Classification and Certification of Floating Offshore Wind Turbines

November 2010

Guidance Note
NI 572 DT R00 E

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MARINE DIVISION
GENERAL CONDITIONS

ARTICLE 1

1.1. - BUREAU VERITAS is a Society the purpose of whose Marine Division (the "Society") is the classification (" Classification ") of any ship or vessel or structure of any type or part of it or system therein collectively hereinafter referred to as a "Unit" whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

The Society:

- prepares and publishes Rules for classification, Guidance Notes and other documents ("Rules");
- issues Certificates, Attestations and Reports following its interventions ("Certificates");
- publishes Registers.

1.2. - The Society also participates in the application of National and International Regulations or Standards, in particular by delegation from different Governments. Those activities are hereafter collectively referred to as " Certification ".

1.3. - The Society can also provide services related to Classification and Certification such as ship and company safety management certification; ship and port security certification, training activities; all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board.

1.4. - The interventions mentioned in 1.1., 1.2. and 1.3. are referred to as " Services ". The party and/or its representative requesting the services is hereinafter referred to as the " Client ". **The Services are prepared and carried out on the assumption that the Clients are aware of the International Maritime and/or Offshore Industry (the "Industry") practices.**

1.5. - The Society is neither and may not be considered as an Underwriter, Broker in ship's sale or chartering, Expert in Unit's valuation, Consulting Engineer, Controller, Naval Architect, Manufacturer, Shipbuilder, Repair yard, Charterer or Shipowner who are not relieved of any of their expressed or implied obligations by the interventions of the Society.

ARTICLE 2

2.1. - Classification is the appraisement given by the Society for its Client, at a certain date, following surveys by its Surveyors along the lines specified in Articles 3 and 4 hereafter on the level of compliance of a Unit to its Rules or part of them. This appraisement is represented by a class entered on the Certificates and periodically transcribed in the Society's Register.

2.2. - Certification is carried out by the Society along the same lines as set out in Articles 3 and 4 hereafter and with reference to the applicable National and International Regulations or Standards.

2.3. - **It is incumbent upon the Client to maintain the condition of the Unit after surveys, to present the Unit for surveys and to inform the Society without delay of circumstances which may affect the given appraisement or cause to modify its scope.**

2.4. - The Client is to give to the Society all access and information necessary for the safe and efficient performance of the requested Services. The Client is the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out.

ARTICLE 3

3.1. - **The Rules, procedures and instructions of the Society take into account at the date of their preparation the state of currently available and proven technical knowledge of the Industry. They are not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.**

Committees consisting of personalities from the Industry contribute to the development of those documents.

3.2. - The Society only is qualified to apply its Rules and to interpret them. Any reference to them has no effect unless it involves the Society's intervention.

3.3. - The Services of the Society are carried out by professional Surveyors according to the applicable Rules and to the Code of Ethics of the Society. Surveyors have authority to decide locally on matters related to classification and certification of the Units, unless the Rules provide otherwise.

3.4. - **The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not in any circumstances involve monitoring or exhaustive verification.**

ARTICLE 4

4.1. - The Society, acting by reference to its Rules:

- reviews the construction arrangements of the Units as shown on the documents presented by the Client;
- conducts surveys at the place of their construction;
- classes Units and enters their class in its Register;
- surveys periodically the Units in service to note that the requirements for the maintenance of class are met.

The Client is to inform the Society without delay of circumstances which may cause the date or the extent of the surveys to be changed.

ARTICLE 5

5.1. - The Society acts as a provider of services. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty.

5.2. - The certificates issued by the Society pursuant to 5.1. here above are a statement on the level of compliance of the Unit to its Rules or to the documents of reference for the Services provided for.

In particular, the Society does not engage in any work relating to the design, building, production or repair checks, neither in the operation of the Units or in their trade, neither in any advisory services, and cannot be held liable on those accounts. Its certificates cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

5.3. - The Society does not declare the acceptance or commissioning of a Unit, nor of its construction in conformity with its design, that being the exclusive responsibility of its owner or builder, respectively.

5.4. - The Services of the Society cannot create any obligation bearing on the Society or constitute any warranty of proper operation, beyond any representation set forth in the Rules, of any Unit, equipment or machinery, computer software of any sort or other comparable concepts that has been subject to any survey by the Society.

ARTICLE 6

6.1. - The Society accepts no responsibility for the use of information related to its Services which was not provided for the purpose by the Society or with its assistance.

6.2. - If the Services of the Society cause to the Client a damage which is proved to be the direct and reasonably foreseeable consequence of an error or omission of the Society, its liability towards the Client is limited to ten times the amount of fee paid for the Service having caused the damage, provided however that this limit shall be subject to a minimum of eight thousand (8,000) Euro, and to a maximum which is the greater of eight hundred thousand (800,000) Euro and one and a half times the above mentioned fee.

The Society bears no liability for indirect or consequential loss such as e.g. loss of revenue, loss of profit, loss of production, loss relative to other contracts and indemnities for termination of other agreements.

