GUIDELINE

NKRE-GL-FOWT01

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ClassNK

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Guidelines for Floating Offshore Wind Turbines

— Classification Survey —

RENEWABLE ENERGY

Revision History

I. July 2012 New issue

II. December 27, 2021 New issue (Document No.: NKRE-GL-FOWT01, Edition: December 2021)

- Added the document number
- Added the subtitle (Classification Survey for Floating Offshore Wind Turbines) to the document title
- Unification of the overall document appearance to a new format
- Full revision based on the following reference standards and specifications
  - Technical Standards for Floating Offshore Wind Power Generation (Safety Policy Division, Maritime Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Kokkaian No. 286, March 3, 2020)
  - IEC TS 61400-3-2: 2019
  - IEC 61400-3-1: 2019
  - IEC 61400-1: 2019
  - IEC 61400-6: 2020

* Correction of error and Minor change have applied on March 31, 2022 (No change of Document No.)

Supplementary Provisions

1. These guidelines shall be effective from January 1, 2022.
2. In the case of vessels other than those falling under the following items, the provisions then in force shall remain applicable regardless of the provisions of these guidelines.
   (1) FOWT for which the application for a classification survey during manufacturing, etc., is accepted on or after April 1, 2022

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Chapter 1 General

1.1 General

1.1.1 Application

-1. These guidelines specify the requirements for the materials, welding, stability, structure, equipment, machineries, electrical equipment, mooring system, and waterline of offshore wind power generation vessels as defined in Part P of the Rules for the Survey and Construction of Steel Ships (including RNA, tower and mooring system referred to as "FOWT" in this guideline) which are continuously moored at designated sites during their service life .

-2. In principle, these guidelines shall apply to floating substructures which are unmanned except at the time of maintenance or surveys.

-3. These guidelines assume FOWT that are installed in a sea area with a water depth where the facilities are not affected by shallow sea. If the floating substructure is installed in a sea area where the effect of the shallow sea cannot be ignored, its effect shall be appropriately considered.

-4. In addition to the provisions of these guidelines, attention must also be paid to compliance with the domestic laws and regulations for the sea area where the FOWT will be installed.

1.1.2 Equivalent efficacy

-1. A FOWT that does not comply with some of the provisions of this guideline may be considered to comply with these guidelines in cases where ClassNK considers the efficacy to be equal to or greater than that for items that comply with the provisions of these guidelines.

1.1.3 FOWT with new concepts

-1. For FOWT that is a different type or is equipped with equipment different from those specified in these guidelines, the structures, equipment, and equipment shall be evaluated individually in accordance with the basic way of thinking behind the provisions of these guidelines. However, a separate risk assessment shall be performed.

1.1.4 Design life and service life

-1. The design life of the FOWT shall be either the number of years of service life in the design specifications for the RNA installed, or 20 years, whichever is greater.

-2. This guideline assume that the service life for the FOWT is 20 years. It shall be noted that if the service life assumed in the design exceeds 20 years, then additional consideration will be required according to that period.

1.1.5 Wind turbines (RNA)

-1. The RNA on the FOWT shall be ones which ClassNK has recognized as appropriate.

-2. The RNA that ClassNK has recognized to be appropriate as referred to in -1. above shall be able to satisfy that requirement by obtaining wind farm certification. In the case of FOWTs for demonstration for testing, it shall be acceptable to obtain prototype certification instead of wind farm certification.

1.1.6 Machineries and electrical equipment installed on floating substructure

-1. The machineries and electrical equipment relating to the safety of the floating substructure shall comply with the provisions of Part D and Part H of the Rules for the Survey and Construction of Steel Ships.

1.1.7 Fire extinguishing equipment

-1. Appropriate fire extinguishing equipment shall be provided as appropriate for the machineries and electrical equipment installed on the floating substructure.

1.2 Normative references

1.2.1 General

-1. Where an anno domini year is specified? for the following standards and guidelines, the version of the year mentioned shall apply, and subsequent revised versions (including Supplements) shall not apply. If there is no anno domini year written for a normative reference, the most recent version (including Supplements) shall apply.

[J-01] Technical Standards for Floating Offshore Wind Power Generation (Safety Policy Division, Maritime Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Kokkaian No. 286, March 3, 2020)

-2. In order to meet the requirements of the standard listed in -1. above, the following standards referenced by this guideline shall form part of the provisions. Where an anno domini year is written for these normative references, the version of the year mentioned shall apply, and subsequent revised versions (including Supplements) shall not apply. If there is no anno domini year written for a normative reference, the most recent version (including Supplements) shall apply.

[R-01] NKRE-GL-WFC01 Wind Farm Certification Onshore Wind Power Plant Edition, July 2021 edition

[R-02] IEC TS 61400-3-2: 2019 : Wind energy generation system
Part 3-2: Design requirements for floating offshore wind turbines

[R-03] IEC 61400-3-1: 2019 : Wind energy generation system
Part 3-1: Design requirements for fixed offshore wind turbines

[R-04] IEC 61400-1: 2019 : Wind energy generation system
Part 1: Design requirements

[R-05] IEC 61400-6:2020 : Wind energy generation systems
Part 6: Tower and foundation design requirements

[R-06] Ministerial Ordinance Prescribing Technical Standards for Wind Power Generation Facilities (Ministry of Economy, Trade and Industry, Ordinance of the Ministry of International Trade and Industry No. 53 of 1997, final revision: Ordinance of the Ministry of Economy, Trade and Industry No. 32 of March 31, 2017)

[R-07] Interpretation of Technical Standards for Wind Power Generation Facilities (Ministry of Economy, Trade and Industry, No. 20140328, Bureau of Commerce No. 1, April 1, 2014)

[R-08] Annotations to the Ministerial Ordinance Prescribing Technical Standards for Wind Power Generation Facilities and its Interpretation (Ministry of Economy, Trade and Industry, revised on June 21, 2021)

[R-09] Official Explanation of Technological Standards for Offshore Wind Power Generation Facilities (March 2020 edition) (Committee on Study of Developing Offshore Wind Power Generation Facilities)

1.3 Definitions and abbreviations

1.3.1 Terms and definitions

-1. The definitions of the key terms used in these guidelines are given in Table 1-1.

Table 1-1 Definition of terms

No.	Term	Definition
1	Co-directional (of wind and waves)	Acting in the same direction.
2	Current	The flow of water past a fixed location, usually indicated by its speed and direction
3	Design wave	A deterministic wave with a defined height, period and direction, used in the design of floating substructures and towers. The design wave may be accompanied by a requirement for the use of a particular periodic wave theory.
4	Designer	The party or parties responsible for the design of a FOWT
5	Environmental conditions	Environmental characteristics (wind, waves, flow, water level, sea ice, marine growth, scour, overall seabed movement, etc.) that may affect the behavior of a FOWT.
6	External conditions (of floating substructures and towers)	Factors affecting offshore wind turbines, including the environmental conditions and other meteorological factors (temperature, snow, ice, etc.).
7	Extreme significant wave height	The expected value of the significant wave height extrapolated from the extreme value distribution of significant wave heights at the site, where the

No.	Term	Definition
		annual probability of exceedance is 1/N ("return period": N years)
8	Extreme wave height	The expected value of the highest individual wave height (generally the zero up-crossing wave height) with an annual probability of exceedance of 1/N ("return period": N years)
9	Fast ice cover	A rigid and continuous cover of motionless ice
10	Fetch	The distance over which the wind blows over the sea with approximately constant wind speed and wind direction
11	Highest astronomical tide	The highest still water level that can be predicted to occur under any combination of astronomical conditions and average meteorological conditions. Storm surges, which are meteorologically generated and essentially irregular, are superimposed on the tidal changes, so a total still water level that exceeds the highest astronomical tide may occur.
12	Hub height (of a wind turbine)	The height of the center of the wind receiving area of the wind turbine rotor above the mean sea level
13	Hummocked ice	Ice shards and ice floes piled up into ridges when large ice floes meet with each other or with a rigid obstacle, for example a floating substructure
14	Ice floe	A sheet of ice several meters to several kilometers in size that is not firmly frozen to a shore, either still or in motion
15	Icing	A build-up of a cover of ice or frost on parts of an offshore wind turbine that can result in an increased load and/or changed properties
16	Load effect	The effect of a single load or combined loads on a structural component or system. Internal force, stress, strain, motion, etc.
17	Lowest astronomical tide	The lowest still water level that can be predicted to occur under any combination of astronomical conditions and average meteorological conditions. Storm surges, which are meteorologically generated and essentially irregular, are superimposed on the tidal changes, so a total still water level that is below the lowest astronomical tide may occur.
18	Manufacturer	The party or parties responsible for the design/manufacture/construction of FOWT
19	Marine conditions	Characteristics of the marine environment (waves, sea currents, water level, sea ice, marine growth, seabed movement, scour, etc.) that may affect the behavior of wind turbines
20	Marine growth	Surface coating on structural components (including members) caused by plants, animals and microorganisms
21	Metocean	An abbreviation for meteorological and oceanographic
22	Multi-directional (of wind or waves)	A distribution of directions
23	Floating offshore wind turbine (FOWT)	A structure consisted of RNA, tower, floating substructure and mooring system
24	Floating offshore wind turbine site	The general term for the location or planned location of individual offshore wind turbines either alone or within a wind farm
25	Reference period	A period during which stationarity is assumed for a given stochastic process, such as wind speed, sea level or response
26	Rotor-nacelle assembly (RNA)	The part of the wind turbine that is supported by support structure
27	Sea floor	The interface between the sea and the seabed
28	Sea floor slope	The local gradient of the sea floor. For example, that related to a beach.
29	Sea state	The condition of the sea in which its statistics remain stationary
30	Seabed	Underneath the sea floor
31	Seabed movement	The movement of the seabed due to natural geological action
32	Scour	The removal of the seabed soil by currents and waves, or caused by structural elements interrupting the natural flow conditions above the sea floor
33	Significant wave height	A statistical measure of the height of waves in a sea state, defined as either the average height of the highest one third of the zero up-crossing waves, or as the height equivalent to $4\sigma_\eta$ when σ_η is the standard deviation of the sea surface elevation. When distinction is necessary, the former height is called the statistical significant wave height, and the latter height is called the spectrum

No.	Term	Definition
		significant wave height. Note: Normally, the former height is represented by $H_{1/3}$, and the latter height is represented by H_s or H_{m0}. In deep sea, $H_{1/3} \approx 0.956 H_s$ on average, regardless of the shape of the wave spectrum. (ISO 21650:2007) (Refer to IEC61400-3-1[R-03] Footnote 3) Also, in IEC61400-3-1[R-03] Annex B, $H_{1/3} = H_s$ when the Goda equation is applied.
34	Splash zone	The outer part of a floating substructure that is frequently wetted by waves and tidal variations. It is defined as the zone between the highest still water level with a return period of one year increased by the crest height of a wave with height equal to the significant wave height with a return period of one year, and the lowest still water level with a return period of one year reduced by the trough depth of a wave with height equal to the significant wave height with a return period of one year. In the case of a floating substructure that has a constant draft even when the water level changes, the splash zone may be considered to be 5 m above and 4 m below the still water level.
35	Still water level	The abstract water level calculated by including the effects of tides and storm surges, but excluding the changes due to waves. The still water level may be above, at, or below the mean sea level.
36	Storm surge	An irregular movement of the sea caused by changes in the wind and/or atmospheric pressure
37	Floating substructure	A floating structure on which RNA and tower are mounted (Figure 1-1)
38	Tidal current	Current resulting from tides
39	Tides	The regular and predictable movements of the sea caused by astronomical forces
40	Tower	The part between a floating substructure and a rotor-nacelle assembly
41	Tsunami	A long-period sea wave caused by a rapid vertical movement of the sea floor
42	Uni-directional (of wind or waves)	Acting in a single direction.
43	Water depth	The vertical distance between the sea floor and the still water level. As there are several options for the still water level, there may be more than one value for the water depth.
44	Wave crest elevation	The vertical distance between the crest of a wave and the still water level
45	Wave direction	The mean direction in which a wave travels.
46	Wave height	The vertical distance between the highest and lowest points on the water surface of an individual zero-up-crossing wave.
47	Wave period	The time interval between the two zero up-crossings which bound a zero up-crossing wave
48	Wave spectrum	A frequency-domain description of the sea surface elevation in a sea state
49	Zero up-crossing wave	The portion of the time history of wave elevation between zero up-crossings. The zero up-crossing point is the point at which the sea surface rises (rather than falls) through the still water level.
50	Type of floating substructure	The types of floating substructure in these guidelines are shown in Table 1-2.
51	Mooring system	This is the equipment used to hold a floating substructure for a long period of time or permanently at the predetermined position in the sea area of installation. Mooring systems are generally classified into the types shown in Table 1-3
52	Mooring facilities	The mooring facilities are the facilities connected to the mooring system for a floating substructure. They are separate structures independent of the floating substructure and may consist of a large buoy in CALM, a mooring structure in SALM, fixed structures such as dolphins and jackets, or sinkers/piles laid onto the seabed.
53	Weathertight	Weathertight means that wind, rain and sea water will not penetrate the floating substructure or tower in any sea conditions.
54	Watertight	Watertight means that under the water pressure for which the surrounding structure is designed, water will not pass through that structure in any

No.	Term	Definition
		direction.
55	Downflooding	Downflooding is any flooding of the interior of any part of the buoyant structure of the floating substructure through openings which cannot be closed watertight or weathertight, as appropriate, in order to meet the intact or damage stability criteria, or which are required for operational reasons to be left open.
56	Lift facilities	Lift facilities means elevators and other elevating equipment.
57	Elevator	An elevator is elevating equipment with a cage structure that moves up and down along rails.
58	Support structure	The structure that supports RNA and consists of tower, floating substructure and mooring system.

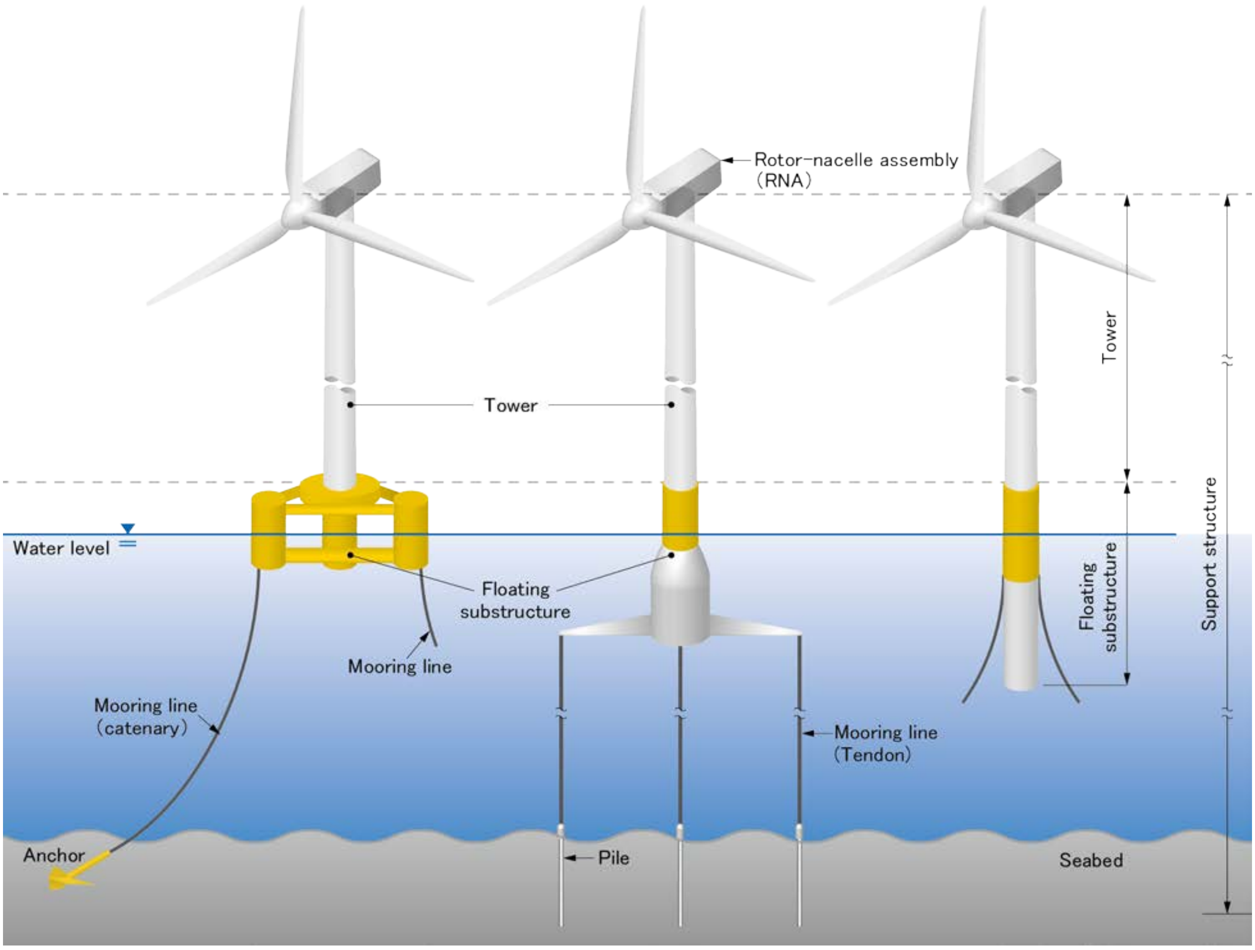

Figure 1-1 Floating substructure definitions

Table 1-2 Definition of floating substructure types

No.	Type of floating substructure	Definition
1	Semi-submersible type	A type which is submerged to a given draft to be in a semi-submerged state and consists of parts such as a deck on which RNA and tower are installed, a column, a footing or a lower hull, and bracings.
2	Barge type	A displacement type such as a normal barge.
3	Spar type	A type which has a large part of the buoyant body submerged and the water plane made smaller by extending the buoyant body in the vertical direction.
4	Tension leg platform (TLP) type	A type that is moored using the tensile force generated by forced buoyancy when a floating substructure that is semi-submerged forcibly is connected to the seabed with a tension mooring line.
5	Others	Types other than No. 1 to No. 5.

