2021

Guidelines for Floating Offshore Wind Turbine Platform

GL-0027-E

KR

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APPLICATION OF
"GUIDELINES FOR FLOATING OFFSHORE WIND TURBINE PLATFORM"

1. Unless expressly specified otherwise, the requirements in the Guidelines apply to Floating Offshore Wind Turbine Platform for which contracts for construction are signed on or after 1 Jan 2022.

Effective Date 1 Jan 2022

CONTENTS

CHAPTER 1 GENERAL

Section 1 General

101. Application

1. This Guidelines is to be applied to the surveys, hull, equipment and machinery and other facilities of unmanned floating substructure and sttion keeping system that are moored for a long time in a specific sea area for wind power generation.

2. Attention is to be paid to plied to the International Conventions and National Regulations of the coastal state in which the unit is located during operation, and statutory requirements of the International Conventions and the National Authority may be stricter than requirements of this Guidance.

102. Classification of units

The classification of floating substructures is as follows.

(1) Barge type
Ship type is the unit in the shape of an ordinary tanker or cargo ship having displacement hull.

(2) Column-stabilized type or Semi-submersible type
Column-stabilized type is a unit consisting of deck with top-side installations, surface piercing columns, submerged lower hulls, bracings, etc., which are semi-submerged to a predetermined draft during operation.

(3) Tension Leg Platform (TLP)
TLP is a unit which fully buoyant and is restrained below its natural flotation line by mooring elements which are attached in tension to gravity anchors or piles at the sea floor.

(4) Spar
Spar is a unit which is deep draft, vertical floating structures, usually of cylindrical shape, supporting a topside deck and moored to the seafloor. The hull can be divided into upper hull, mid-section and lower hull.

(5) There may be other types of units, which are not specified in (1) to (4) above, such as cylindrical type.

103. Equivalence and novel features

1. The Society may consider the acceptance of alternatives to the Guidelines, provided that they are deemed to be equivalent to the Guidelines to the satisfaction to the Society.

2. The Society may consider the classification of the construction and equipment based on or applying novel design principles or features, to which the Rules are not directly applicable, on the basis of experiments, calculations or other supporting information provided to the Society.

3. The risk evaluation may be applicable for justification of equivalence or novel features.

Section 2 Definition

201. Application

The definitions of terms and symbols which appear in the Guidelines are to be as specified in this Section, unless otherwise specified, and definitions of terms and symbols not specified in the Guidelines are to be as specified in **Rules for the Classification of Steel Ships, Rules for the Classification of Mobile Offshore Units** and **Guidance for Floating Production Units**.

202. Definition

1. Floating Offshore Wind Turbine (hereinafter referred to as FOWT) is a wind turbine with a substructure supported by a buoyancy and station keeping system.

2. Rotor nacelle assembly (hereinafter referred to as RNA) refers to a facility installed at the top of a tower in which rotor components including blades, hubs, shafts and spinners and nacelle including power generation and control facilities are combined.

3. Tower refers to the structural element connecting RNA and floating substructure.

4. Floating support structure means a structure excluding RNA as part of a FOWT consisting of a tower, floating substructure and station keeping system.

5. Floating substructure means a structure for providing buoyancy excluding RNA, tower and station keeping systems, also called hull.

6. Station keeping system refers to a system capable of limiting the movement and/or acceleration of the FOWT within the prescribed limits, maintaining the intended direction, and limiting the movement of the top of the tower.

7. Mooring systems are such systems to keep the unit at a specific position of designated service area permanently or for long periods of time. Spread mooring system is generally used. This system consists of mooring lines connected to piles, sinkers, etc., which are firmly embedded into the seabed, the other end of which is individually connected to winches, or stoppers which are installed on a unit, the definitions of each category being as given in the followings.

(1) Catenary Mooring(CM) is defined as mooring forces obtained mainly from the net weight of spreaded catenary mooring lines.

(2) Taut Mooring(TM) is defined as mooring lines arranged straight and adjusted by high initial mooring forces, and the mooring forces obtained from the elastic elongation of these lines.

8. Anchor is a device attached to the end of a mooring line or tendon and partially or completely embedded in the sea bed to limit the movement of the mooring line or tendon and transfer the load to the sea floor. Types include drag anchors, anchor piles (dirven, jetted, suction, torpedo/gravity embedded and drilled and grouted), gravity anchors and plate anchors.

9. Tendon refers to a component of station keeping system that forms a vertical link between the TLP type floating substructure and the subsea foundation to provide position holding and floating stability to the FOWT.

10. Air gap is the gap between the highest water surface and the lowest exposed portion not designed to withstand wave shocks occurring in extreme environmental conditions.

11. Environmental conditions refer to environmental characteristics (wind, waves, tidal currents, tides, ice, sea growth, seabed erosion/movement, etc.) that can affect the operation of a wind turbine.

12. Return period corresponds to N years, which is the basis of the annual excess probability (1/N years), and for floating offshore wind turbine structures, N is 1 or 50 years.

13. Fetch is the distance the wind blows over the sea at a constant wind speed and direction.

14. Hub height refers to the height of the area center of the wind turbine rotor above average sea level.

15. Marine growth refers to the phenomenon of surface coating of structural components caused by plants, animals and bacteria.

16. Scour is the removal of soil above the seabed by tidal currents and waves or structural elements that impede natural flow on the seabed.

17. Splash zone is the area outside the support structure exposed to seawater due to changes in waves and tidal waves. It means the area between the water levels in the maximum still water.

18. Sea water level is the abstract water level calculated including the effects of tides and storm surges but excluding changes due to waves and may not be equal to the mean sea level water level.

19. Storm surge is a change in water level due to wind and/or atmospheric changes associated with a storm.

20. Wind profile refers to the mathematical expression of wind speed change according to the height above sea level according to the wind shear law (refer to IEC 61400-3-1).