6.3. - All claims are to be presented to the Society in writing within three months of the date when the Services were supplied or (if later) the date when the events which are relied on of were first known to the Client, and any claim which is not so presented shall be deemed waived and absolutely barred. Time is to be interrupted thereafter with the same periodicity.

ARTICLE 7

7.1. - Requests for Services are to be in writing.

7.2. - **Either the Client or the Society can terminate as of right the requested Services after giving the other party thirty days' written notice, for convenience, and without prejudice to the provisions in Article 8 hereunder.**

7.3. - The class granted to the concerned Units and the previously issued certificates remain valid until the date of effect of the notice issued according to 7.2. here above subject to compliance with 2.3. here above and Article 8 hereunder.

7.4. - The contract for classification and/or certification of a Unit cannot be transferred neither assigned.

ARTICLE 8

8.1. - The Services of the Society, whether completed or not, involve, for the part carried out, the payment of fee upon receipt of the invoice and the reimbursement of the expenses incurred.

8.2. Overdue amounts are increased as of right by interest in accordance with the applicable legislation.

8.3. - The class of a Unit may be suspended in the event of non-payment of fee after a first unfruitful notification to pay.

ARTICLE 9

9.1. - The documents and data provided to or prepared by the Society for its Services, and the information available to the Society, are treated as confidential. However:

- clients have access to the data they have provided to the Society and, during the period of classification of the Unit for them, to the **classification file** consisting of survey reports and certificates which have been prepared at any time by the Society for the classification of the Unit;
- copy of the documents made available for the classification of the Unit and of available survey reports can be handed over to another Classification Society, where appropriate, in case of the Unit's transfer of class;
- the data relative to the evolution of the Register, to the class suspension and to the survey status of the Units, as well as general technical information related to hull and equipment damages, are passed on to IACS (International Association of Classification Societies) according to the association working rules;
- the certificates, documents and information relative to the Units classed with the Society may be reviewed during certificating bodies audits and are disclosed upon order of the concerned governmental or inter-governmental authorities or of a Court having jurisdiction.

The documents and data are subject to a file management plan.

ARTICLE 10

10.1. - Any delay or shortcoming in the performance of its Services by the Society arising from an event not reasonably foreseeable by or beyond the control of the Society shall be deemed not to be a breach of contract.

ARTICLE 11

11.1. - In case of diverging opinions during surveys between the Client and the Society's surveyor, the Society may designate another of its surveyors at the request of the Client.

11.2. - Disagreements of a technical nature between the Client and the Society can be submitted by the Society to the advice of its Marine Advisory Committee.

ARTICLE 12

12.1. - Disputes over the Services carried out by delegation of Governments are assessed within the framework of the applicable agreements with the States, international Conventions and national rules.

12.2. - Disputes arising out of the payment of the Society's invoices by the Client are submitted to the Court of Nanterre, France.

12.3. - **Other disputes over the present General Conditions or over the Services of the Society are exclusively submitted to arbitration, by three arbitrators, in London according to the Arbitration Act 1996 or any statutory modification or re-enactment thereof. The contract between the Society and the Client shall be governed by English law.**

ARTICLE 13

13.1. - **These General Conditions constitute the sole contractual obligations binding together the Society and the Client, to the exclusion of all other representation, statements, terms, conditions whether express or implied. They may be varied in writing by mutual agreement.**

13.2. - The invalidity of one or more stipulations of the present General Conditions does not affect the validity of the remaining provisions.

13.3. - The definitions herein take precedence over any definitions serving the same purpose which may appear in other documents issued by the Society.

BV Mod. Ad. ME 545 k - 17 December 2008

GUIDANCE NOTE NI 572

NI 572

Classification and Certification of Floating Offshore Wind Turbines

SECTION 1 FLOATING OFFSHORE WIND TURBINES - THE FLOATING PLATFORM

APPENDIX 1 EXTRACTS FROM IEC 61400 SERIES -1 AND -3

November 2010

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SECTION 1 FLOATING OFFSHORE WIND TURBINES - THE FLOATING PLATFORM

1 General

1.1 Application

1.1.1 General

This Guidance Note gives requirements and recommendations for the classification of floating platforms designed as the support of Floating Offshore Wind Turbines (FOWT).

These requirements and recommendations are to be considered in addition to the relevant requirements of the IEC 61400-3: Wind turbines - Design requirements for offshore wind turbines, which are adopted for classification purposes.

The scope of this Guidance Note covers floating platforms supporting single- or multiple-turbines with horizontal or vertical axes.

1.1.2 Types of floating platforms

Three categories of floating platforms are considered inside of this Guidance Note:

- Ballast floating platforms that achieve stability by using ballast weights placed below a global buoyancy center, which creates a righting moment and high inertial resistance to pitch and roll and usually enough draft to offset heave motion
- Tension Leg Platforms (TLP), that achieve stability through the use of tendons
- Buoyancy floating platforms, that achieve stability by the use of distributed buoyancy, taking advantage of weighted water plane area for righting moment.

The classification of any other type of floating platform is to be considered by the Society on a case by case basis.