Table 1-3 Classification of mooring system

No.	Mooring system	Definition
1	Spread Mooring System (SMS)	A system consisting of multiple mooring lines that are lashed to piles, or sinkers, etc., on the seabed, where the ends of each mooring line are individually connected to winches or stoppers on the floating substructure. These are classified into the types in (1) to (3) below. (1) Catenary Mooring (CM) This refers to mooring when the mooring force is obtained mainly from the dead weight of a catenary mooring line (or for those with an intermediate buoy or an intermediate sinker, from their buoyancy or dead weight). Here, "mooring line" refers to a chain, wire rope, synthetic fiber rope or combination thereof for the purpose of maintaining the position of a floating substructure, as well as to any connectors such as shackles, and intermediate buoys or intermediate sinkers, etc., but excludes mooring facilities such as piles and sinkers that are located on the seabed. (2) Taut Mooring (TM) This refers to mooring when the mooring force is obtained from the elongation of mooring lines that are put under tension by adjusting the initial tension. Here, the mooring line is as defined in (1) above. (3) Tension Mooring System (TMS) This is mooring composed of support foundations such as piles or sinkers installed on the seabed, multiple tension mooring lines arranged in the vertical direction, and coupling equipment for attaching tension mooring lines to the floating substructure, where the aim is to firmly hold the heaving, rolling and pitching of the floating substructure with the tension of the mooring lines and with the increased buoyancy generated by pulling the floating substructure downward with the tension mooring lines. Here, tension mooring lines include mooring lines that are steel pipes, chains, wire ropes and synthetic fiber ropes, etc. The lines are arranged straight and under high tension conditions and the system mainly utilizes the high tensile force due to the elastic elongation of the lines.
2	Single Point Mooring (SPM)	A single point mooring system is in which weathervaning is possible, where the direction of the floating substructure changes with the wind direction and wave direction. The typical systems are as shown below. (1) CALM(Catenary Anchor Leg Mooring) CALM is a system with a large buoy that is connected to a seabed fixed point by a catenary mooring line. The floating substructure is moored to the buoy by a mooring line or a yoke structure. (2) SALM(Single Anchor Leg Mooring) SALM is a system using mooring structures with buoyancy located at or near the sea level. The floating substructure is moored to this

No.	Mooring system	Definition
		mooring structure by a rope or a yoke structure. The mooring structure itself is connected to the seabed. (3) Turret Mooring This is a system where the floating substructure has a turret with a structure which only allows the floating substructure to move in the rotational direction relative to the turret, so weathervaning is possible. The turret may be built into the floating substructure, or installed in front of or behind the floating substructure. The turret is generally connected to the seabed with a spread mooring system.
3	Others	Types other than No. 1 to No. 2.

1.3.2 Definition of abbreviations

-1. The definitions of the main abbreviations used in these guidelines are given in Table 1-4.

Table 1-4 Definition of abbreviations

No.	Abbreviations	Definition
1	COD	Co-directional
2	DLC	Design load case
3	ECD	Extreme coherent gust with direction change
4	ECM	Extreme current model
5	EDC	Extreme direction change
6	EOG	Extreme operating gust
7	ESS	Extreme sea state
8	ETM	Extreme turbulence model
9	EWLR	Extreme water level range
10	EWM	Extreme wind speed model
11	EWS	Extreme wind shear
12	HAT	Highest astronomical tide
13	LAT	Lowest astronomical tide
14	MIC	Microbiologically influenced corrosion
15	MIS	Misaligned
16	MSL	Mean sea level
17	MUL	Multi-directional
18	NCM	Normal current model
19	NSS	Normal sea state
20	NTM	Normal turbulence model
21	NWH	Normal wave height
22	NWLR	Normal water level range
23	NWP	Normal wind profile model
24	SSS	Severe sea state
25	SWL	Still water level
26	UNI	Uni-directional

1.3.3 Meaning and units of symbols

-1. The meanings and units of the main symbols used in these guidelines are specified in Table 1-5.

Table 1-5 Definition of symbols

Symbol	Meaning	Units
U	Ultimate	-
F	Fatigue	-
N	Normal	-
A	Abnormal	-

1.4 Installation

1.4.1 General

-1. The manufacturer of the FOWT shall prepare an installation procedure manual that specifies the requirements for the installation of the FOWT.

-2. The installation procedure shall be such that the work can be interrupted as necessary without endangering workers or applying unacceptable loads to the structure.

-3. A risk assessment shall be carried out if the FOWT is to be installed in a congested sea area or to be deployed on a large scale.

1.4.2 Documents to be submitted

-1. The manufacturer of the FOWT shall prepare the drawings, specifications and instructions for the installation and construction of the FOWT specified in 8.3. The manufacturer shall provide details of all loads, weights as well as special tools and procedures necessary to install the FOWT.

-2. In addition to -1. above, the manufacturer shall prepare a written instruction manual including the following items regarding the safety of the FOWT, and shall submit it to ClassNK for approval. The instruction manual shall be provided to the person responsible for the management of the FOWT. In addition, if there is any change to the instruction manual, an instruction manual on the relevant matter shall be prepared and similar measures shall be taken.

(1) General layout drawing
(2) Maintenance manual
(3) Crisis management manual
(4) Other data necessary for proper power generation

1.5 Maintenance and inspection

1.5.1 General

-1. The floating substructure and tower shall be equipped with a safe means of access for maintenance and inspection. The means of access shall comply with the relevant regional and national laws and regulations as well as international laws.

1.5.2 Design requirements for safe survey and maintenance

-1. The walkways and platforms on the floating substructure shall be located above the height that will be splashed with water during survey and maintenance operations. For safety, it is recommended to consider the removal of marine growth. When there is a risk of icing, restriction of access to ladders and platforms under icing conditions shall be considered. The risk of structural damage caused by falling ice shall also be considered.

-2. The design shall provide adequate clearance between the rotating blade tips and any walkway or platform.

-3. Facilities for helicopter landing and takeoff shall comply with all aspects of relevant national and international laws and regulations regarding the structural safety, clearance, fire protection and markings, etc., of landing platforms.

-4. Obstacle lights and markings for marine navigation and aviation shall comply with the relevant national and international laws and regulations.

-5. If the FOWT are equipped with lift facilities, it shall comply with the requirements specified in 5.7.

1.5.3 Maintenance manual

-1. A maintenance manual complying with 1.5.3 shall be prepared and included in the documents specified in 1.4.2-2. The document shall also be provided to the maintenance personnel.

-2. The maintenance and inspection procedures described in the maintenance manual shall have consider the safety of the personnel.

-3. It shall be clearly stated in the manual that the necessary safety measures for personnel who will enter enclosed compartments are that a person on standby is aware of the dangerous situation and is able to start a rescue immediately if necessary.

-4. The maintenance manual shall be written in a language that the personnel can understand.

-5. The maintenance manual shall contain at least the following items.

(1) Maintenance and inspection procedures
(2) Maintenance and inspection intervals
(3) Methods for safe access to the FOWT
(4) Actions during bad weather
(5) Monitoring procedures for marine growth
(6) Drawings of the installation and construction of the FOWT
(7) Emergency measures in accordance with 1.5.4

-6. The maintenance manual shall be accompanied by a maintenance and inspection record. The maintenance and inspection record shall include at least the following items.

(1) Outlines and dates of maintenance and inspection performed
(2) Outlines of any defects discovered and the dates and time of discovery
(3) Measures for defects
(4) Dates and time when a defect was repaired

1.5.4 Emergency procedures

-1. The emergency situations assumed shall be identified in the maintenance manual and the actions to be taken by the personnel shall be specified.

-2. The maintenance manual shall state that in the event of a fire, or when components or structure of the FOWT is damaged, it is desirable that no one approach the FOWT until the risk is clearly assessed.

Chapter 2 External conditions

2.1 General

2.1.1 General

-1. The loads. durability and operation of the FOWT are affected by environmental conditions. To ensure an appropriate level of safety and reliability, the parameters related to environmental conditions shall be properly considered in the design and specified in the design documents. The environmental conditions are mainly divided into wind conditions, marine conditions, earthquake and tsunami conditions, and other environmental conditions.

-2. For the geological features of the site, the impact of any changes in the geological features over time due to seabed deformation, scour or other seabed instabilities shall be given appropriate consideration in comparison with the specifications for the seabed fixed points.

-3. The external conditions are subdivided into the normal and the extreme categories. The normal external conditions are generally related to recurrent structural loading conditions. The extreme external conditions represent rare external design conditions. The design load cases shall consist of the external conditions, wind turbine operation modes and other design conditions, in the combinations that are considered to be important.

-4. The values of the basic design parameters shall be specified in the design documentation.

-5. In addition to the provisions of Part II, Chapter 1 of the Technical Standards for Floating Offshore Wind Power Generation [J-01], the external conditions shall also be calculated in accordance with the provisions of this chapter.

2.2 Wind conditions

2.2.1 General

-1. The FOWT shall be designed to safely withstand the wind conditions adopted as the design standards.

2.2.2 Wind conditions during wind turbine power production

-1. For the wind conditions during wind turbine power production, the following values at the hub height for each FOWT shall be calculated. When calculating by direction, the divisions shall be 30 degrees or less, and the representative value of all directions shall be demonstrated as the weighted average value based on both the distribution of the frequency of occurrence by direction and the probability distribution by direction of wind speed.

(1) Mean wind speed (Probability distribution for each direction, weighted average value of all directions/energy density distribution for each direction)

(2) Turbulence intensity [Normal turbulence model (NTM) and extreme turbulence model (ETM)] (by each direction / representative value)

(3) Wind shear exponent (by each direction / representative value)

(4) Flow inclination (by each direction / representative value)

(5) Air density

(6) Normal temperature range

(7) Other conditions designated by the type certification of wind turbines

-2. The following standards may be applied in the calculation of the wind conditions during wind turbine power production. However, the validity of the application of provisions based on these standards shall be shown in light of the site conditions.

(1) IEC TS 61400-3-2:2019 [R-02] 6.1.1, 6.1.2

(2) IEC 61400-3-1:2019 [R-03] 6.4.3

-3. If the site is located in Japan and is subject to the regulations of the Electricity Business Act, then in addition to -2. above, the requirements of -4. to -7. below shall also be satisfied.

-4. The estimation of the wind conditions during power production for each FOWT shall be based on measurement data acquired by using meteorological masts installed at one or more points which are representative of the planned offshore wind farm, or on measurement data from remote sensing device confirmed to have the same level of accuracy with a measurement mast.

-5. For the measurements specified in -4. above, the measurement height shall be not less than 2/3 of the planned hub height.

The measurement period shall be a sufficient period to obtain reliable data and shall be at least one year to include seasonal effects. The representative radius of observation data satisfying these conditions can be 10 km.

-6. If measurements using vertical lidar is selected among other methods such as met-masts and remote sensing device, NKRE-GL-WFC01 [R-01] Annex A shall be applied and the evaluation of the measurement data shall be in accordance with KRE-GL-WFC01 [R-01] 2.2.2. If measurements are implemented with the remote sensing device such as a scanning lidar, or floating lidar, this shall be as judged appropriate by ClassNK.

-7. The calculation of the wind conditions during power production for each FOWT shall be carried out using airflow analysis for which validity has been sufficiently confirmed. The verification of the validity of the airflow analysis shall be conducted by using the airflow analysis to calculate the wind conditions at the position of the meteorological mast and then comparing the results with the measurement data regarding the average wind speed, turbulence intensity, and wind shear for each direction. The details of this demonstration of the validity of the airflow analysis shall follow NKRE-GL-WFC01 [R-01] Annex B.2.

-8. For the turbulence intensity in -1. (2) above, the effective turbulence intensity shall be estimated with consideration of the wake effects from neighboring wind turbines when necessary. Also, with regards to the wind turbine operation, the effect shall also be appropriately considered if sector management is to be applied. The estimation of effective turbulence intensity shall follow NKRE-GL-WFC01 [R-01] 2.2.7.

2.2.3 Wind conditions during wind turbine parked by storm

-1. For the wind conditions during wind turbine parked by storm, the following values at the hub height for each FOWT shall be calculated.

(1) 10 minutes average wind speed with a 50-year return period
(2) 3 seconds average wind speed with a 50-year return period
(3) 10 minutes average wind speed with a 1-year return period
(4) 3 second average wind speed with a 1-year return period
(5) Turbulence intensities for wind speeds with 50-year and 1-year return periods
(6) Wind shear exponents for wind speeds with 50-year and 1-year return periods
(7) Air densities for wind speeds with 50-year and 1-year return periods
(8) Other conditions designated by the type certification of the wind turbine

-2. The following standards may be applied in the calculation of the wind conditions during wind turbine parked by storm. However, the validity of the application of provisions based on these standards shall be shown in light of the site conditions.

(1) IEC TS 61400-3-2:2019 [R-02] 6.1.1, 6.1.2
(2) IEC 61400-3-1:2019 [R-03] 6.4.3

-3. If the site is located in Japan and the FOWT? is subject to the regulations of the Electricity Business Act, then the wind conditions at the time of wind turbine parked by storm shall be calculated based on NKRE-GL-WFC01 [R-01] 2.3, and the values to be adopted as design values shall be determined by also taking into consideration the wind conditions calculated based on -2. above.

-4. The calculation of the wind conditions at the time of wind turbine parked by storm for each FOWT shall be carried out using airflow analysis for which validity has been sufficiently confirmed. The verification of the validity of the airflow analysis shall be conducted by using the airflow analysis to calculate the wind conditions at the meteorological mast and then comparing the results with the measurement data regarding the mean wind speed, turbulence intensity, and wind shear for each direction. The details of this confirmation process? of the validity of the airflow analysis shall follow NKRE-GL-WFC01 [R-01] Annex B.2.

2.3 Marine conditions

2.3.1 General

-1. The FOWT shall be designed to safely withstand the marine conditions adopted by the design standards.

-2. The design of the FOWT shall be based on environmental conditions that include the marine conditions representative of the floating offshore wind turbine site.

-3. The following standards may be applied in the calculation of the sea state conditions. However, the validity of the application of provisions based on these standards shall be shown in light of the site conditions.

(1) IEC TS 61400-3-2:2019 [R-02] 6.3.3

(2) IEC 61400-3-1:2019 [R-03] 6.4.3

2.3.2 Marine conditions during power production

-1. For the marine conditions during wind turbine operation, the following values for each FOWT position shall be calculated.

(1) Annual average significant wave height and corresponding significant wave period
(2) The joint probability distribution of the significant wave height and significant wave period corresponding to the 10 minutes average wind speed at hub height by direction
(3) Water level
(4) Current
(5) Other conditions assumed in the wind turbine type certification

2.3.3 Marine conditions during wind turbine parked by storm

-1. For the sea state conditions during wind turbine parked by storm, the following values for each FOWT position shall be calculated.

(1) Extreme significant wave heights with 50-year and 1-year return periods
(2) Range of significant wave periods for extreme significant wave heights with 50-year and 1-year return periods
(3) Maximum wave heights with 50-year and 1-year return periods
(4) Wave spectrum
(5) Extreme water levels with 50-year and 1-year return periods
(6) Extreme flows with 50-year and 1-year return periods
(7) Other conditions set in the wind turbine type certification

2.3.4 Waves

-1. The following standard shall be referred to for the waves to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.2

2.3.4.1 Normal sea state (NSS)

-1. The following standard shall be referred to for the normal sea state (NSS) to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.2.2

2.3.4.2 Severe sea state (SSS)

-1. The following standard shall be referred to for the severe sea state (SSS) to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.2.3

2.3.4.3 Extreme sea state (ESS)

-1. The following standard shall be referred to for the extreme sea state (ESS) to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.2.4

2.3.5 Currents

-1. The following standard shall be referred to for the flow to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.3.1

-2. The provisions of 2.3.5.1 and 2.3.5.2 shall be followed for the sub surface current and wind-generated current. However, this shall not apply when the underwater flow and the wind-driven flow are considered simultaneously and the validity of that has been confirmed by experiments, etc.