21. Redundancy check refers to the design condition in which the FOWT moves to a new position after one mooring line is broken and maintains its position by the remaining mooring lines.

22. Coating condition

Coating condition is defined as follows:

(1) GOOD condition with only minor spot rusting

(2) FAIR condition with local breakdown at edges of stiffeners and weld connections and/or light rusting over 20 % or more of areas under consideration, but less than as defined for POOR condition

(3) POOR condition with general breakdown of coating over 20 % or more, or hard scale at 10 % or more, of areas under consideration

23. Representative spaces are those which are expected to reflect the conditions of other spaces of similar type and service and with similar corrosion prevention systems. When selecting representative spaces, account is to be taken of the service and repair history on board and identifiable critical structural areas and/or suspect areas.

24. Critical structural area are locations which have been identified from calculations to require monitoring or from the service history of the subject unit or from similar units or sister units, if applicable, to be sensitive to cracking, buckling or corrosion which would impair the structural integrity of the unit.

25. Suspect area are locations showing substantial corrosion and/or are considered by the Surveyor to be prone to rapid wastage.

26. Substantial corrosion is an extent of corrosion such that assessment of corrosion pattern indicates a wastage in excess of 75 % of allowable margins, but within acceptable limits.

27. Excessive diminution is an extent of corrosion beyond allowable limits.

28. Corrosion prevention system is normally considered a full hard protective coating. Hard protective coating is usually to be epoxy coating or equivalent. Other coating systems, which are neither soft nor semi-hard coatings, may be considered acceptable as alternatives provided that they are applied and maintained in compliance with the manufacturer's specifications.

28. Remote Inspection Techniques (RIT) is a means of survey that enables examination of any part of the structure without the need for direct physical access of the surveyor (refer to IACS Rec.42). ⚓

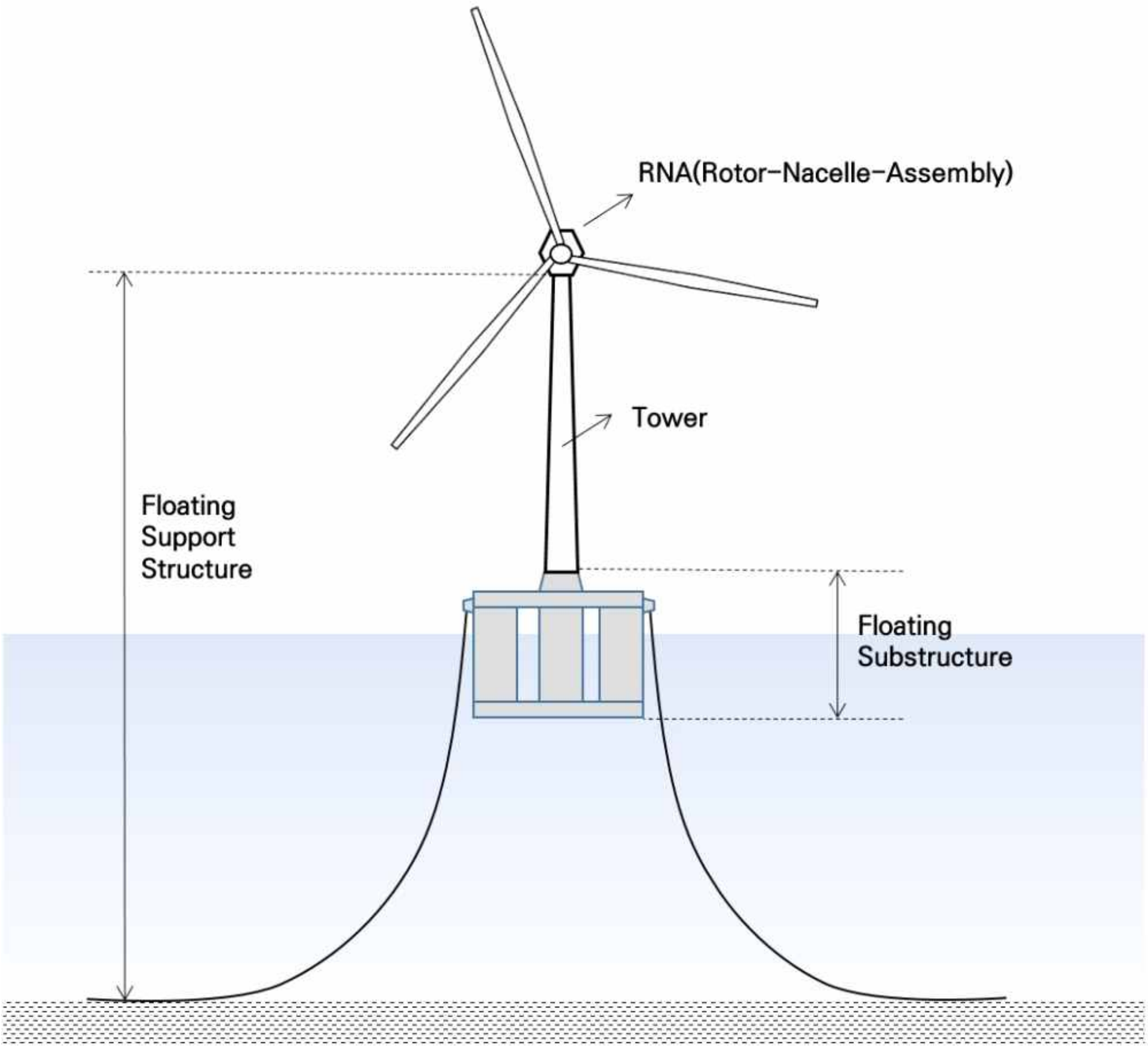

Fig 1 Floating Offshore Wind Turbine Platform (ex: semi-submersible type)

CHAPTER 2 CLASSIFICATION AND SURVEYS

Section 1 General

101. General

1. The classification and surveys of units intended to be classed with the Society or classed with the Society are to be in accordance with the requirements specified in this Chapter.