1.2 Definitions

1.2.1 Floating Offshore Wind Turbine (FOWT)

The FOWT is an electricity production unit using wind power, installed on a floating support, located off the coast.

The main components of the FOWT are:

- the rotor-nacelle assembly (RNA), blades included
- the tower
- the floating platform including its anchoring system.

The tower and the RNA constitute together the top-structure of the Floating Offshore Wind Turbine.

The floating platform and its anchoring system constitute together the sub-structure of the Floating Offshore Wind Turbine.

1.2.2 Society

Society means Bureau Veritas Classification Society with which the offshore unit is classed.

1.2.3 Rules

Rules means Rules to comply with as specified by this Guidance Note (see [1.3.2]).

1.2.4 Administration

Administration means the Government of the State responsible for or managing the area in which the floating offshore wind turbine is operating.

1.2.5 Owner

Owner means the Registered Owner or the Disponent Owner or the Manager or any other party having the responsibility to keep the floating offshore wind turbine seaworthy, having particular regard to the provisions relating to the maintenance of class.

1.2.6 Approval

Approval means the review by the Society of documents, procedures or other items related to classification / certification, verifying solely their compliance with the relevant Rules requirements, or other referential where requested. The reviewed plans and documents receive a formal approval with or without comments.

1.2.7 Additional class notation

An additional class notation expresses the classification of additional equipment or specific arrangement, which has been requested by the Interested Party.

1.2.8 Additional service feature

An additional service feature may be assigned to complete a service notation. It gives further precision regarding the type of service of the floating unit, for which specific rule requirements are applied.

1.3 Principles of classification and certification

1.3.1 Classification/certification process

The classification/certification process of a Floating Offshore Wind Turbine consists of:

- the certification of the turbine and its major components in accordance with International Standard IEC 61400-3, as referred to in [1.3.2] and/or national Regulations required by the Administration

- for the floating platform: the review of plans and calculations, surveys, checks and tests intended to demonstrate that rules requirements are met (refer to [1.3.2])
- the assignment of a classification notation according to [1.1], and the issue of a Certificate of Classification, where compliance with the Rules is found
- the periodical, occasional and class renewal surveys performed to record that the unit in service meets the conditions for maintenance of class.

An alternative approach, showing a level of performance equivalent to the Rules or agreed by the Administration, is authorized as far as the class is concerned, under reserve of the agreement of the Owner to accept any deviation from the Rules.

1.3.2 Rules

The various elements of the design, manufacture, assembly, installation, erection, commissioning, operation and maintenance of a floating offshore wind turbine are to meet the requirements of the present Guidance Note in addition to those stated in both:

- International Standard IEC 61400-3 Wind Turbines – Part 3: Design Requirements for Offshore Wind Turbines, whenever applicable for floating offshore wind turbine.
- Bureau Veritas Rules for the Classification of Offshore Units (NR445) hereafter referred to as Offshore Rules.

The risk based approach may be considered as an alternative or as a complement to Rules to support the adoption of deviations or modifications from the rules requirements. In such a case, the risk assessment documents are to be submitted and agreed by the Society.

1.3.3 National and International Regulations

Floating offshore wind turbines operating in national waters are to comply with the Administration rules in addition to the Society rules.

In case of disagreement between rules, the Administration rules will prevail on the Society rules, except when the later provide a higher safety level. In this case, decision will be taken in agreement between the Society and the Owner, on a case by case basis.

In case of application of statutory requirements, attention is drawn upon the necessary agreement of the flag and/or coastal Authorities.

1.4 Classification notations

1.4.1 General

Classification notation of a Floating Offshore Wind Turbine installation is composed by a structural type notation completed by a service notation **FOWT** and by any relevant additional class notation or additional service feature as defined under Offshore Rules.

1.4.2 Structural type notation

The type notation, as defined under Offshore Rules, Pt A, Ch 1, Sec 1 [4.3], may be one of the following: **TLP**, **SPAR**, **semi-submersible**, etc..

1.4.3 Additional class notation

Additional class notations are those defined in Offshore Rules, Pt A, Ch 1, Sec 2, [6].

1.4.4 Additional service feature

Additional service features are those defined in Offshore Rules. Pt A, Ch 1, Sec 2, [7]. For example, the additional service feature **POSA** may be assigned to units equipped with position anchoring equipment complying with the applicable requirements of Bureau Veritas' Guidance Note NI 493 "Classification of Mooring Systems for Permanent Offshore Units".

1.4.5 Site and transit notations

Site notation may be granted to the floating offshore wind turbine as referred to in Offshore Rules, Pt A, Ch 1, Sec 2 [5.1].

The notation **transit**, as defined in Offshore Rules, Pt A, Ch 1, Sec 2 [5.2.1], is to be completed by **transit - specific criteria**, when the criteria for the assessment in towing/transit phase are based on data and assumptions specified by the party applying for classification. These criteria are to be stated in the Design Criteria Statement, which is referred to on the unit's Classification Certificates.