2.3.5.1 Sub-surface currents

-1. The following standard shall be referred to for the sub-surface currents to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.3.2

2.3.5.2 Wind-generated, near-surface currents

-1. The following standard shall be referred to for the wind-generated, near-surface currents to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.3.3

2.3.5.3 Normal current model (NCM)

-1. The following standard shall be referred to for the normal current model (NCM) to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.3.4

2.3.5.4 Extreme current model (ECM)

-1. The following standard shall be referred to for the extreme current model (ECM) to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.3.5

2.3.6 Water level

-1. The following standard shall be referred to for the water level to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.4.1

2.3.6.1 Normal water level range (NWLR)

-1. The following standard shall be referred to for the normal water level range (NWLR) to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.4.2

2.3.6.2 Extreme water level range (EWLR)

-1. The following standard shall be referred to for the extreme water level range (EWLR) to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.4.3

2.3.7 Sea ice

-1. The following standard shall be referred to for the sea ice to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.5

2.4 Earthquakes and tsunamis

2.4.1 General

-1. The impact of an earthquake shall be appropriately considered. The earthquake to be considered shall be set as the largest level which has occurred in the past in the vicinity of the site, or, if the site is in Japan, it shall be set by referring to the regional disaster prevention plan determined by the local government in the vicinity of the site. In addition, when adopting a mooring type in which vertical force is generated at a seabed fixed point, the liquefaction of the ground when an earthquake occurs in particular shall be given appropriate consideration.

-2. The impact of a tsunami shall be appropriately considered. The tsunami to be considered shall be set as the largest tsunami which has occurred in the past in the vicinity of the site, or, if the site is in Japan, it shall be set by referring to the regional disaster prevention plan determined by the local government in the vicinity of the site. However, in cases where the water depth of the sea area of installation is sufficiently deep, the effect of a tsunami may be treated as tidal level fluctuation and flow.

-3. For the purposes of these guidelines, it is not necessary to consider earthquakes and tsunamis simultaneously. Also, when considering either an earthquake or a tsunami, the annual average value of wind conditions and marine conditions may be applied.

2.5 Other environmental conditions

2.5.1 General

-1. The FOWT shall also be designed to safely withstand the other environmental conditions listed in 2.5.2 to 2.5.6 in light of the site conditions.

-2. The following standards may be applied in the calculation of the other environmental conditions. However, the validity of the application of provisions based on these standards shall be shown in light of the site conditions.

(1) IEC TS 61400-3-2:2019 [R-02] 6.3.5

(2) IEC 61400-3-1:2019 [R-03] 6.4.5

2.5.2 Marine growth

-1. The following standard shall be referred to for the marine growth to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.6

2.5.3 Snow load

-1. If the impact of snow cover on the FOWT cannot be ignored, it shall be given appropriate consideration.

2.5.4 Sea ice

-1. The following standard shall be referred to for the sea ice to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 6.3.3.5

2.5.5 Seabed deformation and scour

-1. If the impact of seabed deformation and scour at the seabed fixed points of the FOWT cannot be ignored, it shall be given appropriate consideration.

2.5.6 Lightning strikes

-1. The following standards shall be referred to for the thinking on lightning strikes to be considered in the design of the FOWT.

(1) Ministerial Ordinance Prescribing Technical Standards for Wind Power Generation Facilities[R-06]

(2) Interpretation of Technical Standards for Wind Power Generation Facilities [R-07]

(3) Annotations to the Ministerial Ordinance Prescribing Technical Standards for Wind Power Generation Facilities and its Interpretation[R-08]

Chapter 3 Loads

3.1 General

3.1.1 General

-1. In addition to considering the load on the FOWT based on the external conditions specified in Chapter 2, the load acting on the support structure from the RNA shall also be appropriately considered.

-2. In order to appropriately calculate the load indicated in -1. above, coupled analysis in the time domain shall be performed for a model with the RNA mounted on the support structure. Sufficient simulation length to accurately estimate the loads shall be secured in the analysis. The loads may also be estimated by using a model test deemed appropriate by ClassNK. In this case, the details of the design load estimation shall be submitted to ClassNK.

-3. In addition to the provisions of Part II, Chapter 2, Section 2 of the Technical Standards for Floating Offshore Wind Power Generation [J-01], the loads shall also be calculated in accordance with the provisions of this chapter.

3.1.2 Gravitational and inertial loads

-1. The following standards shall be referred to for the gravitational and inertial loads to be considered in the design of the FOWT.

(1) IEC TS 61400-3-2:2019 [R-02] 7.3.2

(2) IEC 61400-3-1:2019 [R-03] 7.3.2

3.1.3 Aerodynamic loads

-1. The following standards shall be referred to for the aerodynamic loads to be considered in the design of the FOWT.

(1) IEC TS 61400-3-2:2019 [R-02] 7.3.3

(2) IEC 61400-3-1:2019 [R-03] 7.3.3

3.1.4 Actuation loads

-1. The following standard shall be referred to for the actuation loads to be considered in the design of the FOWT.

(1) IEC 61400-3-1:2019 [R-03] 7.3.4

3.1.5 Hydrodynamic loads

-1. The following standards shall be referred to for the hydrodynamic loads to be considered in the design of the FOWT.

(1) IEC TS 61400-3-2:2019 [R-02] 7.3.5

(2) IEC 61400-3-1:2019 [R-03] 7.3.5

3.1.6 Sea ice loads

-1. The following standards shall be referred to for the sea ice loads to be considered in the design of FOWT.

(1) IEC TS 61400-3-2:2019 [R-02] 7.3.6

(2) IEC 61400-3-1:2019 [R-03] 7.3.6

3.1.7 Other loads

-1. The following standards shall be referred to for the other loads to be considered in the design of the FOWT.

(1) IEC TS 61400-3-2:2019 [R-02] 7.3.7

(2) IEC 61400-3-1:2019 [R-03] 7.3.7

3.2 Design situations and load cases

3.2.1 General

-1. The FOWT shall be assessed for structural integrity based on conditions encompassing the most critical conditions to be experienced during the service life.

3.2.2 Design load cases

-1. The design load cases in Table 3-1 shall be taken into account based on the operation modes or other design conditions (Combining specific assembly, construction or maintenance conditions with external conditions, etc.). In this table, the design load case for each design condition is defined by the wind conditions, sea state conditions, electrical conditions, and other external conditions.

-2. If the FOWT will be installed at a site where sea ice is expected to occur, the design load cases shown in Table 3-2 shall be considered in addition to those in -1. above.

-3. For each design load case, the analysis types are denoted by "F" and "U". "F" means the analysis of fatigue loads to be used for the evaluation of fatigue strength. "U" means the analysis of ultimate strength related to material strength and structural integrity

-4. The design load cases indicated by "U" are classified into normal states (N) and abnormal states (A). Normal design load cases occur frequently throughout the design service life of the FOWT. The wind turbine is either in a normal state, or in some cases, has a minor failure or abnormal state. The abnormal design conditions only occur very infrequently. This usually corresponds to design conditions where a serious failure leads to the activation of protection systems. The partial safety factor γ_f applied to the ultimate load is different depending on whether the design conditions are N or A. This safety factor follows Table 5-1.

-5. In addition to the provisions up to the preceding paragraph, the following standards shall be referred to for the setting of the design conditions and design load cases.

(1) IEC TS 61400-3-2:2019 [R-02] 7.4

(2) IEC 61400-3-1:2019 [R-03] 7.4.1

-6. Depending on the FOWT, if there is any design load case other than those shown in Table 3-1 that is thought to impact the structural safety, then it shall be appropriately considered.

3.2.3 Power production (DLC 1.1 to DLC 1.6)

-1. The following standards shall be referred to for these design conditions.

(1) IEC TS 61400-3-2:2019 [R-02] 7.4

(2) IEC 61400-3-1:2019 [R-03] 7.4.2

3.2.4 Power production plus occurrence of fault or loss of electrical network connection (DLC 2.1 to DLC 2.6)

-1. The following standards shall be referred to for these design conditions.

(1) IEC TS 61400-3-2:2019 [R-02] 7.4

(2) IEC 61400-3-1:2019 [R-03] 7.4.3

3.2.5 Start up (DLC 3.1 to DLC 3.3)

-1. The following standards shall be referred to for these design conditions.

(1) IEC TS 61400-3-2:2019 [R-02] 7.4

(2) IEC 61400-3-1:2019 [R-03] 7.4.4

3.2.6 Normal shutdown (DLC 4.1 to DLC 4.3)

-1. The following standards shall be referred to for these design conditions.

(1) IEC TS 61400-3-2:2019 [R-02] 7.4

(2) IEC 61400-3-1:2019 [R-03] 7.4.5

3.2.7 Emergency stop (DLC 5.1)

-1. The following standards shall be referred to for these design conditions.

(1) IEC TS 61400-3-2:2019 [R-02] 7.4

(2) IEC 61400-3-1:2019 [R-03] 7.4.6

3.2.8 Parked (standstill or idling) (DLC 6.1 to DLC 6.4)

-1. The following standards shall be referred to for these design conditions.

(1) IEC TS 61400-3-2:2019 [R-02] 7.4

(2) IEC 61400-3-1:2019 [R-03] 7.4.7

-2. When DLC 6.2 in Table 3-1 is omitted in consideration with the introduction of power back-up system, it shall be noted that a separate examination by ClassNK must be undertaken as the wind turbine (RNA) design evaluation in the Wind Farm Certification to check the validity of the assessment. NKRE-GL-WFC01 [R-01] 5.4 can be referred to for the requirements for the RNA.

3.2.9 Parked plus fault conditions (DLC 7.1 to DLC 7.2)

-1. The following standards shall be referred to for these design conditions.

(1) IEC TS 61400-3-2:2019 [R-02] 7.4

(2) IEC 61400-3-1:2019 [R-03] 7.4.8

3.2.10 Towing, installation, maintenance, and repair (DLC 8.1 to DLC 8.4)

-1. The following standards shall be referred to for these design conditions.

(1) IEC TS 61400-3-2:2019 [R-02] 7.4

(2) IEC 61400-3-1:2019 [R-03] 7.4.9

3.2.11 Sea ice design load cases

-1. For the FOWT that will be installed at a site where sea ice is expected to occur, the load cases shown in Table 3-2 shall also be considered in the design.

-2. Refer to the standard below for the concept of the sea ice design load cases D1 to D7.

(1) IEC 61400-3-1:2019 [R-03] 7.4.10

Table 3-1 Design Load Case (DLC)

DLC	Wind condition	Waves	Direction of wind and waves	Flow	Water level	Other conditions	Type of analysis	Partial safety factor
1) Power production								
1.1	NTM $V_{in}<V_{hub}<V_{out}$	NSS $H_s=E[H_s\|V_{hub}]$	COD and UNI	NCM	MSL	*1.1	U	N (1.25)
1.2	NTM $V_{in}<V_{hub}<V_{out}$	NSS Joint probability distribution of H_s, T_p and V_{hub}	MIS and MUL	NCM	NWLR or MSL or higher	-	F	-
1.3	ETM $V_{in}<V_{hub}<V_{out}$	NSS $H_s=E[H_s\|V_{hub}]$	COD and UNI	NCM	MSL	-	U	N
1.4	ECD $V_{hub} = V_r$ - 2 m/s, V_r and V_r + 2 m/s	NSS $H_s=E[H_s\|V_{hub}]$	MIS and wind direction changes	NCM	MSL	-	U	N
1.5	EWS $V_{in}<V_{hub}<V_{out}$	NSS $H_s=E[H_s\|V_{hub}]$	COD and UNI	NCM	MSL	-	U	N
1.6	NTM $V_{in}<V_{hub}<V_{out}$	SSS $H_s=H_{s.SSS}$	COD and UNI	NCM	NWLR	-	U	N
2) Power production plus occurrence of fault or loss of electrical network connection								
2.1	NTM $V_{in}<V_{hub}<V_{out}$	NSS $H_s=E[H_s\|V_{hub}]$	COD and UNI	NCM	MSL	*2.1	U	N
2.2	NTM $V_{in}<V_{hub}<V_{out}$	NSS $H_s=E[H_s\|V_{hub}]$	COD and UNI	NCM	MSL	*2.2	U	A
2.3	EOG $V_{hub} = V_r \pm 2$ m/s and V_{out}	NSS $H_s=E[H_s\|V_{hub}]$	COD and UNI	NCM	MSL	*2.3	U	A
2.4	NTM $V_{in}<V_{hub}<V_{out}$	NSS $H_s=E[H_s\|V_{hub}]$	COD and UNI	NCM	NWLR or MSL or higher	*2.4	F	-
2.5	NWP $V_{in}<V_{hub}<V_{out}$	NSS $H_s=E[H_s\|V_{hub}]$	COD and UNI	NCM	MSL	*2.5	U	N
2.6	NTM $V_{in}<V_{hub}<V_{out}$	SSS	MIS and MUL	NCM	NWLR	*2.6	U	A
3) Start up								
3.1	NWP $V_{in}<V_{hub}<V_{out}$	NSS $H_s=E[H_s\|V_{hub}]$	COD and UNI	NCM	NWLR or MSL or higher	-	F	-
3.2	EOG $V_{hub}=V_{in}$, $V_r \pm 2$ m/s and V_{out}	NSS $H_s=E[H_s\|V_{hub}]$	COD and UNI	NCM	MSL	-	U	N
3.3	EDC $V_{hub}=V_{in}$, $V_r \pm 2$ m/s and V_{out}	NSS $H_s=E[H_s\|V_{hub}]$	MIS and wind direction changes	NCM	MSL	-	U	N

DLC	Wind condition	Waves	Direction of wind and waves	Flow	Water level	Other conditions	Type of analysis	Partial safety factor
4) Normal shutdown								
4.1	NWP $V_{in}<V_{hub}<V_{out}$	NSS $H_s=E[H_s\|V_{hub}]$	COD and UNI	NCM	NWLR or MSL or higher	-	F	-
4.2	EOG V_{hub} = V_r ± 2 m/s and V_{out}	NSS $H_s=E[H_s\|V_{hub}]$	COD and UNI	NCM	MSL	-	U	N
4.3	NTM $V_{in}<V_{hub}<V_{out}$	SSS, or the most severe conditions that become the safety threshold for the control or the protection system	MIS and MUL	NCM	MSL	*4.3	U	N
5) Emergency stop								
5.1	NTM V_{hub} = V_r ± 2 m/s and V_{out}	NSS $H_s=E[H_s\|V_{hub}]$	COD and UNI	NCM	MSL	-	U	N
6) Parked (standstill or idling)								
6.1	EWM $V_{hub}=V_{ref}$	ESS $H_s=H_{s50}$	MIS and MUL	ECM U= U_{50}	EWLR	-	U	N
6.2	EWM $V_{hub}=V_{ref}$	ESS $H_s=H_{s50}$	MIS and MUL	ECM U= U_{50}	EWLR	*6.2	U	A
6.3	EWM $V_{hub}=V_{ref}$	ESS $H_s=H_{s50}$	MIS and MUL	ECM U= U_{50}	EWLR	*6.3	U	N
6.4	NTM $V_{hub}<0.7V_{ref}$	NSS Joint probability distribution of H_s, T_p and V_{hub}	COD and MUL	NCM	NWLR or MSL or higher	-	F	-
7) Parked plus fault conditions								
7.1	EWM $V_{hub}=V_1$	ESS $H_s=H_{sl}$	MIS and MUL	ECM U= U_l	NWLR	-	U	A
7.2	NTM $V_{hub}<0.7V_{ref}$	NSS Joint probability distribution of H_s, T_p and V_{hub}	COD and MUL	NCM	NWLR or MSL or higher	-	F	-
8) Towing, assembly, maintenance and repair								
8.1	Stipulate separately					-	U	N
8.2	EWM $V_{hub}=V_l$	ESS $H_s=H_{sl}$	COD and UNI	ECM U= U_l	EWLR	-	U	A
8.3	NTM $V_{hub}<0.7V_{ref}$	NSS Joint probability distribution of H_s, T_p and V_{hub}	COD and MUL	NCM	NWLR or MSL or higher	*8.3	F	-
8.4	Stipulate separately					-	F	-

<Remarks>

(1) The notes on other conditions are as follows.

*1.1: For extrapolation of extreme loads on the RNA

*2.1: Normal control system fault or loss of electrical network or primary layer control function fault

*2.2: Abnormal control system fault or secondary layer protection function related fault

*2.3: External or internal electrical fault including loss of electrical network

*2.4: Control system fault, electrical fault or loss of electrical network

*2.5: Low voltage ride through

*2.6: Fault of sea-state limit protection system

*4.3: Maximum operating sea state limit

*6.2: Loss of electrical network

*6.3: Extreme yaw misalignment

*8.3: No grid during installation period

(2) Table 3.1 uses the following abbreviations.