2. In the case of items not specified in this Chapter, the requirements specified in **Pt 1** of **Rules for the Classification of Steel Ships** are to be applied.

Section 2 Classification

201. Classification

Floating substructure and station keeping system built and surveyed for the classification in accordance with this Guidelines or in accordance with requirements deemed to be equivalent to this Guidance by the Society will be assigned a class and registered in the Register of Ship.

202. Class notations

1. The class will be distinguished by the class notations and the class notations assigned to the unit classed with the Society are to be in accordance with the requirements specified in **Pt 1, Ch 1, 201.** of **Rules for the Classification of Steel Ships**. However, the platform type notation and special feature notation shall be assigned as followings(*).

(1) The following platform type notation shall be assigned according to the purpose of unit.
Floating Offshore Wind Turbine Platform

(2) The following special feature notations shall be assigned according to the type of unit.
(A) Barge
(B) Column-stabilized or Semi-submersible
(C) Spar
(D) TLP

(3) If there is no certificate according to an international standard for a tower or a tower and a floating substructure connection structure (Interface platform), the relevant connection structure is included in the scope of entry. According to the owner's request which , if the owner requests the Classification of RNA and tower, the following special features can be given.
(A) RNA
(B) Tower

(4) The special feature about the installation site means that the floating substructure was designed and manufactured in consideration of all environmental conditions of the sea area and can only be operated in the sea area. To specify the installed site and fatigue strength design life, the following special features are given.
(A) site name
(B) 00 years

(Note *) The class notation described in this Guidelines is applicable only when the Guidelines is revised as a Rules or a Guidance.

203. Maintenance of classification

1. Platforms classed with the Society are to be subjected to the surveys to maintain the classification and are to be maintained in good condition in accordance with the requirements specified in this Chapter.

2. Even if the classed floating substructure falls under any of the following cases, the drawings or data must be submitted to the Society for approval before construction begins, and these modifications, etc. are to be inspected by the Surveyor. In other words, the Classification Survey during Construction manufacturing should be performed.

(A) In case of structural change or remodeling of floating substructure and station keeping system for life extension

(B) In case of changing the site
(C) In case of replacing RNA or towers that may affect the location and stability of floating substructure.

3. The relocation and change are possible with the approval of the Society for following cases only:.
(1) in case of relocating the floating substructure to another location in the same site,
(2) in case of changing another anchor type with the same performance.

204. Classification Survey during Construction

1. General

At the Classification Survey during Construction, the hull, machinery and equipment are to be examined in detail in order to ascertain that they meet the relevant requirements of this Guidance.

2. Submission of plans and documents

(1) At the Classification Survey during Construction, the following plans and documents are to be submitted to the Society for approval before the work is commenced.
(A) Floating substructure
(a) Transverse section showing scantlings
(b) Longitudinal section showing scantlings
(c) Deck construction plan (including details where helicopter deck is applicable)
(d) Framing
(e) Shell expansion
(f) Final stability data
(g) Methods and locations for non-destructive testing
(h) Construction plan of watertight bulkheads and deep tanks indicating the highest position of tank and positions of tops of overflow pipes
(i) Construction of superstructures and deckhouses
(j) Details of arrangement and closing devices of watertight doors and hatchways, etc.
(k) Seatings of dynamos and other important auxiliary machinery (including where applicable)
(l) Construction of machinery casings (including where applicable)
(m) Construction of cargo handling appliances and its foundation (including where applicable)
(n) Pumping arrangements (including where applicable)
(o) Construction of fire protection
(p) Means of escape
(q) mooring arrangements and towing arrangements
(r) Welding details and procedures
(s) Details of corrosion control arrangements
(t) Documents in respect of maintenance, corrosion control and inspection
(u) Protection details of service ship boating
(v) Structural details of interface between tower and floating substructure
(W) Other plans and/or documents considered necessary by the Society
(B) Machinery, Electrical installation and control system
(a) Overall arrangement of machinery spaces
(b) Piping system diagram
(c) Plans and data relevant to machinery installation specified in **Pt 5, Ch 8** of **Rules for the Classification of Steel Ships**.
(d) Electrical installations specified in **Pt 6, Ch 1** of **Rules for the Classification of Steel Ships**, and automatic and remote control system specified in **Pt 6, Ch 2** of **Rules for the Classification of Steel Ships**.
(e) Fire extinguishing arrangements
(f) Electrical schematic diagram
(g) electrical equipment layout
(h) Other plans and/or documents considered necessary by the Society
(C) Station keeping system
(a) Mooring line layout
(b) Drawing of the hoisting device
(c) Drawing of anchoring system
(d) Details of anchor and mooring line connection

(e) Details of the connection between the floating substructure and the mooring line
(f) Active positioning systems (if applicable);
(g) Other drawings and data deemed necessary by the Society.
(D) Wind turbine components
(a) RNA detailed specifications and drawings
(b) Thrust curve and wind direction moment calculation by wind turbine
(c) Tower structural drawings
(d) Other drawings and data deemed necessary by the Society
(2) At the Classification Survey during Construction, the following plans and documents are to be submitted to the Society for reference.
(A) Specifications and environmental data of installation site
(B) General arrangement
(C) Summary of distributions of fixed and variable weights
(D) Plan indicating design loadings for all decks
(E) Preliminary stability data
(F) Results from relevant model tests or dynamic response calculations and structural analysis and calculation for relevant loading conditions
(G) Resultant forces and moments from wind, waves, current, mooring and other environmental loadings taken into account in the structural analysis
(H) Calculations for significant operational loads from derrick and other equipment
(I) Lines or offsets
(J) Capacity plans and sounding tables of tanks
(K) Plans showing arrangement of watertight compartments, openings, their closing appliances, etc., necessary for calculation of stability
(L) Other plans and/or documents considered necessary by the Society
Submitted calculations are to be suitably referenced.