Note 1: In the case of wet transit/towing (unit afloat) between the construction site and the intended site for operation, the unit is to be granted with the notation **transit - specific criteria**. Dry transit/towing of the unit is not covered by the notation **transit**.

1.5 Documents to be submitted

1.5.1 Plans and documents to be submitted for approval

They are including, at least, documents as follows:

- arrangements drawings
- structural drawings of the floating platform and of top-structures, RNA excluded
- details of anchoring system.

Structural plans of sub-structure are to show details of connections of the various parts and, in general, are to specify the materials used, including their manufacturing processes, welding procedures and heat treatments.

1.5.2 Plans and documents to be submitted for information

They are documents not directly concerned by Rules, but providing information necessary for the approval of the submitted plans and documents. These documents are not subjected to any assessment by the Society.

When direct calculation analyses are carried out by the Designer according to the rule requirements, they are to be submitted to the Society for information.

They are including documents, as follows:

- general description of the offshore wind turbine
- client's specifications
- reports on site specific conditions (soil data, metocean report, etc.)
- basic engineering documents, specifications of the installation
- detailed engineering documents prepared by the concerned Engineering Departments
- documents related with the wind turbine primary components (blades, rotor, bearings, gearbox, brakes, generator, etc.), providing, at least, data on their masses, inertias and stiffnesses.
- description of principles used on the control and safety systems
- calculation notes covering design load cases and other relevant parameters (including unit's installation conditions)
- supporting calculations as necessary to demonstrate the adequacy of the design for all relevant conditions.

1.5.3 Additional documents

The Society may request any additional document found relevant, during the course of the approval process.

1.6 Assembly, installation and erection

1.6.1 General

Survey of installation is performed on the basis of general provisions of Offshore Rules, and particularly those of Offshore Rules, Pt B, Ch 3, Sec 6.

The installation procedures prepared by the relevant Contractor are to be submitted to the Society for examination.

Installation tolerances are to be specified in the installation procedures, and duly taken into account in design calculations.

The installation operations are to be surveyed, including, but not limited to:

- installation of anchors
- deployment of mooring lines
- test loading of anchor and lines
- connection to floating platform and tensioning
- post-installation inspection of the system
- reviews and surveys address only the issues under the scope of classification, especially:
  - conformity of all components to classification requirements (as attested by Inspection Certificates)
  - integrity of installed parts
  - conformity to design of the system as installed.

Surveys include attendance of operations at site by the surveyor of the Society, following an agreed program.

The surveyor of the Society reviews records and other documentation of the installation operations, prior to the delivery of a Certificate.

2 External conditions

2.1 General

2.1.1 Floating offshore wind turbines are subject to environmental and electrical conditions that may affect their loading, durability and operation.

2.1.2 Normal and extreme external conditions are to be associated with normal design situations, fault design situations, and design situations during transportation, installation and maintenance of the floating offshore wind turbine. Combination of these conditions and design situations are used to check the structural integrity of the floating offshore wind turbine. They are used for the definition of design load cases, and are referring to:

- power production conditions, without failure of any component
- power production conditions, with occurrence of fault (mechanical or electrical faults)
- normal start up and shut down of the installation
- emergency shut down
- standstill or idle conditions, without occurrence of fault
- standstill or idle conditions, with occurrence of fault
- conditions during transport, assembly, maintenance and repair
- other conditions.

2.2 Environmental conditions

2.2.1 General

Environmental conditions are divided into wind conditions, marine conditions and other environmental conditions.

The calculation of environmental data for the extreme (severe storm) conditions and the methods by which the maximum loads are evaluated for waves, wind, current, and for water level when relevant, are to be based on return periods of:

- 50 years, for floating platform
- 100 years, for anchoring system.

Note 1: The return period of 1 year may be required for the design of the top-structure, according to IEC 61400-3

2.2.2 Environmental conditions at site

Environmental conditions at the floating offshore wind turbine site are to be assessed as the basis of design and/or design verification according to Chapter 12 of IEC 61400-3.

The external conditions taken as the basis of the design of an offshore wind turbine are to be stated clearly in the design documentation.

2.3 Electrical power network conditions

2.3.1 Electrical conditions are referring to network conditions.

2.3.2 Normal electrical power network conditions are defined based on reference range values for parameters such as: nominal voltage, nominal frequency, voltage imbalance, auto-reclosing cycles and outages, as given under [6.6] of IEC 61400-3.

3 Principles of structural design

3.1 General

3.1.1 Design basis

The purpose of structural design calculations is to keep the probability of limit states being reached below certain values prescribed for the type of the FOWT structures (as per the ISO standard 2394). These limit states are divided into the following two categories:

- ultimate limit states, which correspond to the maximum load-carrying capacity or, in some cases, to the maximum applicable strain or deformation
- serviceability limit states, which concern the normal use.

The structural design consists on the verification of the structural integrity of the load-carrying components. The ultimate, buckling and fatigue strengths of structural members are to be verified by calculations and/or tests to demonstrate the structural integrity of the FOWT with the appropriate safety level.