Vr ± 2 m/s: The sensitivity to all wind speeds within this range shall be analyzed.

(3) When a wind speed range is indicated in Table 3.1, wind speeds leading to the most adverse condition for FOWT design shall be considered. The range of wind speeds may be represented by a set of discrete values, in which case the resolution shall be sufficient to assure accuracy of the calculation. (In general, a resolution of 2 m/s is considered sufficient.) In the definition of the design load cases, reference shall be made to the wind conditions and sea state conditions described in Chapter 2.

(4) Except for the design load cases that involve a transient change in the mean wind direction (DLC 1.4 and DLC 3.3) and parked (standstill or idling) design condition, the wind and wave directions may be generally assumed to be the same in the analysis of the loads acting on the FOWT.

(5) In some cases, wind and waves from multiple directions may have an important effect on the loads acting on the FOWT. This mainly depends on how non-axisymmetric the FOWT are. In some design load cases shown in Table 3.1, load calculations may be performed by assuming that the wind and waves act from one of the worst-case directions (uni-directional). However, in this case, the structural integrity shall be demonstrated by applying the calculated worst-case load in the relevant direction on the FOWT.

(6) The average or extreme yaw misalignment to be considered for each design load case shall be in accordance with the provisions of IEC 61400-1:2019 [R-04]. The yaw misalignment is defined as the horizontal deviation of the wind turbine rotor axis from the wind direction.

Table 3-2 Design Load Case [Sea ice] (DLC)

DLC	Sea ice condition	Wind condition	Water level	Type of analysis	Partial safety factor
Power production					
D 1	Horizontal load due to temperature fluctuations	NTM $V_{hub} = V_r \pm 2$ m/s and V_{out} Wind speed resulting maximum thrust	NWLR	U	N
D 2	Horizontal load from water level fluctuations or arch effects	NTM $V_{hub} = V_r \pm 2$ m/s and V_{out} Wind speed resulting maximum thrust	NWLR	U	N
D 3	Horizontal load from moving ice at relevant velocities $h=h_{50}$ or largest value of moving ice	NTM $V_{in}<V_{hub}<V_{out}$	NWLR	U	N
D 4	Horizontal load from moving ice at relevant velocities **Use values of h corresponding to expected history of moving ice occurring.*	NTM $V_{in}<V_{hub}<V_{out}$	NWLR	F	-
D 5	Vertical force from fast ice covers due to water level fluctuations	No wind load applied	NWLR	U	N
Parked					
D 6	Pressure from hummocked ice and ice ridges	EWM Turbulent wind model $V_{hub}=V_1$	NWLR	U	N
D 7	Horizontal load from moving ice at relevant velocities **Use values of h corresponding to expected history of moving ice occurring.*	NTM $V_{hub} < 0.7\ V_{ref}$	NWLR	F	-
D 8	Horizontal load from moving ice at relevant velocities $h=h_{50}$ or largest value of moving ice	EWM Turbulent wind model $V_{hub}=V_1$	NWLR	U	N

3.3 Load and load effect calculation

3.3.1 General

-1. The load and load effect calculation shall be carried out using a method that appropriately takes into account the dynamic response of FOWT to the relevant combination of external conditions.

-2. The following standards shall be referred to for the loads and load effects on the FOWT.

(1) IEC TS 61400-3-2:2019 [R-02] 7.5.1

(2) IEC 61400-3-1:2019 [R-03] 7.5.1

3.3.2 Relevance of hydrodynamic loads

-1. The following standard shall be referred to for the relevance of hydrodynamic loads.

(1) IEC TS 61400-3-2:2019 [R-02] 7.5.2

(2) IEC 61400-3-1:2019 [R-03] 7.5.2

3.3.3 Calculation of hydrodynamic loads

-1. The following standards shall be referred to for the calculation of hydrodynamic loads.

(1) IEC TS 61400-3-2:2019 [R-02] 7.5.3

(2) IEC 61400-3-1:2019 [R-03] 7.5.3

3.3.4 Calculation of sea ice loads

-1. The following standard shall be referred to for the calculation of sea ice loads.

(1) IEC TS 61400-3-2:2019 [R-02] 7.5.4

3.3.5 Calculation of other loads

-1. The static wind pressure acting on the RNA, tower, and floating substructure may be calculated using equation (3.1). If the shielding effect is to be taken into account when calculating the wind pressure, a detailed examination shall be conducted separately.

$$P = 0.611 C_s V(z)^2 \tag{3.1}$$

Where:

C_s : Drag coefficient, shown in Table 3-3.

$V(z)$: Wind speed at height z $[m]$

Table 3-3 Drag coefficient *Cs*

Structural members	*Cs*
Spherical shell structures	0.4
Cylindrical structures	0.5
Main hulls	1.0
Deck houses	1.0
Independent structural members (Cranes, shaped steel, beams, etc.)	1.5
Parts below the deck (smooth surfaces)	1.0

-2. If the floating substructure is to be landed on the ground during construction work, such as during the installation of the RNA, then the loads on the floating substructure in the severest condition shall be calculated based on all assumed external forces, with consideration given to the construction specifications such as the use of mound, etc.

-3. For tanks to carry seawater ballast, the water head based on the position of the overflow pipe and the additional water head due to the motion of the FOWT shall be appropriately calculated as a load on the structural members constituting the tank based on the provisions in Chapter 14 of Part C of the Rules for the Survey and Construction of Steel Ships, or based on specifications and standards deemed appropriate by ClassNK. The loads to be considered when something other than seawater is to be used as ballast shall be as deemed appropriate by ClassNK.

3.4 Simulation requirements

3.4.1 General

-1. A dynamic simulation using a structural dynamic model shall be used for the estimation of the loads and load effects on the FOWT. Also, the corresponding stochastic wind and wave information is inputted to certain load cases. In these cases, the time for the load data shall be long enough to ensure the statistical reliability of the inferred results for the characteristic load effect. Generally, for the average wind speed at hub height and the sea conditions considered in the dynamic simulations, in principle, six or more ten-minute stochastic simulations (or one continuous one-hour simulation) shall be carried out.

-2. The following standard shall be referred to for the simulations performed to calculate the loads and load effects.

(1) IEC TS 61400-3-2:2019 [R-02] 7.5.6

(2) IEC 61400-3-1:2019 [R-03] 7.5.6

-3. For dynamic simulations, the models to be used and the validity of the results shall be fully demonstrated. The demonstration should be carried out by comparing the results either with the measured data from water tank test or with the measured data from demonstration equipment. When the results of multiple simulation tools are combined, the verification shall also be carried out by comparing the results between the different dynamic simulations, in addition to the verification results for each individual model applied.

3.4.2 Other requirements

-1. For the setting of the design load cases and the calculations of the loads and load effects, it should be noted that items such as the following standards must also be considered in light of the site conditions and the characteristics of the FOWT.

(1) IEC TS 61400-3-2:2019 [R-02] 7.5.7

(2) IEC 61400-3-1:2019 [R-03] 7.5.7

-2. The following standard may be referred to for general matters concerning attenuation.

(1) IEC 61400-3-1:2019 [R-03] 7.5.5

Chapter 4 Materials and welding

4.1 General

4.1.1 General

-1. The materials and welding used on the support structure shall comply with the following (1) to (4).

(1) The materials used for the main structure shall comply with the provisions of Part K of the Rules for the Survey and Construction of Steel Ships. If there are no provisions on an item in Part K of the Rules for the Survey and Construction of Steel Ships, or if it is difficult to comply with Part K, the item may be used if standards deemed appropriate by ClassNK are used as the conformity standards and ClassNK grants special approval.

(2) If the main load is applied in the thickness direction of steel material, then steel material with special consideration of the characteristics in the thickness direction shall be used.

(3) Welding work on the main structure shall comply with the provisions of Part M of the Rules for the Survey and Construction of Steel Ships. If it is difficult to comply with Part M of the Rules for the Survey and Construction of Steel Ships, then if standards deemed appropriate by ClassNK are used as the conformity standards and ClassNK grants special approval, those standards may be followed.

(4) The following parts and equipment used in mooring system shall be approved by ClassNK in accordance with the provisions of Part L of the Rules for the Survey and Construction of Steel Ships. If there are no provisions on an item in Part L of the Rules for the Survey and Construction of Steel Ships, or if it is difficult to comply with Part L, the item may be used if standards deemed appropriate by ClassNK are used as the conformity standards and ClassNK grants special approval.

- Chains
- Wire ropes
- Synthetic fiber ropes
- Equipment and apparatus used on mooring lines
- Anchors and related components
- Chain stoppers and fairleaders

-2. Regardless of the provisions in -1. above, the steel materials, the flanges, and the bolt, nut and flat washer sets for flange connection that are used on towers may be used when it is deemed appropriate by ClassNK as the materials for the following items. However, it should be noted that it will be necessary to have a separate confirmation by ClassNK that the item was produced based on the details designated or certified.

(1) "Designated building materials" in Article 37 of the Building Standards Act

(2) Materials approved by the Minister of Land, Infrastructure, Transport and Tourism in 2002 or before

(3) Materials certified for performance evaluation in conformity with the Technical Standards for Wind Power Generation Facilities

Chapter 5 Structural design

5.1 General

5.1.1 General

-1. For all the loads and load effects calculated based on the provisions of Chapter 3, it shall be verified that the structural members constituting the floating substructure and tower are sound, and a permissible level of safety shall be confirmed.

-2. It should be noted that in principle, the provisions of this chapter are based on the assumption of floating substructures and towers made of steel. Floating substructures and towers that are a material other than steel shall be as deemed appropriate by ClassNK.

-3. In addition to the provisions of Part II, Chapter 2, Section 3 of the Technical Standards for Floating Offshore Wind Power Generation [J-01], the structural design shall also be performed in accordance with the provisions of this chapter.

-4. In the case of a FOWT that will be installed in an ice water area, in addition to the provisions of this chapter, either the provisions of Chapter 5 of Part I of the Rules for the Survey and Construction of Steel Ships may be applied, or generally accepted criteria/standards for the design of marine structures such as ISO may be followed.

-5. The strength of the floating substructure and tower during towing and installation shall be as deemed appropriate by ClassNK.

-6. The FOWT shall not collapse or become adrift as a result of an earthquake or tsunami.

-7. If ClassNK deems it appropriate, the structural design may be verified by model testing and prototype tests.

5.2 Structural specifications and arrangements

5.2.1 General

-1. Consideration shall be given to both the classification of the structural members of the floating substructure and tower, and the category of use of the steel materials. The provisions of 6.2 of Part P of the Rules for the Survey and Construction of Steel Ships may be applied to the category of use of steel materials. Cases where the plate thickness exceeds that specified in 6.2 of Part P of the Rules for the Survey and Construction of Steel Ships shall be as deemed appropriate by ClassNK.

-2. In cases where a large opening such as a moonpool or a turret mooring system is provided on the floating substructure, it shall be reinforced as necessary, and attention shall be paid to the continuity of strength.

-3. When a tank is installed on the floating substructure, either its size shall be such that there is no motion of the liquid in the tank in resonance with the pitching and rolling of the FOWT, or a swash bulkhead shall be installed in the tank. However, this shall not apply when the structural members in the tank have sufficient strength against the load due to the motion of the liquid in the tank.

-4. The arrangement of other structures shall be as deemed appropriate by ClassNK.

5.3 Ultimate strength

5.3.1 General

-1. It shall be shown that the structural members constituting the floating substructure and tower are sound for the loads and load effects calculated from the design load cases for the ultimate load specified in Chapter 3.

-2. When applying the partial safety factor method, the uncertainties and variations of loads and materials, the uncertainties of analytical methods and the importance of structural members in the event of failure shall be considered using the partial safety factor. The following standards shall be followed for the details in this case.

(1) IEC TS 61400-3-2:2019 [R-02] 7.6.1

(2) IEC 61400-3-1:2019 [R-03] 7.6

-3. The following standard shall be followed when applying the working stress design method.

(1) IEC TS 61400-3-2:2019 [R-02] 7.6.6

-4. In addition to the provisions up to the preceding paragraph, in a case where the water head and additional water head are calculated for 3.3.5-3 based on the provisions in Chapter 14 of Part C of the Rules for the Survey and Construction of Steel Ships, the structural specifications shall satisfy the requirements of Chapter 14 of the Rules for the Survey and Construction of Steel

Ships. If the water head and the additional water head have been calculated based on specifications and standards deemed appropriate by ClassNK, the structural specifications shall satisfy the requirements of those specifications and standards.

5.3.2 Partial safety factor

-1. The partial safety factor with respect to the ultimate load shall be applied the value specified in Table 5-1.

-2. When it has been proven by actual measurement data, etc., that the uncertainty for the load is small, alternative partial safety factor may be applied instead of -1 above. However, it shall be shown the validity of the alternative partial safety factor quantitatively.

Table 5-1 Partial safety factor for loads γ_f

Unfavorable loads a)		Favorable loads b)
Type of design situation (see Table 3-1 and Table 3-2)		All design situations
Normal (N)	Abnormal (A)	
1.35	1.1	0.9

Note a) If the gravity load is considered to be an unfavorable load, the partial safety factor for the gravity load shall be 1.0.

Note b) Initial tension and gravity loads that significantly reduce the overall load response are considered to be favorable loads. However, in the load cases for towing, installation, maintenance and repairs, the partial safety factor for the design load shall be 1.5 if the manufacturer specifies values for the transportation and construction in bulk instead of DLC 8.1 to DLC 8.4.

5.3.3 Design proof stress

-1. The design proof stress of the floating substructure and tower shall be determined in accordance with generally accepted standards/specifications for the design of offshore structures, such as ISO. In addition, the standard yield strength for the material shall be used as the material strength characteristic value for the floating substructure and tower. The design proof strength of the tower may also be determined by IEC 61400-1: 2019[R-04] or IEC 61400-6: 2020 [R-05].

-2. In case where multiple standards/specifications are combined, the validity of that combination shall be shown.

5.4 Fatigue strength

5.4.1 General

-1. It shall be shown that the structural members constituting the floating substructure and tower are sound for the loads and load effects calculated from the design load cases for the fatigue load specified in Chapter 3.

-2. A member subjected to repeated stress shall have sufficient strength against fatigue in consideration of factors such as the magnitude of the repeated stress, the number of cycles, the average stress, and the shape of the member.

-3. The design life for fatigue strength shall not be less than the service life of the floating substructure and tower.

-4. The following standard shall be referred to regarding the way of thinking about fatigue strength.

(1) IEC TS 61400-3-2:2019 [R-02] 7.6.3

5.4.2 Fatigue strength evaluation

-1. Fatigue strength shall be evaluated for the areas of concentrated stress where there is a risk that harmful fatigue cracks may occur, for points subject to reaction forces from mooring devices, and also for the joints between plate members where evaluation is deemed necessary by ClassNK.

-2. The principle shall be to consider all kinds of repeated loading when examining fatigue strength. In addition, appropriate consideration shall be given to the concentration of stress on the notches and structural discontinuities present in the members to be evaluated.

-3. When considering fatigue strength, consideration shall also be given to whether the periodical surveys specified in Chapter 8 are feasible, and whether each of the individual structural members are easily accessible for surveys. In case when there is a possibility that the survey is difficult to conduct, the special measures, such as increasing the safety factor, shall be taken.

-4. Fatigue strength shall be evaluated by calculating the cumulative fatigue damage based on the linear damage rule. It should be noted that it is necessary to show the validity of the application of the method used for fatigue strength evaluation, and the validity of the setting of the parameters applied, such as those related to the S-N diagram and thickness effect.

5.4.3 Measures to improve fatigue strength

-1. For parts which become a problem for the fatigue strength under a corrosive environment, efforts shall be made to prevent corrosion, such as with electric corrosion protection.

-2. For the parts that are critical for fatigue strength, special attention shall be paid to weld defects, etc., during the fabrication work. It is also recommended to perform appropriate surface treatment in addition to full penetration welding for the welding of these parts.

5.5 Anticorrosion measures and corrosion reserve thickness

5.5.1 General

-1. With regard to the anticorrosion measures for the floating substructure and tower, appropriate corrosion protection measures shall be taken with consideration of factors such as the assumed service life, maintenance methods and corrosion environment of the floating substructure and tower.

5.5.2 Corrosion protection measures

-1. The corrosion protection measures given in Table 5-2 shall be implemented as standard in accordance with the corrosion environment to which the structural members of the floating substructure and tower will be exposed.