3. Presence of Surveyor

(1) At the Classification Survey during Construction, the presence of the Surveyor is required at the following stages of the work in relation to hull and equipment. of FOWT
(A) When the tests of the materials specified in **Pt 2, Ch 1** of **Rules for the Classification of Steel Ships** and the equipment specified in **Pt 4** of **Rules for the Classification of Steel Ships** are carried out.
(B) When the tests of welding specified in **Pt 2, Ch 2** of **Rules for the Classification of Steel Ships** are carried out.
(C) When designated by the Society during shop work or sub-assembly.
(D) When each block is assembled and erected.
(E) When each part of the hull is completed.
(F) When structural tests, leak test, hose tests and non-destructive tests are carried out.
(G) When performance tests are carried out on closing appliances of openings, anchoring and mooring equipment, fire detection systems, etc.
(H) When each part of the fire protection construction is completed.
(I) When measurement of principal dimensions, hull deflection, etc. are carried out.
(J) When a loading instrument is installed on board.
(K) When the load line mark is marked.
(L) When the onboard tests and stability experiments are carried out.
(M) When deemed necessary by the Society.
(2) At the Classification Survey during Construction, the presence of the Surveyor is required at the following stages of the work in relation to machinery.
(A) When the tests of materials of main parts of machinery specified in **Pt 2** of **Rules for the Classification of Steel Ships** are carried out.
(B) Main parts of machinery
(a) When the tests specified in either **Pt 5** or **Pt 6** of **Rules for the Classification of Steel Ships** according to the kind of machinery are carried out.
(b) When the materials are assembled for construction of the parts and the parts are assembled for installation on board.
(c) When machining of the main parts is finished and, if necessary, at appropriate stages during machining.
(d) In case of welded construction, before welding is commenced and when it is completed.

(e) When the shop trials are carried out.
(C) When main parts of machinery are installed on board.
(D) When performance tests/onboard tests are carried out on measurement instruments, remote control devices of closing appliances, remote control devices for machinery and gears, automatic control devices, mooring equipment, fire extinguishing equipments, piping, etc.
(E) When deemed necessary by the Society.
(3) When installing a draft scale for semi-submersible structures
(4) In the case of registration inspection during manufacturing, the Surveyor is to be present in the following construction phase in relation to the station keeping system.
(A) When installing materials to parts and parts to floating substructures
(B) When the production of each part is completed and, if necessary, when it is subjected to processing
(C) Other cases deemed necessary by the Society
(5) In the case of registration inspection during manufacturing, the Surveyor shall be present in the following construction phase in relation to RNA and tower.
(A) When the tower is installed on a floating substructure
(B) When the tower is registered with the classification, when installing RNA in the tower
(C) When RNA or/and tower is registered with the Society, when each part is manufactured and installed
(D) Other cases deemed necessary by the Society

4. Tests

(1) At the Classification Survey during Construction, hydrostatic tests, leak tests and performance tests, etc are to be carried out in accordance with the relevant requirements of this Guidelines
(2) Hydrostatic tests, leak tests or airtight tests are to be carried out as specified in this Guidelines corresponding to the kind of machinery and electrical installations.
(3) In case where station keeping systems, etc. are installed on board units at works different from the shipbuilding yards where hull structures are constructed (including the sea areas of the site of operation), surveys necessary in order to tow the hull structures of units to their site of operation are to be carried out. In this cases, the tests, examinations or inspections for the support structures of installations are to be carried out at suitable places/occasions before the final inspection at the site of operation.

5. Survey during the installation of units at their site of operation

During the installation of station keeping system, the following items are to be verified and surveyed by the Surveyor.
(1) The components of positioning systems are to be examined for normalities before installation.
(2) Certificates are to be confirmed for those components which are required to be tested at manufacturer facilities.
(3) The area around the seabed mooring points is to be examined and reported on by divers or remotely operated vehicles(ROVs) before installation to ensure that there is no obstruction.
(4) During the installation of units to their seabed mooring points, the following is to be verified.
(A) Proper locking of all connecting shackles from mooring lines to seabed mooring points, and from mooring lines to mooring lines
(B) Sealing of all kenter shackle locking pins
(C) Correct size and length of all the components of mooring lines
(D) Whether seabed mooring points are installed in their designed position and are orientated within allowable design tolerance.
(5) Mooring lines are to be confirmed to be paid out as designed and in accordance with predetermined procedures.
(6) After mooring systems are deployed at their site of operation, the following tests are required for each mooring line.
(A) During tests, each mooring line is to be pulled to its maximum design load determined by dynamic analysis for the intact design condition and held at that load for 30 minutes. The integrity of the entire mooring line from the seabed mooring point to the connecting end at the hull structure of the unit as well as movement of the seabed mooring point is to be verified.
(B) Notwithstanding (a) above, the test load for soft clay may be modified as deemed appropriate by the Society. Even in such cased, however, test loads cannot be reduced less than 80% of the maximum intact design loads.

(C) Notwithstanding (a) and (b) above, the tensioning tests of mooring lines may be waived in cases where detailed investigation reports are submitted to the Society and deemed appropriate. In such cases, however, preloading each seabed mooring point in required. The load of this preloading is not to be less than the mean intact design tension, and such that the integrity and proper alignment of mooring lines can be verified.

(7) Mooring lines are to be verified for firm and adequate connections to chain stoppers.

(8) Catenary angles of mooring lines are to be measured and verified for compliance with design specifications and tolerances.

(9) During installation, it is to be verified that the risers and other supporting facilities of units are not deformed or damaged, buoyancy tanks, etc. are in their correct position, and flow lines are firmly and adequately connected.

(10) Upon completion of installation, the connection of units to their periphery facilities is to be verified for compliance with design specifications. Divers or ROVs are to be arranged as necessary for the survey of any underwater parts deemed necessary by the Surveyors.