3.1.2 Partial safety factors

The uncertainties and variabilities in loads and materials are to be defined by partial safety factors for loads and materials, for ultimate limit state analysis, buckling and fatigue failures.

The adopted values of safety factors are to be validated by:

- either making reference to values prescribed by recognized international standards, such as IEC 61400-3, whenever applicable,
- or by submitting a written technical report, with basic assumptions and methodology used for the calculation of these factors.

3.2 Design philosophy

3.2.1 General

The design of FOWT structures is considering the following categories of loads: fixed, operational, external (environmental and electrical), accidental, testing and temporary construction loads, as defined in Offshore Rules, Pt B, Ch 2, Sec 3.

Load combinations are to be considered on the basis of Offshore Rules, Pt B, Ch 2, Sec 3, [6], and by making a cross reference to minimum load cases given by:

- either recognized standards, such IEC 61400-3, whenever applicable
- or by specific technical report, stating on the minimum load cases to consider.

3.2.2 Design methodology - dynamic analyses

Design load cases for the overall strength of the FOWT are to be applied on a global dynamic model, which takes into account all main components of the structure, in view of capturing:

a) the global structural behaviour of both the top-structure and the sub-structure

b) any coupling effects caused by the simultaneous application of external loads (aerodynamic, hydrodynamic, electric, etc).

The choice of dynamic models for the implementation of the design procedure remains of the entire responsibility of the FOWT project-developer. He has to make sure that the adopted dynamic models take into account:

- any non linear behaviour of the structure
- any coupling effects due to simultaneous application of external loads.

If these effects are not considered as being relevant for the structure, in that case, the project-developer has to provide the technical evidences, either by the performance of tests or calculations.

Details of the design methodology are to be reported by the FOWT project-developer, who has also to demonstrate that:

a) the calculation of wind loads acting on the top-structure of the FOWT complies with IEC 61400-3

b) the calculation of loads acting on the sub-structure complies with the Offshore Rules, excepted for the wind loads

c) the load cases adopted for the design of the FOWT are defined on the basis of both:

   - minimum load cases required by IEC 61400-3
   - load combinations of Offshore Rules, given in Pt B, Ch 2, Sec 3.

The whole aspects listed hereabove are to be verified by the Society.

The input data required for the structural design of main components of both the top-structure and the sub-structure are obtained from global analyses carried out for relevant load cases. These results obtained from dynamic calculations, corrected to consider the load safety factors, are to be used on the scantling of main components of the FOWT.

3.2.3 Design methodology - exceptions

Quasi-static analyses may be accepted, on a case by case basis, by adopting relevant dynamic amplification factors, which are to be approved by the Society.

3.3 Load cases

3.3.1 General

Forces acting on the structure are calculated based on external conditions given under [2].

The FOWT is considered as a set of a floating platform with a top-structure of a special type, for which wind loads acting on the top-structure are to be calculated according to IEC 61400-3 standard.

A specific table of design load cases applicable to the FOWT is to be defined. This customised table of load cases has to contain, as a minimum, load conditions obtained from a cross analysis between the Offshore Rules and the IEC 61400 series -1 and -3. Special care is to be drawn, in view to avoid any ambiguity regarding the choice of applicable safety factors.

Main abbreviations used for the definition of wind and wave conditions as per IEC 61400 series -1 and -3, as well as, design load cases of IEC 61400-3, are reminded in App 1.

3.3.2 Load combinations from the Offshore Rules

Load combinations are to be considered for each of operating conditions corresponding to the structural type of the FOWT.

The Offshore Rules are considering:

a) load cases for overall strength calculation
   - load cases 1 “static” (still water)
   - load cases 2 “design” (with environment)
   - load cases 3 “accidental”
   - load cases 4 “testing”

b) load cases for fatigue evaluation, considering:
   - the various operating conditions of the unit
   - the direction and the intensity of environmental actions

c) local loads of different natures, which are to be combined to generate local loads qualified as, “static”, “design”, “accidental” or “testing”.

Load case named “static”, as listed under a) hereabove, is associated to a stability load case, and is to be considered under that topic, in [4].

3.3.3 Wind loads acting on the top-structure

Load cases acting on the top-structure, composed by the tower and rotor nacelle assembly (RNA), are to be defined in terms of wind conditions for the specific site, according to IEC 61400-1.

These conditions are referring to wind models for:

- normal wind profile
- normal turbulence
- extreme wind speed
- extreme operating gust
- extreme direction change
- extreme coherence gust
- extreme coherent gust with direction change
- extreme wind shear.

These calculations may be completed by full scale measurements.

3.3.4 Loads acting on the sub-structure

Loads acting on the sub-structure are to comply with Offshore Rules. They are including:

- wave loads
- current loads
- inertia loads
- ice and snow
- vortex shedding
- local pressure on hull and exposed decks
- slamming

All of these hereabove listed items are those given under the Offshore Rules, Pt B, Ch 2, Sec 3, [3], wind loads excluded.