Table 5-2 Standard corrosion protection measures

<table>
<tr><th colspan="3">Structural members</th><th>Corrosion protection measures</th></tr>
<tr><td>Above the splash zone</td><td>External shell</td><td>Upper deck, side shell</td><td>Coating with a coating material that has rust resistance and weather resistance</td></tr>
<tr><td>Splash zone</td><td>External shell</td><td>Side shell</td><td>Effective coating or lining. It shall be noted that the corrosion environment of the splash zone is more severe than that of other component members.</td></tr>
<tr><td>Below the splash zone</td><td>External shell</td><td>Side shell, bottom shell</td><td>Coating with a coating material that has sea water resistance, electric corrosion protection, or a combination thereof</td></tr>
<tr><td>Inside ballast tanks</td><td colspan="2">Bulkheads, floors, girders and other girder members, longitudinal members and other stiffeners</td><td>Coating with a coating material that has sea water resistance, or a combination of coating and electric corrosion protection</td></tr>
<tr><td colspan="3">Main structural members and compartment internal members other than the above</td><td>Coating with rust-resistant coating material</td></tr>
</table>

5.5.3 Corrosion reserve thickness

-1. The corrosion reserve thicknesses suitable for the corrosion environments that structural members are exposed to are as shown in Table 5-3. In cases where the corrosion environment is extremely severe, corrosion reserve thickness values larger than those specified in Table 5-3, or the addition of appropriate anticorrosion measures may be required.

-2. If additional anticorrosion measures that ClassNK has deemed appropriate are taken on the floating substructure and tower, then the corrosion reserve thicknesses specified in -1. above may be reduced as ClassNK deems appropriate.

Table 5-3 Corrosion reserve thickness on one side of structural members

<table>
<tr><th colspan="2" rowspan="2">Corrosion environment</th><th colspan="2">Corrosion reserve thickness on one side (mm)</th></tr>
<tr><th>Assumed service life
20 years</th><th>Assumed service life
30 years</th></tr>
<tr><td rowspan="2">Inside ballast tanks</td><td>Face of girder members</td><td>1.0</td><td>1.3</td></tr>
<tr><td>Other than the above</td><td>0.8</td><td>1.0</td></tr>
<tr><td colspan="2">Exposed to the atmosphere (above the splash zone)</td><td>1.0</td><td>1.1</td></tr>
<tr><td colspan="2">Splash zone</td><td>1.0</td><td>1.1</td></tr>
<tr><td colspan="2">Exposed to sea water (below the splash zone)</td><td>0.5</td><td>0.6</td></tr>
<tr><td colspan="2">Other than the above</td><td>0.5</td><td>0.6</td></tr>
</table>

(Remarks) If the assumed service life is between the categories in the table, the values shall be determined by linear interpolation and rounded up to one decimal place. Also, if the assumed service life is greater than 30 years, the values shall be determined by linear extrapolation from the values for 20 years and 30 years and rounded up to one decimal place.

5.6 Structural design of other equipment

5.6.1 General

-1. With regard to the ancillary equipment installed in a substructure, it shall be verified that the structure of the ancillary equipment is sound for the external conditions specified in Chapter 2 in the same way as for the structural members constituting the floating substructure and tower, and a permissible level of safety shall be confirmed.

5.6.2 Mooring equipment

-1. For the positions where equipment related to mooring system, such as chain stoppers and fairleaders, is attached to the floating substructure, it is assumed that the points will be parts where stress is concentrated, so sufficient attention shall be paid to the evaluation of the structural integrity of those installation positions.

-2. The detailed specification of structures shall be sufficiently considered to ensure that the loads that the chain stoppers and fairleaders receive from the mooring lines can be appropriately transmitted to the structural members of the floating substructure. In addition, the structural members of the floating substructure shall be reinforced as necessary.

5.6.3 Fenders

-1. Appropriate protection, such as fender installation, shall be provided at the points where work vessels or other vessels will touch the floating substructure.

-2. The loads on fenders shall be appropriately calculated based on the external conditions specified in Chapter 2. In addition, the following standard shall be referred to for the loads that fenders receive from work vessels, etc.

(1) IEC TS 61400-3-2:2019 [R-02] 7.4.9.2

-3. In addition to the structural integrity of the fender itself against the load assumed in -2. above, the structural integrity of the parts where the fender is attached to the floating substructure shall also be verified and the reinforcement of the structural members of the floating substructure shall be conducted as necessary.

-4. With regard to fenders, it should be noted that their use means severe wear on the ship contact position and its surroundings, and sufficient consideration shall be given to that point in the strength evaluation. In addition, from the perspective of usability, measures such as making their replacement possible should be taken.

5.6.4 Ladders, handrails, and others

-1. When a ladder or a handrail is installed on an exposed part of the floating substructure and tower for movement, inspections or surveys, the load assumed for the ladder or handrail shall be appropriately calculated based on the external conditions specified in Chapter 2.

-2. In addition to the structural integrity of the ladders and handrails themselves against the load assumed in -1. above, the structural integrity of the parts where the ladders and handrails are attached to the floating substructure and tower shall also be verified and the reinforcement of the structural members shall be conducted as necessary.

-3. In addition, the same consideration shall be given to the ancillary equipment that may be subjected to loads based on the external conditions specified in Chapter 2 on exposed parts of the floating substructure and tower.

5.6.5 Helicopter decks

-1. If a helicopter deck is to be provided on the FOWT, its deck load may follow 3.2.7 of Part P of the Rules for the Survey and Construction of Steel Ships.

-2. Other structural integrity shall be as deemed appropriate by ClassNK.

5.7 Lift facilities

5.7.1 General

-1. In cases where there are special circumstances that make it difficult to comply with the provisions of this section, it shall be possible to not comply with the provisions of this section if ClassNK deems it appropriate based on consideration of the structure and usage of the lift facilities.

-2. ClassNK will approve the use of items that are not specified in this section based on consideration of whether or not there is an effect on the utility of the lift facilities of the FOWT.

5.7.2 Materials, structure and performance

-1. Unless otherwise specified, the materials used on lift facilities shall be fire-resistant and corrosion-resistant. However, this shall not apply in cases deemed appropriate by ClassNK.

-2. The structure of lift facilities shall cause no danger to operators in normal use.

-3. Lift facilities shall be such that even if the FOWT are in an inclined state, the equipment will not hinder maintenance work and surveys.

-4. Lift facilities shall be such that its performance is not hindered by the vibration of the FOWT.

5.7.3 Arrangement, etc.

-1. Lift facilities shall be located in a place where it can be raised and lowered without danger.

5.7.4 Safety factor, etc.

-1. Elevating equipment shall be such that, under normal states of use, when a load corresponding to the limit load is applied, the safety factors for the breaking strength of the important parts of the equipment are not less than the values specified in Table 5-4.

-2. The elevating equipment shall be such that no abnormality will occur even if the load applied is 1.25 times the limit load.

-3. The elevating equipment shall operate reliably even if the load applied is 1.10 times the limit load.

Table 5-4 Safety factors for elevating equipment

Category	Safety factor
Main rope or chain	10.0
Cage	7.5
Supporting beam	5.0
Other metal structures	5.0

5.7.5 Safety devices, etc.

-1. Elevating equipment shall be equipped with safety devices to protect occupants.

-2. Elevating equipment shall be provided with a device that ensures that the main rope is wound flat on the hoisting device drum.

-3. The elevating equipment shall use three or more main ropes and the ropes shall have sufficient strength to prevent dropping if one rope is cut.

5.7.6 Special measures

-1. In addition to the provisions of this section, lift facilities shall comply with any additional requirements deemed necessary by ClassNK for the structure and conditions of use of that lift facilities.

5.7.7 Lift facilities survey record books, etc.

-1. The owner of the FOWT shall create a lift facilities survey record book for the lift facilities.

-2. The owner of the FOWT shall attach the certificate of elevating equipment limit load, etc., designation prescribed in 8.3.3-3. to the lift facilities survey record book.

-3. When an inspection prescribed in 5.7.8 is conducted on the lift facilities, the owner of the FOWT shall record that such inspection was conducted in the lift facilities survey record book.

5.7.8 Inspection of elevating equipment

-1. The owner of the FWOT shall conduct inspections to check that there are no abnormalities on elevating equipment for which the limit load and maximum number of occupants have been designated pursuant to the provisions of 8.3.3-3.

5.7.9 Indication of the limit load, etc.

-1. The owner of a FOWT shall indicate the specified limit load and maximum number of occupants at an easily visible location on the lift facilities.

Chapter 6 Mooring system

6.1 General

6.1.1 General

-1. For the purpose of maintaining the position of the FOWT, the mooring system shall have sufficient capacity to hold the FOWT in place in all the planned operating conditions and shall also be safe for the equipment on the seabed.

-2. Mooring system shall satisfy the provisions of this chapter. However, the provisions of ISO 19901-7 may be satisfied instead of the provisions of this chapter. In addition, the following standard may be referred to.

(1) IEC TS 61400-3-2:2019 [R-02] 14

-3. For the mooring system for a FOWT that will be installed in a sea area where low temperature, freezing and icing, etc., are assumed to occur, either the effects of those phenomena shall be considered, or appropriate protective measures shall be taken.

-4. In the case of a system where the mooring facilities defined in No. 52 of Table 1-1 are connected to the mooring system of the FOWT to maintain the position of the FOWT, the mooring facility structure and the mooring system shall be as deemed appropriate by ClassNK.

-5. In addition to the provisions of Part II, Chapter 3 of the Technical Standards for Floating Offshore Wind Power Generation [J-01], the structural design shall also be performed in accordance with the provisions of this chapter.

6.1.2 States to be considered in the design of mooring system

-1. The design of mooring system shall take into account all possible mooring states, including the followings.

(1) Intact state

The state in which all the components of the FOWT and mooring system are normal.

(2) State with single mooring line broken

This is the state where there is maximum tension on the mooring lines when it is assumed that the floating substructure is intact but one mooring line has broken. In the intact state, it is not necessarily the case that the most severe conditions will be created by assuming that the break is on the line where the greatest tension occurs (the lead line). Therefore, this state is defined as the most severe state identified when analysis is conducted for various cases such as the breaking of the lead line and the breaking of adjacent lines.

(3) Transient state with a single mooring line broken

This is the state when the floating substructure is in transient motion (including overshoot) from when one of the mooring lines breaks (in principle, the lead line) until the FOWT reaches a steady state due to the remaining mooring lines.

(4) State of floating substructure damage

This is the state where the floating substructure is assumed to be damaged as specified in 7.3, but all components of the mooring system are normal.

-2. In the analysis of the transient state with a single mooring line broken, the effect of the tension increase on mooring lines due to the overshoot, etc., of the FOWT shall be examined. In addition, the clearance to the facilities around the FOWT shall also be evaluated.

-3. For SALM (Single Anchor Leg Mooring), in place of the breaking of a single mooring line, analysis shall be conducted regarding a loss of buoyancy due to single compartment damage on the SALM structure.

-4. The mooring system analysis when support from thrusters is included shall be as deemed appropriate by ClassNK.

6.2 Mooring system analysis

6.2.1 General

-1. The mooring system analysis shall be conducted based on the external conditions in Chapter 2. The analysis shall include evaluation of the hydrodynamic forces resulting from these external conditions, the responses of the FOWT, and the corresponding line tension.

-2. Mooring system shall be subjected to the mooring system analysis deemed appropriate by ClassNK for all assumed mooring states. In this case, the effect of FOWT draft changes shall also be considered. In addition, when mooring with a mooring facility that is independent of the FOWT, such as a separate CALM buoy, the mooring system analysis shall be performed as an entire system, with these mooring facilities included.

-3. When a mooring line is used, the mooring system analysis shall be carried out with the assumption that the structure and its arrangement keep that excessive bending will not occur in the mooring line at points where the mooring line touches the equipment on floating substructure such as fairleaders.

-4. The seabed fixed points (anchors, sinkers, piles, etc.) of FOWT mooring system and mooring facility shall be such that they do not slip, lift up or fall over due to the assumed tension from the mooring lines.

-5. The mooring system analysis shall be carried out assuming that the mooring system is affected by steady components such as force of wind, current and wave drift force, as well as by dynamic force wind and wave induced. In this case, the load shall be assumed to come from all directions, and the analysis shall be conducted for the state in which the load acting on the mooring system becomes the maximum. However, in cases where the directionality can be identified based on the data from the sea area where the FOWT will be installed, an examination based on the directions peculiar to the said sea area may be permitted.

-6. Depending on the subject of the analysis, either quasi-static analysis, or dynamic analysis deemed appropriate by ClassNK shall be conducted, and the maximum FOWT displacement and the maximum line tension shall be calculated.

6.2.2 Mean environmental forces, etc.

-1. The calculation of the steady forces due to the wind and current are to be in accordance with Chapter 2 and Chapter 3. However, when calculating the steady wind force, the following (1) and (2) shall be applied.

(1) The one minute average wind speed shall be used. When the wind speed data is not given as the one minute average wind speed, it is necessary to obtain the appropriate spectrum from the data and to use statistical methods to convert it to the one minute wind speed, or to apply an appropriate conversion factor.

(2) It is not necessary to consider the partial safety factor defined in 5.3.2.

-2. The steady wave drift force and fluctuating wave drift force shall be determined by model tests or by using a hydrodynamic numerical calculation program verified by model test results, etc. Also, the steady wave drift force may be determined according to standards deemed appropriate by ClassNK.

6.2.3 Maximum offset

-1. Maximum offset may be calculated as the sum of the offset due to steady components such as wind, current, and wave (steady drift), and dynamic motion offset due to the dynamic components of forces induced by waves (high and low frequency).

-2. The maximum offset may also be the larger of the values calculated based on the following equations 6.1 and 6.2 using the steady offset and significant amplitude or maximum amplitude of the maximum offset obtained from model tests or analysis methods deemed appropriate by ClassNK. However, this shall not apply when a time history motion calculation is performed.

$$S_{max} = S_{mean} + S_{lf(max)} + S_{wf(sig)} \tag{6.1}$$
$$S_{max} = S_{mean} + S_{lf(sig)} + S_{wf(max)} \tag{6.2}$$

Where:

S_{mean} : Steady offset of the FOWT due to wind, current and steady drift force

$S_{lf(sig)}$: Significant amplitude of displacement due to low frequency motion

$S_{wf(sig)}$: Significant amplitude of displacement due to motion of the same period as the significant wave period

The maximum amplitude of the low frequency motion $S_{lf(max)}$ and the maximum amplitude of the motion of the same period as the wave period $S_{wf(max)}$ may be calculated by multiplying their corresponding significant amplitudes by the factor C.

In this case, the factor C is as follows.

$$C = \frac{1}{2}\sqrt{2\ln N}$$

$$N = \frac{T}{T_a}$$

T: The time (in seconds) for which storm conditions are assumed to continue, with 10,800 seconds (3 hours) as the minimum. However, it is necessary to have a larger T in sea areas such as those where typhoons hit.

T_a: Average response of zero up-crossing period (seconds)

In case of low frequency components, T_a may be taken as the natural period T_n of the FOWT with mooring system. T_n can be calculated as follows using the mass of the FOWT m (including the added mass, etc.) and the stiffness of the mooring system k relative to the horizontal motion of the FOWT (side to side, fwd to aft, yaw motion).

$$T_n = 2\pi\sqrt{\frac{m}{k}}$$

In such cases, information about the stiffness of mooring systems, damping forces, and other parameters which may affect the maximum values of low frequency motion are to be submitted to ClassNK for reference.

-3. In the case of a single point mooring system, for the motion in waves, the maximum offset shall be calculated by a nonlinear time history motion calculation or model tests. In such case, wave irregularity and wind variability shall be considered.

6.2.4 Calculation of mooring line tensions, etc.

-1. In the calculation of the maximum tension of mooring lines, the severest combination of wind, wave and current (generally all in the same direction) for each mooring line in storm wind and wave conditions with a 50 year return period shall be considered, and a sufficient number of combinations of incident angles shall be considered. In certain sea areas, combinations of wind, waves and current coming from different directions that may cause higher tension shall also be taken into account as necessary.

-2. The calculation of the tension of mooring lines shall at least consider the following items (1) to (3). If necessary, the item (4) may be examined. The calculated maximum tension on the mooring lines shall in principle have the safety factor listed in Table 6-1 against the designated breaking load of the mooring line. If values other than those listed in Table 6-1 are used for the safety factor, the appropriateness of applying those values shall be shown.

(1) Static tension of mooring lines due to dead weight and buoyancy
(2) Steady tension of mooring lines due to the steady horizontal offset of the FOWT by wind, waves and current
(3) Quasi-static variable tension of mooring lines due to the motion of the FOWT due to waves
(4) Tension taking into account the elastic elongation of the mooring line in cases where the mooring lines are used in a relatively taut condition (generally at shallow water depths), or in cases when low rigidity mooring lines are used, such as synthetic fiber ropes

Table 6-1 Safety factors for mooring lines

Condition	Safety factor	
	Chains and wire ropes	Synthetic fiber ropes
Intact		
Dynamic analysis	1.67	2.50
Quasi-static analysis	2.00	3.00
One mooring line broken (equilibrium condition after breaking)		
Dynamic analysis	1.25	1.88
Quasi-static analysis	1.43	2.15
One mooring line broken (transient condition)		
Dynamic analysis	1.05	1.58
Quasi-static analysis	1.18	1.77

-3. The maximum tension of the mooring line T_{max} may be the greater of the values calculated using equations 6.3 and 6.4 below. However, this shall not apply when a time history motion calculation is performed.

$$T_{max} = T_{mean} + T_{lf(max)} + T_{wf(sig)} \quad (6.3)$$
$$T_{max} = T_{mean} + T_{lf(sig)} + T_{wf(max)} \quad (6.4)$$

Where:

T_{mean} : Steady tension of mooring line due to steady components of wind, current and wave drift force

$T_{lf(sig)}$: Significant amplitude of the low frequency tension

$T_{wf(sig)}$: Significant amplitude of the tension of variation components with the same period as the wave period

The maximum tension of the low frequency tension $T_{lf(max)}$ and the maximum tension $T_{wf(max)}$ of the variation component with the same period as the wave period shall be calculated by the same methods as those for the low frequency motion and wave frequency calculation described in 6.2.3-2.