6. Onboard tests and stability experiments

(1) After the RNA and tower are mounted on the floating substructure, during the onboard tests of units, the following items are to be verified and surveyed by the Surveyor. The results of onboard tests are to be submitted to the Society.

(A) Performance tests of positioning systems(performance tests of windlass, etc.)

(B) Performance tests of such systems that are necessary for adjusting the draught, inclination, etc. of units, like ballasting systems

(C) Running tests of machinery and electrical installations, etc.(during their operation, no abnormalities in the condition of units are found)

(D) Confirmation of safety systems(fire/gas detection systems, fire extinguishing system, emergency shutdown systems)

(E) Function test of communication systems

(F) Emergency procedures against fires, etc.

(G) Confirmation of fire extinguishing system

(a) Fire pumps

(b) Portable fire extinguishers

(H) Function tests of detection and alarm systems

(a) Fire detection systems

(b) Emergency shutdown systems

(I) Confirmation that all systems of the unit are functioning normally

(J) Confirmation of normal/emergency function if RNA or/and towers are registered with the classification

However, if the items specified above are verified by simulating installed conditions at shipbuilding yards, such onboard tests may be dispensed with.

(2) Stability experiments are to be carried out at suitable occasions after the completion of the main structures of units and before proceeding to the site of operation. A stability information booklet prepared on the basis of the stability particulars determined by the results of stability experiments is to be approved by the Society and provided on board.

205. Classification Survey after Construction

1. General

At the Classification Survey after Construction, the examination of the hull, machinery, equipment and station keeping system are carried out as required for the Special Survey corresponding to the age, kind and purpose of the unit and the actual scantlings, etc. of the main parts of the unit are to be measured as necessary.

2. Submission of plans and documents

At the Classification Survey after Construction, plans and documents as may be required for the Classification Survey during Construction are to be submitted. If plans and documents cannot be obtained, facilities are to be given for the Surveyor to take the necessary information from the unit.

3. Onboard tests and stability experiments

At the Classification Survey after Construction, onboard tests and stability experiments are to be carried out in accordance with the requirements specified in **204. 6**. However, onboard tests and stability experiments may be dispensed with provided that sufficient information based on previous tests is available and neither alteration nor repair affecting onboard tests and stability experiments has been made after such previous tests.

Section 3 Surveys

301. General

1. Units classed with the Society are to be subjected to the following surveys to maintain the classification.

(1) Special Surveys
(2) Annual Surveys
(3) Docking or In-water Surveys
(4) Occasional Surveys(including Alteration Survey)

2. In the Annual Surveys and Special Surveys to hull and equipment of units, the requirements among those in Pt 1, Ch 2 of Rules for the Classification of Steel Ships which are deemed especially difficult to apply in relation to the type and purpose of units may be modified in their application under the approval of the Society on the occasion of plan approval for Classification Survey, submitting information in relation to the maintenance, corrosion control and inspection.

3. It is the responsibility of the owner/operator of the unit to report to the Society without delay any damage, defect or breakdown, which could invalidate the conditions for which a classification has been assigned so that it may be examined at the earliest opportunity by the Surveyor. All repairs found necessary by the Surveyor are to be carried out to his satisfaction.

4. Plan and procedures for Special Surveys and Drydocking Surveys(or In-water Survey in lieu of Docking Survey) are to be submitted for review in advance of the survey and made available on board. These should include drawings or forms for identifying the areas to be surveyed, the extent of hull cleaning, non-destructive testing locations(including NDT methods), nomenclature, and for the recording of any damage or deterioration found. Submitted data, after review by the Society, will be subject to revision if found to be necessary in light of experience.

5. Repair

(1) Any damage in association with wastage over the allowable limits(including buckling, grooving, detachment or fracture), or extensive areas of wastage over the allowable limits, which affects or, in the opinion of the Surveyor, will affect the unit's structural, watertight or weathertight integrity, is to be promptly and thoroughly (see 102. 13) repaired. For location where adequate repair facilities are not available, consideration may be given to allow the unit to proceed directly to a repair facility. This may require temporary repairs for the intended voyage.
(2) Additionally, when a survey results in the identification of structural defects or corrosion, either of which, in the opinion of the Surveyor, will impair the unit's fitness for continued service, remedial measures are to be implemented before the unit continues in service.
(3) Where the damage found on structure mentioned in (1) is isolated and of a localised nature which does not affect the unit's structural integrity, consideration may be given by the Surveyor to allow an appropriate temporary repair to restore watertight or weather tight integrity and impose a Condition of Class in accordance with IACS PR.

302. Annual Survey

1. Due range

(1) Annual Survey is to be carried out within 3 months before or after each anniversary date.
(2) Survey planning meeting shall be held prior to the commencement of inspection.

2. Scope

The survey consists of an examination for the purpose of verifying, as far as practicable, that the hull, structure, equipment, and machinery are maintained in accordance with the applicable Rule requirements

3. Hull and equipment

At each Annual Survey the exposed parts of the hull, deck, structures attached to the deck, includ-

ing supporting structure, accessible internal spaces, and the applicable parts listed below are to be generally examined and placed in satisfactory condition as found necessary. And the Surveyors are to be satisfied at each Annual Survey that no material alterations have been made to the unit, its structural arrangements, subdivision, superstructure, fittings, and closing appliances upon which the stability calculations or the load line assignment is based.
Suspect areas identified at previous surveys are to be examined. Thickness measurements are to be taken of the areas of substantial corrosion and the extent of thickness measurements is to be increased to determine the extent of areas of substantial corrosion. Table 1 may be used as guidance for these additional thickness measurements. These extended thickness measurements are to be carried out before the Annual Survey is credited as completed.