3.3.5 Accidental load cases

Accidental load cases to be considered for the design of the floating offshore wind turbines are those referred to in:

- IEC 61400-3
- Offshore Rules, Pt B, Ch 2, Sec 3, [6.3.4].

Accidental load cases from the Offshore Rules are based on loads referred to in Offshore Rules, Pt B, Ch 2, Sec 3, [1.5] and [4]. They make reference to events, such as:

- collisions by supply boats or other craft
- impact by dropped objects
- breaking of mooring lines.

Any other accidental load cases may be considered on a case by case basis.

4 Stability and subdivision

4.1 General

4.1.1 Scope

Stability and watertightness of floating offshore wind turbine are to comply with applicable requirements of Offshore Rules, Part B, Chapter 1, or subject to a preliminary agreement, in accordance with other particular specifications based on the same principles or relevant National or International Regulations, assuming the environmental conditions specified in [2].

4.1.2 Stability conditions

Stability is to be assessed for intact conditions.

Damage stability is to be considered according to Offshore Rules, except for the cases of explicit exclusion given in the terms of the contract, and approved by National Authorities.

4.1.3 Stability criteria

The stability criteria are those stated in Offshore Rules, Pt B, Ch 1, Sec 3.

5 Structural design: top-structure and sub-structure

5.1 Scantling procedure

5.1.1 General

The scantling of main components of a FOWT is based on the results obtained from global dynamic analyses described in [3.2.2].

These results are given either in terms of external forces or in terms of motions and accelerations to be applied on the different components of the structure. They are to be used as input data for the structural design.

Several calculation runs are to be performed for each of these main components, to take into consideration all relevant load combinations defined in [3.3].

5.2 Design criteria

5.2.1 General

Design criteria are to be based on the Offshore Rules, by taking into consideration the partial load-safety factors customised for the specific project, according to [3.1.2].

5.3 Top-structure

5.3.1 General

The design of the top-structure is to consider the following aspects:

a) structural integrity of main components of the top-structure, including the tower, rotor, blades, and nacelle

b) structural integrity of connecting parts between the top-structure and the sub-structure

c) wind turbine robustness to face motions and accelerations induced by the floating platform

The scantling of the the tower, rotor, blades, and nacelle are not covered by the present Guidance Note. However, the input data required for the performance of these scantlings are to be obtained according to this Guidance Note, as indicated in [5.1.1].

5.3.2 Structural integrity of connecting parts

Connecting parts are parts ensuring the liason between the top-structure and the sub-structure, i.e. they ensure the transmission of loads between the base of the tower and the structure of the floating platform.

The scantling of these parts are to be made by using input data as described in [5.1.1]

5.3.3 Loads induced by motions and accelerations of the floating platform

Motions and accelerations of the floating offshore platform are to be taken into account by the manufacturer of the wind turbine, to confirm the adequacy of the wind turbine to operate under these operating conditions.

These loads are to be expressed in terms of motions and accelerations, to be calculated on the basis of global analyses described in [3.2.2].

5.4 Sub-structure

5.4.1 General

The sub-structure is constituted by the floating platform and by its anchoring system.

Based on results of global dynamic analyses described in [3.2.2], for which external loads are considered simultaneously, the structural design of the major components is to be performed according to the Offshore Rules.

For the performance of design calculations, the partial safety factors, as described in [3.1.2], are to be taken into account.

5.4.2 The floating platform

The design of the floating platform is to be performed based on the Offshore Rules.

5.4.3 Anchoring system

The assessment of main components of mooring lines are to be performed in accordance with NI 493 "Classification of Mooring Systems for Permanent Offshore Units".

The main components of mooring lines are those listed in NI 493, Sec 4, under [1.2.1]. They include:

a) main line components, such as:
   - chain cables and standard fittings
   - steel wire ropes and terminations
   - fibre ropes

b) non-standard fittings and connectors

c) anchors

d) equipment items, such as fairleads and stoppers

e) ancillary components (buoys, sinkers).

APPENDIX 1 EXTRACTS FROM IEC 61400 SERIES -1 AND -3

1 Design load cases

1.1 General

1.1.1 Main abbreviations used on the definition of minimum design load cases (DLC) of the IEC 61400-3, and tables containing these DLC, are given under this appendix.

1.2 Main abbreviations from these IEC series

1.2.1 Three lists of abbreviations with their associated meanings, for terms used on the definition of minimum load cases from both IEC 61400 series -1 and -3 are given hereafter. These lists are referring to wind and marine (waves-current) conditions and general terms. Wind conditions are defined inside of IEC 61400-1, and referred to in boths series -1 and -3. Waves and current conditions are defined inside of IEC 61400-3. General terms are adopted by both IEC 61400 series -1 and -3.