-4. Mooring systems are to be designed so that the single line broken does not cause the progressive failure of the remaining mooring lines. The tension acting on the remaining mooring lines shall in principle have at least the safety factor listed in Table 6-1 against the breaking load of each mooring line. In the calculation of the mooring tension in the equilibrium condition after line breaking, the return period for the external conditions to be considered may be set to one year.

-5. In the analysis of the condition with a single line broken in -4. above, if another structure is to be installed in the vicinity of the FOWT, the safety factor for the FOWT mooring line installed on the opposite side the adjacent structure shall be 1.5 times the value listed in Table 6-1.

-6. When the following (1) and (2) are taken into consideration in addition to -2. above, the required safety factor for the mooring line in the quasi-static analysis method may be taken into account.

(1) Dynamic tension of the mooring line due to the damping force and inertial force acting on the mooring line, generally when the use is in deep water

(2) Quasi-static long-period variable tension of the mooring line due to the low frequency motion of the FOWT in irregular waves when the mooring line is used in a sufficiently slack state (generally when the natural period of the motion of the FOWT in the horizontal plane is sufficiently longer than the normal wave period)

-7. In addition to -1. to -5. above, the following shall be complied with in the case of a taut mooring system.

(1) Such systems are to be designed so that no slack is caused in any mooring line due to changes in line tension.

(2) Changes in the tension of mooring lines due to tidal difference including astronomic tides and meteorological tides are to be considered.

(3) The effects of any changes in the weight and displacements of heavy items carried on board upon the tension of mooring lines are to be sufficiently taken into account.

(4) In cases where the effects of the non-linear behavior of mooring lines on their tension are not negligible, tension due to non-linear behavior is to be considered.

-8. In addition to -1. to -5. above, the mooring system analysis for a tension mooring system may be conducted in accordance with the provisions of 10.4.2 of Part P of the Rules for the Survey and Construction of Steel Ships, or in accordance with international standards for marine structures such as ISO/API.

-9. In addition to -1. to -5. above, the mooring system analysis for a single point mooring system may be conducted in accordance with the provisions of 10.5.2 of Part P of the Rules for the Survey and Construction of Steel Ships, or in accordance with international standards for marine structures such as ISO/API.

6.2.5 Fatigue strength

-1. The range of variable tension T and the number of cycles n shall be considered in the examination of the fatigue life of mooring lines. The evaluation of the fatigue life of a mooring line shall apply the fatigue strength chart ($T-N$ curve) for the range of variable tension and the number of cycles leading to line breakage and follow the degree of fatigue damage D_i calculated based on Miner's rule as shown in equation 6.5. The cumulative fatigue damage D for all assumed sea starte NN (those shown in the joint probability distribution of the significant wave height and significant wave period) is calculated by Equation 6.6, and the value obtained by multiplying D by 3.0 shall not exceed 1.

$$D_i = \frac{n_i}{N_i} \tag{6.5}$$

$$D = \sum_{i=1}^{NN} D_i \tag{6.6}$$

Where:

n_i : Number of cycles of the range of variable tension in the number of cycles block i in the tension interval range i under the given sea conditions i

N_i : The number of cycles until a line is broken, corresponding to when the range of variable tension T_i is applied

-2. It should be noted that when calculating the range of variable tension T in -1. above, the consideration shall include storm wave conditions with a 50 year return period.

-3. The fatigue life shall be considered for each mooring line. The T-N curve for composite lines shall be based on fatigue test data and regression analysis.

-4. Special consideration shall be given to the fatigue strength of the connections between the mooring lines and the FOWT, and to the connections between the mooring lines and the seabed fixed point.

-5. When ClassNK deems it necessary, the effect of vortex-induced vibration shall also be considered.

6.2.6 Corrosion, friction and durability

-1. When a chain is used as a mooring line, the link diameter shall be increased appropriately for protection against corrosion and abrasion with consideration of the salinity of the sea area of installation. For the extra link diameter as a measure for corrosion and wear, the following are the standard values, but the values shall be determined appropriately in light of the site conditions.

- Splash zone and parts in contact with hard ground seabed : 0.2 mm to 0.4 mm per year
- Others : 0.1 mm to 0.2 mm per year

-2. If synthetic rope is used in the mooring lines, it shall be sufficiently confirmed that it has the necessary durability against the external conditions at the site over the expected service life. It shall also be sufficiently noted that there are various restrictions, including at the time of construction, such as regarding exposure to sunlight, contact with the sea floor, the penetration of soil particles, and protection against marine growth.

6.3 Mooring line design

6.3.1 General

-1. Each component of the mooring system shall be designed using a design method that can confirm the most severe load conditions for them.

-2. When using a low rigidity mooring line such as synthetic fiber rope, it is necessary to consider the elastic elongation of the mooring line. It should be noted that in this case, measures such as checking for the occurrence of elastic elongation shall be taken at the time of the installation of the mooring line and at the time of periodical surveys.

6.3.2 Mooring line components and seabed fixed points

-1. The strength of the connecting shackles and links, etc., used to connect mooring lines to the floating substructure or to the seabed fixed points shall in principle have the safety factors shown in Table 6-2 against the breaking tension of the mooring lines and the ultimate strength of those structures.

-2. In the case of a catenary mooring system, the mooring lines shall be sufficiently long so that no uplift is applied at the seabed fixed point under the assumed design conditions. However, in the examination of the state with a single line broken when the seabed soil quality is soft clay, a small angle between the line and the sea floor may be permitted.

-3. Data showing that the seabed fixed point have sufficient holding force against the mooring line tension assumed in 6.2.4 shall be submitted to ClassNK for reference.

-4. In the case of seabed fixed point that rely on the horizontal friction force with the sea floor, and where the weight of the mooring line per unit of length in the sea is constant, the maximum load F_{anchor} acting on the seabed fixed point may be calculated using equations 6.7 and 6.8. It should be noted that if a mooring line in the undersea area is not a single line, or if an intermediate sinker/buoy is used, then the effect of that shall be considered.

$$F_{anchor} = P_{line} - W_{sub} WD - F_{friction} \tag{6.7}$$
$$F_{friction} = f_{sl} L_{bed} W_{sub} \tag{6.8}$$

Where:

P_{line}	:	Maximum tension of mooring line
WD	:	Water depth
f_{sl}	:	The coefficient of friction between the mooring line and the seabed under sliding conditions, which shall be a value set appropriately with consideration of the seabed soil and the type of mooring line. In the case of soft soil, sand and clay, f_{sl} and the friction coefficient at the beginning of sliding f_{st} may follow the values in Table 6-3.
L_{bed}	:	The length of the mooring line on the seabed under adverse weather conditions in the design, which does not exceed 20% of the total length of the mooring line
W_{sub}	:	Weight of the mooring line per unit of length in the sea

-5. The design safety factor for the horizontal holding force of the seabed fixed point in catenary mooring systems and taut mooring systems shall in principle follow Table 6-4. This shall not apply in a case when the maximum required holding force is determined based on dynamic analysis that takes into account the dynamic behavior of the mooring lines.
-6. The design safety factor for the vertical holding force of the seabed fixed point in taut mooring systems shall in principle follow Table 6-5. The values for tension mooring systems shall be as deemed appropriate by ClassNK.
-7. If the effects of scouring cannot be ignored, the necessary measures shall be taken, such as the adjustment of the burial depth at the seabed fixed points, or the control of the flow near the seabed fixed points.

Table 6-2 Safety factor

Safety factor	
Intact	2.50
State with single rope broken	1.43

Table 6-3 Friction factor *f*

Items	Start of slipping (f_{st})	Slipping state (f_{sl})
Chains	1.00	0.70
Wire ropes	0.60	0.25

Table 6-4 Safety factor for the horizontal holding force of the seabed fixed point in catenary mooring systems and taut mooring systems

Safety factor	
Intact	1.50
Extreme state with single rope broken	1.00

Table 6-5 Safety factor for the vertical holding force of the seabed fixed point in taut mooring

Safety factor	
Intact	1.20
Extreme state with single rope broken	1.00

6.4 Mooring equipment

6.4.1 General

-1. The mooring equipment shall comply with the following (1) to (3).

(1) The mooring equipment shall have sufficient redundancy.

(2) Measures shall be taken to enable the normal operation of the mooring equipment to be maintained or restored even if one piece of the equipment malfunctions. For the driving devices in particular, consideration shall be given to ensuring that the functioning will not be lost.

(3) For the mooring equipment used on a semi-submersible type of FOWT, they shall operate at a dynamic inclination of 22.5° in any direction. However, this shall not apply in cases approved by ClassNK based on consideration of the type, size and operating conditions of the FOWT.

-2. The mooring equipment, etc., used in tension mooring systems shall comply with the following (1) to (3).

(1) When laying tension mooring lines, the initial tension of all lines shall be adjusted to be almost uniform. Power equipment capable of adjusting the tension of the mooring lines shall be provided as necessary.

(2) A device which can monitor the tension of a line shall be provided for each tension mooring line.

(3) Data showing that the equipment on the seabed fixed points are designed so that they will not be lifted up under any design load conditions shall be submitted to ClassNK for reference.

6.4.2 Equipment constituting mooring system

-1. The equipment constituting the mooring system shall satisfy the provisions of Chapter 4. However, it shall be noted that when using *Grade 4* chains as specified in 3.2 of Part L of the Rules for the Survey and Construction of Steel Ships, or stronger chains, in principle, repair by welding is not allowable for the looseness of studs, wear of chain diameter or defects, etc.

-2. In the case of equipment designed specifically for the site, such as intermediate sinkers, intermediate buoys, and anchors, sinkers and piles to be the seabed fixed point, items shall be as deemed appropriate by ClassNK.

6.4.3 Chain stoppers

-1. Chain stoppers used in mooring system shall have sufficient strength against the maximum tension of the mooring lines, as deemed appropriate by ClassNK.

-2. When laying taut mooring lines, the initial tension of all lines shall be adjusted to be almost uniform. Power equipment capable of adjusting the tension of the mooring lines shall be provided as necessary.

-3. A device which can monitor the tension of each line shall be provided for taut mooring lines.

6.4.4 Fairleaders

-1. When a chain is used for a mooring line, the standard for the length of a place where the fairleader and the chain come into contact shall be seven times or more the long diameter of the chain.

-2. When a wire or synthetic fiber rope is used for a mooring line, the standard for the length of a place where the fairleader and the wire come into contact shall be 14 times or more the nominal diameter of the wire.

-3. If the standard values specified in -1. or -2. above are not satisfied, then either detailed analysis considering the bending load acting on the mooring line shall be conducted, or mooring system analysis that does not consider the influence of bending shall be conducted by increasing the value of the safety factor shown in Table PS4.2.1 of Part PS of the Rules for the Survey and Construction of Steel Ships to a value deemed appropriate by ClassNK.

6.5 Single point mooring systems

6.5.1 General

-1. The adoption of a single point mooring system shall be in accordance with the provisions of 6.5.2 and 6.5.3, or based on standards and specifications deemed appropriate by ClassNK.

6.5.2 Design loads on structures

-1. The structural members and components of a single point mooring system shall be considered for the most severe combinations of various loads, including at least the following. A detailed examination report shall be submitted to ClassNK as reference data.

(1) Dead weight loads
(2) Dynamic loading due to motion (including consideration of rotational motion around turntables)
(3) Mooring loads
(4) Fatigue loads

-2. In the examination of the design load in turret mooring, the load from the mooring lines, gravity, buoyancy, inertial force, and hydrodynamic force, etc., shall be considered.

6.5.3 Structural elements

-1. In principle, structural elements shall conform to the specifications or standards, etc., deemed appropriate by ClassNK, and also shall have been evaluated for structural strength by appropriate methods such as FE analysis.

-2. In the analysis in -1. above, the allowable value for the von Mises equivalent stress shall be 60% of the specified yield strength (not to exceed 72% of the tensile stress) of the material of the part concerned. However, the allowable value may be increased up to 80% in the transient state when a mooring line breaks.

-3. Structural members shall have sufficient strength against buckling in consideration of their shape and dimensions, and the surrounding conditions.

-4. Fatigue strength shall be examined for the parts designated by ClassNK among the main members such as turrets and yokes.

-5. The mooring facility structure and connections with the mooring system, and the mooring facility connections with the seabed anchorage shall conform to appropriate standards or specifications.

-6. Appropriate reinforcement to withstand the loads shall be conducted on the points where the loads from turrets and yokes, etc., are transmitted to the floating body structural parts and appropriately diffused (the bearing parts of turrets, etc.).

6.5.4 Configuration of equipment

-1. The components used in a single point mooring system (such as turret bearings, driving units, and various connectors) shall conform to the provisions of Chapter 7 of Part PS of the Rules for the Survey and Construction of Steel Ships, and to the specifications and standards deemed appropriate by ClassNK.

-2. Bearings (turret bearings, etc.) subjected to loads from rotating structures and mooring lines shall have a safety factor twice as high as the yield fracture strength of the bearing pressure receiving surface.

-3. Notwithstanding -2. above, swivel bearings, etc., that are not subjected to loads may be ones that comply with appropriate specifications or standards.

Chapter 7 Stability and waterline, etc.

7.1 General

7.1.1 General

-1. The FOWT shall meet the stability criteria in this chapter in all states. Stability in the case of a tension leg platform type shall be as approved separately by ClassNK.

-2. The motion of the floating substructure shall be suitably suppressed so that it does not adversely affect the tower and wind turbine.

-3. For the calculation of stability, both the state without influence from the mooring system and the state with influence from it shall be considered and the calculation shall be based on the more severe state.

-4. In the calculation of the stability, the free surface effect from the liquid in tanks shall be taken into account.

-5. In the calculation of the stability, consideration shall be given as necessary to the effects of the loads due to snow cover and icing based on the data for the sea area where the FOWT will be installed.

-6. Attention shall be paid to the watertightness of the point where the power cable is taken into the floating substructure.

-7. The stability of the FOWT during towing and installation shall be as deemed appropriate by ClassNK.

7.1.2 Stability information booklet

-1. Stability information booklet shall be submitted to and approved by ClassNK. The stability information booklet shall include the results of stability calculation in representative states and, if necessary, in states where there is damage, such as to the equipment constituting the mooring system.

7.1.3 Heeling moment due to wind

-1. The wind load shall comply with the provisions of Chapter 2 and Chapter 3. However, when calculating the wind load, (1) and (2) below shall be followed.

(1) The one minute average wind speed shall be used. When the wind speed data is not given as the one minute average wind speed, it is necessary to obtain the appropriate spectrum from the data and to use statistical methods to convert it to the one minute wind speed.

(2) It is not necessary to consider the partial safety factor defined in 5.4.2.

-2. In the examination of the stability when damaged, it shall be possible to use the wind speed of 25.8 *m/s* (10 m above the sea surface).

-3. The length of the lever for the calculation of the heeling moment due to the wind shall be the vertical distance from the center of the wind pressure to either the center of lateral resistance on the floating substructure beneath the waterline, or preferably to the dynamic center of pressure on the floating substructure beneath the waterline.

-4. The heeling moment due to the wind shall be calculated for each appropriate angle of inclination for each state of the FOWT.

-5. Where it is deemed appropriate by ClassNK, the heeling moment due to the wind may be a cosine function of the angle of inclination.

-6. In place of the provisions in -2. to -4. above, the heeling moment due to the wind may be determined by wind tunnel tests deemed appropriate by ClassNK. When finding this moment, drag and lift effects at various heel angles shall be included.

7.2 Intact stability

7.2.1 General

-1. The FOWT shall have positive stability at the initial equilibrium in still water.

-2. The FOWT shall have sufficient stability against the heeling moment due to wind from all horizontal directions and against the motion of the FOWT due to waves.

-3. The righting moment curve and wind heeling moment curves as shown in Figure 7-1 shall be provided.

-4. The righting moment curve and wind heeling moment curve shall be considered for a sufficient number of states during floating with respect to the most affected axial direction.

-5. The FOWT shall have positive stability from upright to the inclination θ_3 shown in Figure 7-1. Also, the heeling angle shall be up to the greatest angle where the blades of the wind turbine do not touch the water surface.

7.2.2 Semi-submersible type

-1. The FOWT shall satisfy the following conditions on Figure 7-1.