Table 1 Requirements for extent of additional thickness measurement at those areas of substantial corrosion

Structural Member	Extent of Measurement	Pattern of Measurement
Plating	Suspect area and adjacent plates	5 point pattern over $1\ m^2$
Stiffeners	Suspect area	3 measurements each in line across web and flange

(1) All units
- (A) Accessible hatchways, manholes and other openings
- (B) Machinery casings and covers, companionways, and deck houses protecting openings
- (C) Ventilators and overboard discharges from enclosed spaces
- (D) Watertight bulkheads and end bulkheads of enclosed superstructures
- (E) Closing appliances for all the above (A) to (E), including doors, together with their respective securing devices, dogs, sill, coamings and supports
- (F) Freeing ports together with bars, shutters and hinges
- (G) Guard rails, lifelines, gangways, and deck houses accommodating crew
- (H) Windlass and attachment of anchor racks and anchor cables
- (I) The type, location and extent of corrosion control as well as effectiveness, and repairs or renewals should be reported and submitted to the Society at each survey.
- (J) Documentations on board including the stability data, etc. approved by the Society are to be confirmed to be kept on board.
- (K) Where the loading instrument having a stability computation capability is provided on board, the system is to be tested.

(2) Barge type units
In addition to the requirements of above (1) the following items are to be examined:
- (A) The hull and deck structure in vicinity of any other structural changes in section, slots, steps
- (B) Openings in the deck or hull
- (C) The back-up structure in way of structural members or sponsons connecting to the hull

(3) Column-stabilized unit
In addition to the requirements of above (1) the following items are to be examined:
- (A) Columns, diagonal and horizontal braces together with any other parts of the upper hull supporting structure as accessible above the waterline

3. Station keeping system

The spread mooring system is to be generally examined so far as can be seen and placed in satisfactory condition as necessary. In addition, the following above water items are to be examined, placed in satisfactory condition and reported upon, where applicable:
(1) The anchor chain stopper structural arrangements are to be visually examined, including the structural foundations of all of the stoppers or holders. Tensioning equipment is to be generally examined.
(2) The anchor chain's catenary angles are to be measured to verify that the anchor chain tensions are within the design allowable tolerances. Where anchor cables are used, their tensions are to be verified to be within the allowable tensions.
(3) The anchor chains or anchor cables above the water are to be visually examined for wear and tear.

4. Fire protection and fire fighting systems

Following systems are to be verified to confirm no significant changes have been made to any of the systems and that they remain in satisfactory condition.

(1) Fire protection systems, including the following items are to be generally examined and function tested as necessary:

(A) Examination of structural fire protection of accommodation spaces, service spaces and control stations, as accessible

(B) Examination and function testing of fire doors

(C) Examination and testing of ventilation fire-dampers

(D) Examination and testing of ventilation system closures and stoppage of power ventilation

(E) Examination and testing of shutters or water curtains

(2) Fixed fire extinguishing systems should be examined according to **Rules for the Classification of the Mobile Offshore Units**,

(3) All portable and semi-portable extinguishers are to be examined.

(4) Fire detection and alarm systems are to be examined and tested as necessary.

(5) Means of escape be examined according to **Rules for the Classification of the Mobile Offshore Units**,

(6) Emergency stop system

(A) The emergency stop system for selectively or simultaneously disconnecting or stopping electrical equipment is to be tested and inspected in accordance with the operating instructions for the unit.

(B) It is to be confirmed that emergency lighting, general alarm, broadcasting system, distress and safety communication system work properly even after emergency stop.

5. Machinery and electrical equipment

(1) Annual Survey of machinery and electrical systems is mandatory for all types of units.

(2) Survey items not specified in this Paragraph are to be in accordance with the followings.

(A) Surveys for ship type units are to comply with applicable requirements of **Pt 1, Ch 2, 203.** of **Rules for the Classification of Steel Ships**.

(B) Surveys for column-stabilized installations are to comply with applicable requirements of **Ch 2, 302.** of **Rules for the Classification of Mobile Offshore Units**.

(3) Corrosion protection systems are to be examined.

(4) All machinery, pumps and pumping arrangements, including valves, cocks and pipes are to be externally examined during operation.

(5) Structure, piping, electrical systems and machinery foundations are to be generally examined for damage or deterioration.

303. Special Surveys

1. Due range

Special Surveys of hull, structure, equipment, and machinery are to be carried out at 5 year intervals to renew the Certificate of Classification.

(1) The first Special Survey is to be completed within 5 years from the date of the initial Classification Survey and thereafter within 5 years from the credited date of the previous Special Survey. Extensions of class beyond the 5th year may be granted in exceptional circumstances(for a definition of exceptional circumstances, see **Pt 1, Ch 2, 401. 1** of **Rules for the Classification of Steel Ships**). In this case the next period of class will start from the expiry date of the Special Survey before the extension was granted.

(2) Special Survey may be commenced at the fourth Annual Survey and be continued with completion by the fifth anniversary date. Where the Special Survey is commenced prematurely, the entire survey is normally to be completed within 15 months if such work is to be credited to the Special Survey.

(3) Special consideration may be given to Special Survey requirements in the case of units of unusual design, in lay-up or in unusual circumstances. Consideration may be given for extensions of rule-required Special Surveys under exceptional circumstances.

(4) Survey planning meeting shall be held prior to the commencement of inspection.

(5) At the request of the Owner, and upon the Society's approval of the proposed arrangements, a system of Continuous Survey may be undertaken whereby the Special Survey requirements are

carried out in regular rotation in accordance with the requirements of the Society to complete all the requirements of the particular Special Survey within a five year period. Any defects that may affect classification found during the survey, are to be reported to the Society and dealt with to the satisfaction of the Surveyor.

2. Scope

(1) The Special Surveys shall include, in addition to Annual Survey requirements per **302.**, the following examinations, tests, and checks of sufficient extent to verify that the hull, structure, equipment, and machinery are in satisfactory condition and that the unit is in compliance with the applicable Rule requirements for the new period of class of 5 years to be assigned subject to proper maintenance and operation and the periodical surveys carried out at the due dates.

