No. 5-778.93 Hydraulic cylinders.

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

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

106 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.

F 200 Control system

201 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. 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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