$\mathrm{Area}(A + B) \geq 1.3 \times \mathrm{Area}(\mathrm{B} + \mathrm{C})$

However, the heeling angle shall be up to θ_2.

7.2.3 Barge type

-1. The FOWT shall satisfy the following conditions on Figure 7-1.

$\mathrm{Area}(A + B) \geq 1.4 \times \mathrm{Area}(\mathrm{B} + \mathrm{C})$

However, the heeling angle shall be up to θ_2 or θ_3, whichever is smaller.

7.2.4 Spar type

-1. The FOWT shall have stability equal to or greater than that of semi-submersible and barge types.

7.2.5 TLP type

-1. It shall be verified that the floating substructure has adequate stability by a method deemed appropriate by ClassNK.

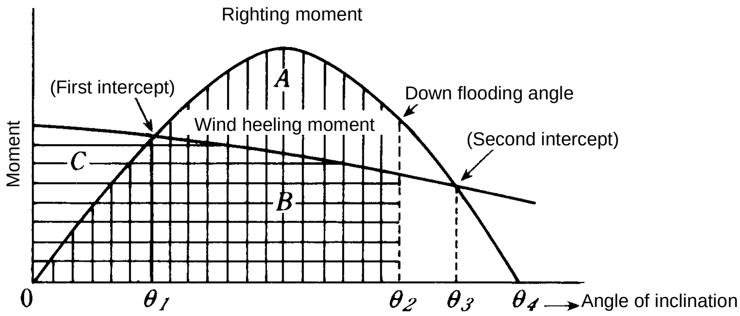

Figure 7-1 Righting moment curve diagram

7.3 Damaged stability

7.3.1 General

-1. The FOWT shall have sufficient freeboard and be partitioned by watertight decks or bulkheads to ensure buoyancy and stability against the flooding of any one compartment as specified in 7.3.2.

-2. The FOWT shall also have positive stability against the heeling moment due to wind from all horizontal directions and against the motion of the FOWT due to waves when there is flooding in one compartment as specified in 7.3.2.

-3. The final waterline after flooding shall be below the lower edge of any opening which is not watertight.

-4. The calculation of the stability when damaged shall not consider the reduction of the heeling angle through the drainage of the damaged compartment, ballast adjustment, water filling in other compartments, or the mooring force.

-5. ClassNK may recognize methods different to those in the provisions in -1. to -4. above in cases where ClassNK deems this appropriate based on consideration of the conditions in the sea area where the FOWT will be installed, and of the measures to prevent the flooding of compartments.

-6. For TLP type FOWTs, it shall be verified that the FOWT has adequate stability by a method deemed appropriate by ClassNK.

7.3.2 Flooding compartments

-1. The compartments subject to flooding shall be those shown in (1) to (3) below.

(1) Compartments adjacent to the outer shell plating in the range from 5.0 m above to 3.0 m below the waterline

(2) Compartments with penetrations below the waterline, such as for submarine cable penetration

(3) Compartments subject to reaction forces from mooring lines, and other points where flooding is possible

7.4 Watertight compartments and closing devices

7.4.1 Watertight compartments

-1. The arrangement of watertight floors and bulkheads and the dimensions of the members shall be effective to the point necessary to comply with damage stability.

-2. The bulkheads deemed to be effective in the calculation of stability when damaged shall be watertight, including at the penetrations such as those for piping, ventilation, and electrical equipment.

7.4.2 Closing devices

-1. The structures and closing devices on all openings through which flooding with seawater is a risk shall comply with the relevant provisions of Part C or Part CS of the Rules for the Survey and Construction of Steel Ships.

-2. Items outside of the flooding compartments that have been given special consideration shall be as deemed appropriate by ClassNK.

7.5 Waterline

7.5.1 General

-1. The freeboard of the FOWT shall be determined based on consideration of the stability, watertightness and structural strength of the FOWT.

-2. A draft scale shall be provided near the waterline.

Chapter 8 Surveys of FOWT

8.1 General

8.1.1 General

-1. The classification survey for a FOWT shall be carried out in accordance with the provisions of this chapter.

-2. The FOWT shall be equipped with equipment (anemometers, wave height meters, wave current meters, etc.) capable of monitoring the environmental conditions which are design conditions of the FOWT (which are mainly the wind conditions, sea state conditions, etc.). However, it is not necessary to provide monitoring equipment for each individual FOWT when environmental data for the sea area in the vicinity of the FOWT installation can be obtained.

8.1.2 General provisions on surveys

-1. The general provisions concerning the classification survey specified in 8.3 shall follow the provisions of Chapter 1 of Part B of the Rules for the Survey and Construction of Steel Ships. In the classification survey, the items necessary for the individual case shall be surveyed, tested or investigated and it shall be confirmed that the state is satisfactory to the surveyor.

-2. For the periodical surveys specified in 8.4, the surveys shall be conducted in accordance with the inspection plans and the documents on inspection procedures given below. In the periodical surveys, the items necessary for the individual case shall be surveyed, tested or investigated and it shall be confirmed that the state is satisfactory to the surveyor.

(1) Inspection plans

These are documents specifying inspection times, the times when the Surveyor is present, the objects and the methods of inspections for Periodical Surveys, which are approved by ClassNK.

(2) Documents on inspection procedures

These are documents based on the inspection plan, specifying detailed inspection procedures (inspection procedures, etc.) and acceptance criteria for periodical surveys which are approved by ClassNK.

-3. With regard to the periodical survey prescribed in 8.4, it shall be possible to omit the survey on an individual FOWT when it is approved by ClassNK in cases when sufficiently reliable information on the safety of the FOWT can be obtained, such as from proven past results on the same type of FOWT, etc.

-4. In surveys on the FOWT, in addition to complying with the provisions in this chapter, attention shall also be paid to compliance with the domestic laws and regulations of the coastal country.

8.2 Equivalency

8.2.1 General

-1. Notwithstanding the provisions of this chapter, ClassNK may approve a inspection plan, survey method, or survey procedure, etc., if it is deemed to have the same or greater efficacy than the inspection plans, survey methods, and survey procedures, etc., for periodical surveys that are specified in this chapter.

8.3 Classification survey during construction

8.3.1 General

-1. The classification survey during manufacturing shall verify that the structure, equipment, machineries, electrical equipment, stability and waterline comply with the applicable provisions of these guidelines.

-2. The classification survey shall comply with the provisions from 8.3.2 to 8.3.8 and also with the applicable provisions of Chapter 2 of Part B of the Rules for the Survey and Construction of Steel Ships, as appropriate for the materials, structure, equipment, machineries, etc.

8.3.2 Drawings and other documents for submission

-1. The following drawings and other documents shall be submitted to and approved by ClassNK prior to the commencement of the construction of a FOWT for which a classification survey during manufacturing is intended.

(1) General

(a) Inspection plans

(b) Documents on inspection procedures

(c) Manual for the safety of floating offshore wind power generation facilities

(2) Floating substructure and mooring system

(a) General arrangement drawings

(b) Cross sections drawings (showing the draft and the draft during towing)

(c) Longitudinal sections drawings

(d) Inspection facilities drawing

(e) Tower anchorage structures drawings

(f) Welding procedure specification and welding procedure plan

(g) Corrosion prevention and painting procedures

(h) Towing equipment drawings

(i) Layout drawings and structural drawings for mooring system

(j) Stability information booklet (including for during towing)

(k) For semi-submersible type of floating substructures, structural drawings of columns, lower hulls, footings, bracing, etc.

(l) For the machineries and electrical equipment relating to the safety of the floating substructure, the drawings for approval specified in each relevant chapter of Part D and Part H of the Rules for the Survey and Construction of Steel Ships.

(m) Other drawings and documents deemed necessary by ClassNK

(3) Tower

(a) General arrangement drawings

(b) Main structural parts detailed drawings

(c) Bolt specifications

(d) Flange specifications

(e) Corrosion prevention and painting procedures

(f) Tower base plate drawings

(g) Anchor bolts drawings

(h) Other drawings and documents deemed necessary by ClassNK

(4) Lift facilities (Limited to FOWT equipped with lift facilities.)

(a) Layout drawing for lift facilities

(b) Structural drawing for lift facilities

(c) Strength calculation sheet for lift facilities

(d) Documents showing the materials used on lift facilities

(e) Documents showing the method of use of lift facilities

-2. For a FOWT for which a classification survey during manufacturing is intended, in addition to the approval drawings and other documents specified in -1. above, the following drawings and other documents shall be submitted to ClassNK for reference.

(1) General

(a) Maintenance manual (including matters related to RNA maintenance)

(b) Offshore tests procedure

(c) Stability tests procedure

(2) Floating substructure and mooring system

(a) Documents regarding the setting of the external environmental conditions (including content indicating the grounds for the setting)

(b) Design basis documents

・ Design Basis Part A: Site conditions (The following items shall be included.)

 − FOWT installation point
 − Wind conditions
 − Sea state conditions
 − Geotechnical conditions (if necessary)
 − Earthquake and tsunami conditions
 − Other environmental conditions
 − Constraints, etc.
 − Other items deemed necessary by ClassNK

・ Design Basis Part C: Floating body and mooring related (The following items shall be included.)

- Codes and standards which form the basis for the project
- Site conditions
- Specifications for the floating substructure (including for the tower anchorage and attached equipment)
- Design methodologies and principles (required performance and verification items, applied materials and their constants, allowable tolerance of shape and corrosion reserve thickness, etc.)
- Design parameters related to the load calculations, and the validity of applying the load analysis method used
- Design load cases table
- Load factors and load reduction factors
- Overview of the load analysis model
- Duration of simulation as well as number of simulations
- Extreme and fatigue design loads and response analyses
- Materials and welding
- Coating and corrosion prevention system
- Other items deemed necessary by ClassNK

(c) Data on coupled analyses

- This shall make it possible to ascertain whether the site-specific loads and load effects on the entire FOWT which includes the RNA, tower, floating substructure and mooring system, have been calculated to comply with the design standard and shall include the following items.
  - Combination of external conditions and design conditions
  - Design load cases defined with reference to the site conditions, RNA operation, and safety systems
  - Partial safety factors
  - Calculation methods (For example, simulation procedures, number of simulations, wind and wave combinations, etc.)
  - Analysis models details and their results, and verification results for them (When combining results from multiple analysis models, the validation results obtained by comparing the results between the analysis models shall be presented in addition to the validation results obtained from each applied analysis model alone.)
  - Other items deemed necessary by ClassNK (It should be noted that this will differ depending on the RNA type.)

(d) Stability information booklet for intact and damaged stability (The following items shall also be included.)

- Displacement curve diagram
- Stability curve diagram and wind heeling moment curve
- Tank capacity diagram, its examination report and sounding diagram
- Drawings of the watertight compartment layout, openings and closing devices, etc., necessary for stability calculations
- Data showing the effects of icing on stability and the wind receiving area

(e) Design calculation documents for the floating substructures

(f) Design calculation documents for the mooring systems

(g) In relation to (b) to (f) above, if an appropriate model test or analysis method was used, then data related to that

(h) For the machineries and electrical equipment relating to the safety of the floating substructure, the data and other documents specified in each relevant chapter of Part D and Part H of the Rules for the Survey and Construction of Steel Ships

(i) Documents outlining the construction process
Documents showing the construction work to be completed and the equipment to be installed, etc., at the shipyard and other intermediate construction sites prior to the installation of the FOWT in the sea area of installation

(j) Documents showing the calculation sheet for strength during towing and the towing method

(k) Test procedures for the tests conducted before the sea area of installation and tests conducted at the time of installation

(l) Installation procedure for mooring system and procedure manual for installation work in the sea area of installation

(m) Other drawings and documents deemed necessary by ClassNK

(3) Tower

(a) Design basis documents

- Design Basis Part B: RNA and tower (The following items shall be included.)
  - Codes and standards which form the basis for the project
  - Site conditions
  - Specifications for the RNA and tower (including the tower anchorage), and if there is any change from the design of type certification, a comparison of the specifications before and after that change
  - Design methodologies and principles (required performance and verification items, applied materials and their constants, allowable tolerance of shape and corrosion reserve thickness, etc.)
  - Design parameters related to the load calculations, and the validity of applying the load analysis method used
  - Design load cases table
  - Load factors and load reduction factors
  - Overview of the load analysis model
  - Duration of simulation as well as number of simulations
  - Extreme and fatigue design loads and response analyses
  - Coating and corrosion prevention system
  - Other items deemed necessary by ClassNK

(b) Data on coupled analyses

- This shall make it possible to ascertain whether the site-specific loads and load effects on the entire FOWT which includes the RNA, tower, floating substructure and mooring system, have been calculated to comply with the design standard and shall include the following items.
  - Combination of external conditions and design conditions
  - Design load cases defined with reference to the conditions on-site, RNA operation, and safety systems
  - Partial safety factor
  - Calculation methods (For example, simulation procedures, number of simulations, wind and wave combinations, etc.)
  - Analysis models details and their results, and verification results for them (When combining results from multiple analysis models, the validation results obtained by comparing the results between the analysis models shall be presented in addition to the validation results obtained from each applied analysis model alone.)
  - Other items deemed necessary by ClassNK (It should be noted that this will differ depending on the RNA type.)

(c) Design calculation documents for the tower structure

(d) Tower installation procedure

(e) Bolt tightening procedure

(e) Bolt maintenance and management procedure

(f) Other drawings and documents deemed necessary by ClassNK

-3. The installation procedure manual referred to in -2. (2) (l) above shall include any of the following items that are relevant. Each work procedure should include confirmation methods and judgment criteria for the validity of the work.

(1) General outline of the FOWT and surrounding facilities

(2) Documents describing the survey results for the seabed conditions at the installation site

(3) Installation procedure for seabed fixed point such as anchors, sinkers and piles, and procedure for the connection of mooring lines to seabed fixed point (At least the following items shall be included.)

(a) Preparations necessary for the installation and work procedure (Including information on the anchors, rigging, and various work barges, etc., used.)

(b) Procedures for determining the location and installation orientation for seabed fixed point (Including tolerances/judgment criteria for the positions and orientation.)

(c) Items to be checked at the completion of installation work according to the type of seabed fixed point (Anchor, sinker, pile, etc.) and judgment criteria for pile driving amount, sinker burial amount, etc.

(d) Procedures for mooring line installation at seabed fixed point (Including measures to prevent the twisting of mooring lines during their installation.)

(4) Tensile test procedure for mooring system

(a) Arrangement of rigging for tensile testing of mooring lines and seabed fixed point

(b) Specifications of the work vessels used for the tensile tests

(c) Procedures detailing the tensile testing

(5) Procedure for installing mooring lines on mooring facilities on the sea

(a) Procedures for rope handling and towing by tugs, etc., for the positioning of the FOWT necessary when attaching the FOWT to mooring facilities on the sea

(b) The ballast state of the FOWT required prior to installation

(c) Procedure manual for the installation sequence for mooring lines, the repositioning of the FOWT, and the application of tension to mooring lines

(d) Method for correcting the tension of mooring lines, and method for deciding the allowable design range for the FOWT position

(e) In the case of a mooring system using a turret, the method for suppressing the rotation of the turret and safety precaution statement concerning the mooring work in general

(f) Procedure for tension application by FOWT ballast adjustment (in the case of tension mooring, etc.)

-4. Notwithstanding the provisions of -1. and -2. above, where the FOWT and tower will be constructed using drawings and other documents that have already been approved for the same place of business, the submission of some of the drawings and data in -1. and -2. above may be omitted as otherwise provided by ClassNK.

8.3.3 Survey for construction works

-1. The timing of the attendance by a surveyor at the work for the structure, equipment, machinery and electrical equipment during the classification survey under manufacturing shall be the times when performing the testing and surveys prescribed in the applicable provisions of 2.1 of Part B of the Rules for the Survey and Construction of Steel Ships and in 8.3.4 to 8.3.8, and when the contents of the data submitted regarding the surveys and testing prescribed in 8.3.2 is verified by ClassNK.

-2. The timing of the attendance by a surveyor at the work related to lift facilities shall be as follows.

(1) When carrying out load testing on the lift facilities

(2) When carrying out efficacy testing on the lift facilities

-3. For the elevating equipment that has undergone and passed the survey by ClassNK (limited to the first load testing), the limit load and maximum number of occupants shall be specified, and a designation statement for elevating equipment limit load, etc., shall be issued.

-4. The maximum number of occupants set forth in the preceding paragraph shall be equal to the maximum integer obtained by dividing the limit load in the load test by 75 *kg*.

-5. Depending on the actual situation of equipment, technology, and quality control, etc., at the manufacturing plant, the timing of the attendance by a surveyor in -1. above may be reduced.

8.3.4 Hydrostatic testing and watertightness testing, etc.

-1. The hydrostatic testing and watertightness testing, etc., in the classification survey during construction shall be based on the provisions of 2.1.5 of Part B of the Rules for the Survey and Construction of Steel Ships.

-2. Notwithstanding -1. above, the testing shall be as deemed appropriate by ClassNK if this is approved by ClassNK after consideration of the design conditions, etc.