a) Wind conditions:
- ECD: Extreme coherent gust with direction change
- EDC: Extreme direction change
- EOG: Extreme operating gust
- EWM: Extreme wind speed model
- EWS: Extreme wind shear
- NTM: Normal turbulence model
- ETM: Extreme turbulence model
- NWP: Normal wind profile model

b) Marine - waves and current conditions:
- COD: Co-directional
- ECM: Extreme current model
- ESS: Extreme sea state
- EWH: Extreme wave height
- EWLR: Extreme water level range
- MIS: Misaligned
- MSL: Mean sea level
- MUL: Multi-directional
- NCM: Normal current model
- NWH: Normal wave height
- NWLR: Normal water level range
- NSS: Normal sea state
- RWH: Reduced wave height
- RWM: Reduced wind speed model
- SSS: Severe sea state
- SWH: Severe wave height
- UNI: Uni-directional

c) General terms:
- DLC: Design load case
- Subscript: Recurrence period in years
- F: Fatigue
- U: Ultimate strength
- N: Normal
- A: Abnormal
- T: Transport and erection
- *: Partial safety factor for fatigue

1.3 Design load cases (ice excluded)

1.3.1 A list of the minimum design load cases from IEC 61400-3 Ch 7 is given in Tab 1, with load cases for ice not included.

1.4 Design load cases for sea ice

1.4.1 A list of the minimum design load cases for sea ice, according to the IEC 61400-3 Ch 7 is given in Tab 2.

Table 1 : Design load cases (DLC)

DLC	Wind condition	Waves	Wind and wave directionality	Sea currents	Water level	Other conditions	Type of analysis	Partial safety factor
1) Design situation: power production								
1.1	NTM $V_{in} < V_{hub} < V_{out}$ RNA	NSS $H_s = E [H_s \mid V_{hub}]$	COD, UNI	NCM	MSL	For extrapolation of extreme loads on the RNA	U	N (1,25)
1.2	NTM $V_{in} < V_{hub} < V_{out}$	NSS H_s, Tp, V_{hub}	COD, MUL	No currents	NWLR or ≥ MSL		F	*

DLC	Wind condition	Waves	Wind and wave directionality	Sea currents	Water level	Other conditions	Type of analysis	Partial safety factor
1.3	ETM $V_{in} < V_{hub} < V_{out}$	NSS $H_s = E [H_s \mid V_{hub}]$	COD, UNI	NCM	MSL		U	N
1.4	ECD $V_{hub} = Vr - 2$ m/s, Vr, Vr + 2 m/s	NSS $H_s = E [H_s \mid V_{hub}]$	MIS, wind direction change	NCM	MSL		U	N
1.5	EWS $V_{in} < V_{hub} < V_{out}$	NSS $H_s = E [H_s \mid V_{hub}]$	COD, UNI	NCM	MSL		U	N
1.6a	NTM $V_{in} < V_{hub} < V_{out}$	SSS $H_s = H_{s,SSS}$	COD, UNI	NCM	NWLR		U	N
1.6b	NTM $V_{in} < V_{hub} < V_{out}$	SWH $H = H_{SWH}$	COD, UNI	NCM	NWLR		U	N
2) Design situation: power production plus occurrence of fault								
2.1	NTM $V_{in} < V_{hub} < V_{out}$	NSS $H_s = E [H_s \mid V_{hub}]$	COD, UNI	NCM	MSL	Control system fault or loss of electrical network	U	N
2.2	NTM $V_{in} < V_{hub} < V_{out}$	NSS $H_s = E [H_s \mid V_{hub}]$	COD, UNI	NCM	MSL	Protection system or preceding internal electrical fault	U	A
2.3	EOG $V_{hub} = Vr \pm 2$ m/s and V_{out}	NSS $H_s = E [H_s \mid V_{hub}]$	COD, UNI	NCM	MSL	External or internal electrical fault including loss of electrical network	U	A
2.4	NTM $V_{in} < V_{hub} < V_{out}$	NSS $H_s = E [H_s \mid V_{hub}]$	COD, UNI	No currents	NWLR or ≥ MSL	Control, protection, or electrical system faults including loss of electrical network	F	*
3) Design situation: start up								
3.1	NWP $V_{in} < V_{hub} < V_{out}$	NSS $H_s = E [H_s \mid V_{hub}]$	COD, UNI	No currents	NWLR or ≥ MSL		U	*
3.2	EOG $V_{hub} = V_{in}$, $Vr \pm 2$ m/s and V_{out}	NSS $H_s = E [H_s \mid V_{hub}]$	COD, UNI	NCM	MSL		U	N
3.3	EDC_1 $V_{hub} = V_{in}$, $Vr \pm 2$ m/s and V_{out}	NSS $H_s = E [H_s \mid V_{hub}]$	MIS, wind direction change	NCM	MSL		U	N
4) Design situation: normal shut down								
4.1	NWP $V_{in} < V_{hub} < V_{out}$	NSS $H_s = E [H_s \mid V_{hub}]$	COD, UNI	No currents	NWLR or ≥ MSL		F	*
4.2	EOG $V_{hub} = Vr \pm 2$ m/s and V_{out}	NSS $H_s = E [H_s \mid V_{hub}]$	COD, UNI	NCM	MSL		U	N
5) Design situation: emergency shut down								
5.1	NTM $V_{hub} = Vr \pm 2$ m/s and V_{out}	NSS $H_s = E [H_s \mid V_{hub}]$	COD, UNI	NCM	MSL		U	N