(2) The examinations of the hull are to be supplemented by thickness measurements and testing as required, to verify that the structural integrity. The aim of the examination is to discover excessive diminution, substantial corrosion, significant deformation, fractures, damages, or other structural deterioration, that may be present.

(3) The Special Survey is to include examination of underwater parts per **304.**

3. Special Survey

(1) Hull, structure and equipments

(A) All units

The following parts are to be examined:

(a) The hull or platform structure including tanks, watertight bulkheads and deck, cofferdams, void spaces, sponsons, chain lockers, duck keels, helicopter deck and its supporting structure, machinery spaces and all other internal spaces are to be examined externally and internally for damage, fractures or excessive diminution. Thickness gauging of plating and framing, non-destructive testing and tightness testing may be required where wastage is evident or suspected.

(b) All tanks, compartments and free-flooding spaces throughout the unit are to be examined externally and internally for excess diminution or damage.

(c) Watertight integrity of tanks, bulkheads, hull, decks and other compartments is to be verified by visual inspection.

(d) Suspect areas and critical structural areas should be examined and may be required to be tested for tightness, non-destructive tested or thickness gauged.

(e) All special and primary application structures and identified critical structural areas are to be subjected to Close-up Survey.

(f) Tanks and other normally closed compartments are to be ventilated, gas freed and cleaned as necessary to expose damages and allow meaningful examination and thickness gauged in case of excessive diminution.

(g) Internal examination and testing of void spaces, compartments filled with foam or corrosion inhibitors, and tanks used only for other non-corrosive products may be waived provided that upon a general examination the Surveyor considers their condition to be satisfactory. External thickness gauging may be required to confirm corrosion control.

(h) Structures such as deck houses, superstructures, helicopter landing areas, raw water (sea water intake) towers and their respective attachments to the deck or hull.

(i) Windlass and attachments of anchor racks and anchor cable fairleads.

(j) Thickness gaugings are to be carried out where wastage is evident or suspect.

(k) Where provided, the condition of corrosion prevention system of ballast tanks is to be examined. Where a hard protective coating is found in POOR condition and it is not renewed, where soft or semi-hard coating has been applied, or where a hard protective coating was not applied from time of construction, the tanks in question are to be examined at annual intervals. Thickness measurements are to be carried out as deemed necessary by the Surveyor (See Table 2).

(l) The Surveyor may extend the thickness measurements as deemed necessary. When thickness measurements indicate substantial corrosion, the extent of thickness measurements is to be increased to determine areas of substantial corrosion. Table 1 may be used as guidance for these additional thickness measurements. These extended thickness measurements are to be carried out before the survey is credited as completed.

(m) Where the loading instrument having a stability computation capability is provided on board, all approved test loading conditions are to be examined.

Table 2 Minimum requirements for Thickness Measurements at Special Survey (Column-stabilized units)

Special Survey No. 1	Special Survey No. 2	Special Survey No. 3	Special Survey No. 4 and Subsequent
1. Suspect areas throughout the unit	1. Suspect areas throughout the unit 2. Representative thickness measurements of columns and bracings in splash zone[2] together with internals in way as deemed necessary by the Surveyor 3. Special portions of structural members and primary structural members[1] where wastage is evident	1. Suspect areas throughout the unit 2. One transverse section (girth belt) of each two columns and two bracings in splash zone[2] together with internals in way as deemed necessary by the Surveyor 3. Representative thickness measurements, throughout, of special portions of structural members and primary structural members[1] 4. Lower hulls in way of mooring lines where wastage is evident 5. One transverse section (girth belt) of each lower hull between one set of columns	1. Suspect areas throughout the unit 2. One transverse section (girth belt) of each one-half of the columns and bracings in splash zone[2] and internals in way as deemed necessary by the Surveyor (i.e., gauge half of the unit's columns and bracings in splash zone[2]) 3. All special portions of structural members and primary structural members[1] 4. Lower hulls in way of mooring lines where wastage is evident 5. One transverse section (girth belt) of each lower hull between one set of columns

(NOTES)

1) Structural members are to be grouped into the following three material application categories according to the design.
   - (a) Primary structural members: Structural members essential to the overall integrity of the unit, such as columns, legs, bracings, lower hulls, footings, bottom mats, shell platings of leg tanks, decks, main deck girders, and so on.
   - (b) Secondary structural members: Structural members of minor importance failure of which is unlikely to affect the overall integrity of the unit, such as internal structural members of primary members specified in (a) and other members.
   - (c) Special portions of structural members: Special portions of the primary structural members specified in (a), such as junctions which are specially important in structural viewpoint or in way of stress concentration and so on.

2) Splash zone is to be considered as the structural area that has been periodically in and out of the water when the unit was at its operating depth, most of the time during the past five-year period. Based on operational record of the unit, additional zones may also be gauged.

(B) Column-stabilized units

In addition to the requirements of (A) the following items are to be examined:

(a) Connections of columns and diagonals to upper hull, structure or platform and lower hull, structure or pontoons. Joints of supporting structure including diagonals, braces and horizontals, together with gussets and brackets. Internal continuation or back-up structure for the above. Non-destructive examination may be required of these areas.

(C) Protection of other openings

(a) Tank protective devices

(i) All tank protective devices, where fitted, are to be examined externally for proper as-

sembly and installation, damage, deterioration or traces of carryover at the outlets.
(ii) All pressure-vacuum valves and pressure relief valves are to be opened out, pressure and vacuum valve discs checked for good contact with their respective seats and/or proved by testing.

(b) Air pipes
All air pipes are to be opened out and closing arrangements and flame screens, if fitted, are to be examined both externally and internally. For designs where the inner parts cannot be properly examined from outside, this is to include removal of the head from the air pipe. Particular attention is to be paid to the condition of the zinc coating in heads constructed from galvanized steel.

(c) Watertight bulkheads
Watertight bulkheads, bulkhead penetrations, end bulkheads of enclosed superstructures are to be examined. In addition, watertight doors are to be operationally tested and effectiveness to maintain tightness is to be confirmed.