8.3.5 Survey for structurers

-1. In the surveys in the shipyard, etc., which will construct the structure of the FOWT, for the items common with ordinary vessels, the surveys shall be carried out in accordance with Chapter 2 of Part B of the Rules for the Survey and Construction of Steel Ships.

-2. When a draft scale is installed

-3. For the tower, surveys shall be carried out at the times designated by ClassNK during the work on the interior of the tower and during the tower assembly, and when the tower is mounted on the floating substructure. The tower surveys shall comply with the following (1) to (3).

(1) The appearance of the tower shall be surveyed, including the welded parts and bolt joint parts.

(2) Nondestructive testing shall be carried out on the main structural members and on the welded joints in places where it is thought that stress is particularly likely to occur.

(3) It shall be confirmed that the tower is mounted in its design position (within the allowable design range).

-4. The surveys necessary for the towing of the FOWT to its installation site shall be conducted.

-5. When the mooring system and RNA, etc., will be mounted in a construction location other than the shipyard (including in the sea area of installation), the survey of the support structure parts, etc., for the installed items. shall be carried out at an appropriate time before the final surveys in the sea area of installation.

8.3.6 Survey for FOWT installation works

-1. As the survey during the mooring system installation work, the following matters shall be confirmed and surveyed in the presence of a ClassNK surveyor.

(1) It shall be confirmed that there is no abnormality in the mooring system components of the FOWT before their installation.

(2) Confirmation of the test results for the equipment for which testing at the manufacturing plants, etc., is required

(3) Report of investigation by divers or ROVs to confirm that there is no obstacle near the FOWT mooring site before its installation

(4) The following matters shall be verified during the installation of the FOWT at the seabed fixed point.

(a) The appropriate fixing between mooring lines and seabed fixed point, and between mooring lines and the connecting shackles

(b) The sealing of Kenter shackle locking pins

(c) Confirmation that the mooring line components are of the correct size and length

(d) Confirmation that the seabed fixed point are located at the design positions and in the positioning reference points (within the allowable design range)

(5) Confirmation that the mooring lines are deployed as designed according to the prescribed procedures

(6) After the mooring system is deployed in the sea area of installation, the following tensile tests shall be carried out on each mooring line.

(a) The tests shall be carried out for 15 minutes at the maximum load for the intact state. The integrity of the mooring from the seabed fixed point to the ends of the connections of the mooring lines to the FOWT shall be confirmed, and it shall be confirmed that there is no movement of the seabed fixed point, etc.

(b) Notwithstanding (a) above, when ClassNK deems it appropriate, it may be possible to reduce the maximum intact load for the tensile testing load on soft clay soil. However, it shall not be possible to go below 80% of the maximum load.

(c) Notwithstanding (a) and (b) above, the tensile testing on the mooring lines may be omitted if a detailed examination report has been submitted and it is deemed appropriate by ClassNK. However, in this case, it is necessary to apply the preloading necessary to generate the maximum holding force to each seabed fixed point. This preloading shall in no case be less than the average intact tensile force, and this preloading load shall be used to confirm the integrity and appropriate arrangement of the mooring lines.

(7) Confirmation of attachment to chain stoppers

(8) The catenary angles of the mooring lines shall be measured to confirm that they are in the normal state according to the design requirements and tolerances.

(9) When the installation has been completed, it shall be confirmed that the connections between the FOWT and the surrounding facilities comply with the design requirements. If necessary, surveys using divers or ROVs shall be conducted to the extent deemed appropriate by the surveyor.

-2. The results of the installation work shall be submitted to ClassNK as the installation work completion report. In addition, when confirmation was conducted by images or video from divers or ROVs, etc., all of the recorded data shall be submitted.

8.3.7 Offshore testing and stability testing

-1. As the offshore testing for the FOWT, the following shall be confirmed and surveyed in the presence of a ClassNK surveyor.

(1) Verification of the RNA control systems

(2) Efficacy testing on the systems that are necessary for the adjustment of the draft and posture, etc., of the FOWT, such as ballast systems.

(3) Operating state of machineries and electrical equipment, etc., relating to the safety of the floating substructure (confirmation that there is no abnormality of the state of the floating substructure during their operation)

(4) Vibration testing to confirm the motion eigenvalue and attenuation coefficient for the floating facilities

(5) In the case of a FOWT equipped with fire extinguishing equipment in accordance with the provisions of 1.1.7, a confirmation of the operation of that fire extinguishing equipment

(6) Of the items above, the testing after installation may be omitted for items that are confirmed at the construction site in a state that simulates the state after installation.

-2. The results of the offshore testing shall be submitted to ClassNK as the offshore testing results report.

-3. Where equipment cannot be checked in the offshore testing for unavoidable reasons, such as the equipment that can only be used after the starting of operations, the equipment shall be checked before the next annual survey.

-4. Stability testing

(1) In the classification survey during manufacturing, stability testing shall be carried out after the completion of the construction. If it is difficult to carry out the stability testing in the state where the RNA is mounted, then it shall be sufficient to carry out the stability testing in the state before the RNA is mounted and then add the effect of the RNA to the result. The stability data, etc., shall be prepared in accordance with the stability criteria established based on the test results and shall be approved by ClassNK.

(2) The results of the stability testing shall be submitted to ClassNK as the stability testing results report.

(3) It shall be possible to omit the stability survey on an individual FOWT when it is approved by ClassNK in cases when sufficiently reliable information on the stability of the FOWT can be obtained, such as from stability testing results on the same type of FOWT, etc.

8.3.8 Drawings, etc. to be retained on floating facilities

-1. Upon completion of the classification survey, it shall be confirmed that the drawings and other documents specified in 1.4.2-2. are provided in the FOWT.

8.3.9 Classification surveys after manufacturing

-1. The current state of the structure, equipment, machineries, electrical equipment, lift facilities, stability, and waterline shall be surveyed at the same level as in the post-construction periodic surveys to be performed on a FOWT that received the classification survey during manufacturing. The survey to be performed shall depend on the model of the FOWT and on the number of years that have elapsed since the FOWT construction, and shall be the special survey for FOWTs with the same or the closest number of years elapsed since construction. It shall be confirmed that the current state of the items conforms to the relevant provisions of these guidelines, and also the dimensions of the main members of the structure of the FOWT and the tower shall be measured.

-2. The drawings and other documents specified in 8.3.2 shall be submitted for the FOWT undergoing the classification survey in -1. above.

-3. The hydrostatic testing and watertightness testing shall be carried out in accordance with the provisions of 8.3.4.

-4. The offshore testing and stability testing shall be carried out in accordance with the provisions of 8.3.7. However, this testing may be omitted if there are data on the results of offshore testing and stability testing, and it can be confirmed that there have been no changes in matters directly related to the contents written in the data.

-5. Upon completion of the classification survey after construction, it shall be confirmed that the drawings and other documents specified in 8.3.8 are provided in the FOWT.

8.4 Periodical surveys

8.4.1 General

-1. The periodical surveys of a FOWT shall be carried out based on a inspection plan and documents on inspection procedure.

-2. The owners and designers of FOWT shall submit inspection plans and documents on inspection procedures in advance and obtain the approval of ClassNK.

8.4.2 Preparations, etc., for periodical surveys

-1. Before a survey is implemented, photographs and records (records of testing results, etc.) indicating the survey results and inspection results up to the previous survey, a inspection plan, a documents on inspection procedure and the manual for the safety of the floating offshore wind power generation facilities shall be submitted to the surveyor.

-2. A record of the maximum environmental conditions encountered in the time from the previous survey to the survey application date shall be submitted to the surveyor.

-3. Calibration records for the survey equipment, etc., to be used in the survey shall be submitted to the surveyor.

-4. The points to be surveyed shall be prepared with cleaning, etc., to prevent any danger during the survey.

-5. If an underwater survey will be implemented, it shall be performed by a place of business approved by ClassNK, and shall either be implemented by a diver skilled in underwater camera operation and underwater television operation, etc., or by a pilot skilled in the operation of remote control equipment.

8.4.3 Annual surveys

-1. In annual surveys, in addition to confirming the records listed in (1) and (2) below, an annual survey may be conducted in the same manner as a special survey for matters deemed particularly necessary by ClassNK or a surveyor, or for items for which a particular application was made by the vessel owner.

(1) The maintenance and inspection records specified in 1.5.3-6.

(2) The records relating to the natural environment specified in 8.4.2-2

(3) Records of the amount of movement of the floating body

8.4.4 Intermediate surveys

-1. In the intermediate surveys, the same survey as in the annual survey shall be performed and also a survey shall be carried out based on a inspection plan and documents on inspection procedure. In addition, a survey may be conducted in the same manner as a special survey for matters deemed particularly necessary by ClassNK or a surveyor, or for items for which a particular application was made by the owner of the FOWT. Furthermore, the intermediate surveys shall in principle include the surveys specified in (1) to (5) below.

(1) Intermediate survey of the structure and equipment

In the intermediate survey, the following items shall be surveyed.

(a) A survey of the current state of the following items to the extent that the current state can be viewed

i) The outer shell plating and exposed decks above the waterline

ii) Ventilation cylinders and air pipes

iii) Watertight bulkheads

iv) Waterline position confirmation

v) Drain pipes, suction pipes, exhaust pipes and valves

vi) Mooring system and structures around the mooring system above waterline

vii) Structures around openings that are within areas that can be surveyed above the waterline

viii) Fire extinguishing equipment (if provided)

(b) A survey of the current state of the openings of doors, etc., that are required to have watertightness and weathertightness, a survey of their closing devices, and an inspection of their fittings

(c) For a FOWT constructed more than 5 years ago, an internal survey of representative ballast tanks. However, the survey may be omitted if special consideration has been given to corrosion, and fatigue strength, etc., which ClassNK deems appropriate.

(d) If the surveyor deems it necessary as a result of the survey in (c) above, the sheet thickness of those ballast tanks shall be measured.

(e) The following shall be carried out in the intermediate surveys of mooring system. However, the survey may be omitted if special consideration has been given to corrosion, and fatigue strength, etc., which ClassNK deems appropriate.

i) A survey of the current state of the structural parts of mooring line stoppers (including the foundation parts)

ii) A survey of the current state of the devices holding the tension of the mooring lines

iii) When catenary mooring is used, measure the catenary angle of the mooring lines and confirm that the tension applied to the mooring lines is within the design tolerance. In other cases, another appropriate method shall be used to ensure that the tension is within the design tolerance.

iv) Visual inspection of the parts of the mooring lines above the sea surface to confirm the absence of wear and tear

v) In the case of a turret type mooring system, a survey of the current state of turning bearings (including verification of the effectiveness of lubrication systems)

vi) In addition, check the current state of structures and equipment within the range where checks are possible above the sea surface and confirm that there is no harmful corrosion, wear or damage, etc.

vii) For the equipment (winches, windlasses, etc.) used in the mooring devices, check that there is no abnormality in the operation status.

(2) Intermediate surveys of machineries and electrical equipment

In the intermediate survey of machineries and electrical equipment, the survey prescribed in 4.3 of Part B of the Rules for the Survey and Construction of Steel Ships shall be carried out in accordance with the types of machineries and the electrical equipment installed on the floating substructure.

(3) Intermediate survey of RNA and towers
In the intermediate survey of the RNA and tower, the surveys listed in (a) to (e) below shall be carried out.
(a) A survey of the current state of the tower and of the joints between the tower and the floating substructure (including a confirmation of the painting status)
(b) A check of the state of bolt tightening within the extent possible
(c) When a welded part on the tower has been repaired, nondestructive testing shall be carried out on the point where the welded part repair was performed.
(d) A survey of the current state of the openings of doors, etc., that are required to have watertightness and weathertightness, a survey of their closing devices, and an inspection of their fittings
(e) Verification of the RNA control systems

(4) Lift facilities
In the intermediate survey of the lift facilities, the surveys in (a) and (b) below shall be carried out.
(a) A survey of the current state of the lift facilities
(b) A check of the operation of emergency stopping devices on the lift facilities

(5) Others
Check the management status of the documents and literature provided in the floating substructure and tower in accordance with the provisions of 8.3.8.

8.4.5 Special surveys

-1. The handling of the start and completion of special surveys shall follow the provisions of 5.1.1 of Part B of the Rules for the Survey and Construction of Steel Ships.

-2. The work for underwater surveys shall be carried out by a place of business approved by ClassNK.

-3. In the special surveys, the same survey as in the intermediate survey shall be performed and also a detailed survey shall be carried out based on an inspection plan and documents on inspection procedure. Furthermore, the special surveys shall in principle include the surveys specified in (1) to (5) below.

(1) Special survey of the structure and equipment
In the special survey, the following items shall be surveyed.
(a) The inside and outside of the floating substructure, the cofferdam, the inside and outside of seawater ballast tanks. However, the survey may be omitted if special consideration has been given to corrosion, and fatigue strength, etc., which ClassNK deems appropriate.
(b) Measurement of the electrical potential to confirm the effectiveness of the anticorrosion system within the design range. Also, if the galvanic anode system is used, the amount of decrease on a representative anode shall be grasped.
(c) If the surveyor deems it necessary as a result of the surveys in (a) and (b) above, the thickness of the structural members shall be measured for the parts in i) and ii) below. In this case, either a proper ultrasonic thickness gauge shall be used, or the thickness shall be measured by an equivalent method, and the measurement records shall be submitted to ClassNK.
  i) Parts where the corrosion of structural members is severe, or where the progression of wear is thought likely to be severe
  ii) Representative parts near the waterline (splash zone)
(d) For the mooring system, the surveys in i) to x) below shall be carried out. However, parts of the surveys may be omitted if special consideration has been given to corrosion, and fatigue strength, etc., which ClassNK deems appropriate. Also, a continuous survey system may be adopted for the surveys of mooring system.
  i) Check of the installation positions of the FOWT and seabed fixed point
  ii) A survey of the current state of the total length of the mooring lines (including the connecting end parts)
  iii) For the parts of the mooring lines where corrosion and wear are likely to progress (for example, parts such as the connections with the sea bottom mooring points where abrasion easily occurs, and the splash zone on the mooring lines near the sea surface), the amount of wear shall be measured after careful examination.
  iv) A survey of the current state of the chains and stoppers (above sea level), performed after their cleaning. If the surveyor deems it necessary, nondestructive testing shall be performed.
  v) A survey of the current state of the turret and related equipment. The amount of wear shall be measured

on parts where corrosion and wear is severe on the structural members, etc., and on FOWT that have been in service for 15 years or longer.

vi) A survey of the current state of the points of high stress and points with a short fatigue life, after their cleaning

vii) A survey of the current state of the connections between the mooring lines and the seabed fixed point, after their cleaning

viii) Measurement of the electrical potential from a representative position on the mooring system underwater, to confirm the effectiveness of the anticorrosion system within the design range

ix) A survey of the current state of the equipment used in the mooring system and testing of its operation

x) On tension mooring system, if the tension mooring line is a pipe, a detailed survey and thickness measurement on that pipe

(e) Nondestructive tests may be required at the points of stress concentration specified by ClassNK.

(2) Special surveys of machineries and electrical equipment

In the special survey of machineries and electrical equipment, a survey of the survey items prescribed in 5.3 of Part B of the Rules for the Survey and Construction of Steel Ships shall be carried out in accordance with the types of machineries and electrical equipment on the floating substructure.

(3) Special survey of RNA and towers

In the special survey of the RNA and tower, the same survey as the intermediate survey shall be carried out.

(4) In the special survey of the lift facilities, the same survey as the intermediate survey shall be carried out, and, if the surveyor finds it necessary as a result of the survey of the current state, an overhaul inspection shall be conducted of the main parts of the hoisting machine or the driving part of the lift facilities. For the overhaul inspection, if the surveyor deems it appropriate based on the maintenance records, etc., an inspection witnessed by the surveyor may be omitted.

(5) Others

Check the management status of the documents and literature provided in the FOWT and tower in accordance with the provisions of 8.3.8.

8.4.6 Periodic review of inspection plans and documents on inspection procedures

-1. The structural members of the FOWT that are to be surveyed and the details of the survey to be conducted on those parts subject to the survey shall be reviewed periodically with consideration of matters such as the results of the periodical inspections and abnormal environmental conditions.

-2. When changes or additions to the inspection plans or documents on inspection procedures occur as a result of the review in -1. above, a change notification and the modified inspection plans and documents on inspection procedures shall be submitted and shall be approved by ClassNK.

8.5 Occasional surveys

8.5.1 General

-1. When a FOWT encounters an external force exceeding the environmental conditions used at the time of the design, the owner of the FOWT shall either conduct an occasional inspection of the structure and report it to ClassNK, or shall apply to ClassNK for an occasional survey.

-2. An application for an occasional survey shall be made to ClassNK when a major part of the FOWT, or important equipment, etc., that was surveyed by ClassNK has been damaged, or is to be repaired, changed or modified.

GUIDELINE

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ClassNK

Guidelines for Floating Offshore Wind Turbines

— Classification Survey —

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