DLC	Wind condition	Waves	Wind and wave directionality	Sea currents	Water level	Other conditions	Type of analysis	Partial safety factor
6) Design situation: parked (standing still or idling)								
6.1a	EWM turbulent wind model $V_{hub} = k_1 V_{ref}$	ESS $H_s = k_2 H_{s50}$	MIS, MUL	ECM	EWLR		U	N
6.1b	EWM steady wind model $V(z_{hub}) = V_{e50}$	RWH $H = H_{red50}$	MIS, MUL	ECM	EWLR		U	N
6.1c	RWM steady wind model $V(z_{hub}) = V_{red50}$	EWH $H = H_{50}$	MIS, MUL	ECM	EWLR		U	N
6.2a	EWM turbulent wind model $V_{hub} = k_1 V_{ref}$	ESS $H_s = k_2 H_{s50}$	MIS, MUL	ECM	EWLR	Loss of electrical network	U	A
6.2b	EWM steady wind model $V(z_{hub}) = V_{e50}$	RWH $H = H_{red50}$	MIS, MUL	ECM	EWLR	Loss of electrical network	U	A
6.3a	EWM turbulent wind model $V_{hub} = k_1 V_1$	ESS $H_s = k_2 H_{s1}$	MIS, MUL	ECM	NWLR	Extreme yaw misalignment	U	N
6.3b	EWM steady wind model $V(z_{hub}) = V_{e1}$	RWH $H = H_{red1}$	MIS, MUL	ECM	NWLR	Extreme yaw misalignment	U	N
6.4	NTM $V_{hub} < 0,7 V_{ref}$	NSS H_s, Tp, V_{hub}	COD, MUL	No currents	NWLR or ≥ MSL		F	*

7) Design situation: parked and fault conditions								
7.1a	EWM turbulent wind model $V_{hub} = k_1 V_1$	ESS $H_s = k_2 H_{s1}$	MIS, MUL	ECM	NWLR		U	A
7.1b	EWM steady wind model $V(z_{hub}) = V_{e1}$	RWH $H = H_{red1}$	MIS, MUL	ECM	NWLR		U	A
7.1c	RWM steady wind model $V(z_{hub}) = V_{red1}$	EWH $H = H_1$	MIS, MUL	ECM	NWLR		U	A
7.2	NTM $V_{hub} < 0,7 V_1$	NSS H_s, Tp, V_{hub}	COD, MUL	No currents	NWLR or ≥ MSL		F	*

8) Design situation: transport, assembly, maintenance and repair								
8.1	To be stated by the manufacturer						U	T
8.2a	EWM turbulent wind model $V_{hub} = k_1 V_1$	ESS $H_s = k_2 H_{s1}$	COD, UNI	ECM	NWLR		U	A
8.2b	EWM steady wind model $V_{hub} = V_{e1}$	RWH $H = H_{red1}$	COD, UNI	ECM	NWLR		U	A
8.2c	RWM steady wind model $V(z_{hub}) = V_{red1}$	EWH $H = H_1$	COD, UNI	ECM	NWLR		U	A
8.3	NTM $V_{hub} < 0,7 V_{ref}$	NSS H_s, Tp, V_{hub}	COD, MUL	No currents	NWLR or ≥ MSL	No grid during installation period	F	*

Table 2 : Design load cases (DLC) for sea ice

DLC	Ice condition	Wind condition	Water level	Type of analysis	Partial safety factors
Design situation: power production					
E_1	Horizontal load from temperature fluctuations	NTM V_{hub} = Vr ± 2 m/s and V_{out} Wind speed resulting in maximum thrust	NWLR	U	N
E_2	Horizontal load from water fluctuations or arch effect	NTM V_{hub} = Vr ± 2 m/s and V_{out} Wind speed resulting in maximum thrust	NWLR	U	N
E_3 For extrapolation of extreme events	Horizontal load from moving ice floe at relevant velocities $H = H_{50}$ in open sea $H = H_m$ for land-locked waters	NTM V_{hub} = Vr ± 2 m/s and V_{out} Wind speed resulting in maximum thrust	NWLR	U	N
E_4	Horizontal load from moving ice floe at relevant velocities $H = H_{50}$ in open sea $H = H_m$ for land-locked waters	$V_{in} < V_{hub} < V_{out}$	NWLR	F	*
E_5	Vertical force from fast ice covers due to water level fluctuations	No wind load applied	NWLR	U	N
Design situation: parked					
E_6	Pressure from hummocked ice and ice ridges	EWM Turbulent wind model $V_{hub} = V_1$	NWLR	U	N
E_7	Horizontal load from moving ice floe at relevant velocities $H = H_{50}$ in open sea $H = H_m$ for land-locked waters	NTM $V_{hub} < 0,7\ V_{ref}$	NWLR	F	*

Achevé d'imprimer sur les presses d'Activ'Company
77 bd Exelmans - 75016 Paris (France)
Novembre 2010