(D) Tank testing
(a) Boundaries of ballast are to be tested with a head of liquid to the top of air pipes or to near the top of hatches.
(b) The testing of other spaces not designed for the carriage of liquid may be omitted, provided a satisfactory internal examination together with an examination of the tanktop is carried out.
(c) The Surveyor may require further tank testing, as deemed necessary.

(2) Station keeping system
Since it is impractical to cover all types of mooring systems, the following are provided as guidance to show the basic intent of the survey requirements. Operators and designers may submit alternative survey requirements based either on service experience or manufacturer' recommendations. In addition to the requirements of the Annual Survey, the following items are to be inspected.
(A) An examination is to be made on all anchor chains for substantial corrosion and wastage. In particular, the areas to be specially examined are the areas having the most relative movement between the chain links. These areas are normally located in way of the seabed touchdown sections of the catenary part of the chains. The chains are to be inspected for looses studs and link elongations. Sufficient representative locations are to be gauged for wear and wastage. Areas susceptible to corrosion, such as the wind-and-water areas, are to be specially gauged, if considered necessary by the attending Surveyor.
(B) A close examination is to be carried out on all mooring components and accessible structural members that carry the mooring loads. These structures include the chain stoppers or cable holders, the structures in way of the chain stoppers or cable holders, structural bearing housing and turret/structural well annulus areas. These structures are to be thoroughly cleaned and examined and any suspect areas are to be nondestructively tested.
(C) A general inspection is also to be carried out on the degree of scour or exposure in way of the anchor or anchor piles to ascertain that these components are not overexposed.
(D) For inaccessible structures, special alternative inspection procedures for inspection of these areas are to be submitted for approval.
(E) The chain tensions are to be checked and where found not in compliance with the specifications are to be readjusted accordingly. Excessive loss of chain or tendon tensions are to be investigated.
(F) Representative areas of the chains are to be examined and checked for substantial wastage. In particular, areas in way of the chain stoppers and the seabed touchdown areas are to be specially examined and measured for substantial wear.
(G) For disconnectable type mooring systems, the disconnect and connect system for the mooring system is to be tested as considered necessary by the Surveyor. Alternatively, records of disconnect/connect operations between the credit date of the last Special Survey and the current due date of same may be reviewed, and if found satisfactory, it may be considered to have been in compliance with this requirement.

(3) Fire protection and fire fighting systems
In addition to the requirements of the Annual Survey, the following items are to be inspected.
(A) Fire protection systems, including the following items are to be tested:
(a) Function testing of all fire doors
(b) Function testing of all ventilation fire-dampers

(c) Function testing of all ventilation system closures and stoppage of power ventilation
(d) Function testing of all shutters or water curtains

(B) Fixed fire extinguishing systems, including the following items are to be tested:
(a) Function testing of all fire pumps. This is to include confirmatory testing of the fire pump capacity and testing of relief valves of the fixed fire main system.
(b) Hydrostatic testing of the fire main system
(c) Hydrostatic testing of fire hoses, as necessary

(C) Fire detection and alarm systems are to be tested.

(D) Gas detection and alarm systems are to be tested.

(E) Means of escape, including the following items are to be tested:
(a) Lighting and grating in way of all escape routes
(b) Contact makers for general alarm system, communication system installed in all emergency control stations

(F) Emergency shutdown systems
(a) Emergency shutdown arrangements provided to disconnect or shutdown, either selectively or simultaneously, of the electrical equipment as outlined in the unit's operating manual, are to be tested.
(b) Services such as the emergency lighting, general alarm system, public address system, distress and safety radio system, that are required to be operable after an emergency shutdown of the installation, are to be verified for their proper operation.

(4) Machinery and electrical equipment
In addition to the requirements of the Annual Survey, the following items are to be inspected.

(A) Correlation with Special Survey of hull
(a) All types of installations are to undergo Special Periodical Survey at intervals similar to those for Special Survey of hull in order that both may be recorded at approximately the same time.
(b) In cases where damage has involved extensive repairs and examination, the survey thereon may be considered as equivalent to a Special Survey.

(B) Machinery Parts to be Examined
(a) All openings to the sea, including sanitary and other overboard discharges together with the cocks and valves connected therewith, are to be examined internally and externally while the installation is in drydock or at the time of underwater examination in lieu of drydocking, and the fastenings to the shell plating are to be renewed when considered necessary by the Surveyor.
(b) Pumps and pumping arrangements, including valves, cocks, pipes, and strainers, are to be examined.
(c) Nonmetallic flexible expansion pieces in the main salt-water circulating system are to be examined internally and externally.
(d) The Surveyor is to be satisfied with the operation of the bilge and ballast systems. Other systems are to be tested as considered necessary.
(e) The foundations of machinery are to be examined.

(C) Electrical Parts to be Examined
(a) Fittings and connections on main switchboards and distribution panels are to be examined.
(b) Cables are to be examined as far as practicable without undue disturbance of fixtures.
(c) All equipment and circuits are to be inspected for possible development of physical changes or deterioration. The insulation resistance of the circuits is to be measured between conductors and between conductors and ground and these values compared with those previously measured. Any large and abrupt decrease in insulation resistance is to be further investigated and either restored to normal or renewed as indicated by the conditions found.
(d) The specified electrical auxiliaries for generators and motors are to be examined and their prime movers opened for inspection if necessary. The insulation resistance of each generator and motor is to be measured.
(e) The accumulator batteries are to be examined, including their maintenance schedule and the society reviewed procedure of maintenance.
(f) Bilge alarm system, if fitted, is to be tested and proven satisfactory.
(g) Non-explosion proof electric motors are to be examined, including automatic power disconnect to motors that are arranged to shut down in case of loss of ventilation.

304. Docking or In-water Survey

1. Due range

(1) The Docking Survey for the inspection of the underwater part of the structure and related matters is to be carried out in conjunction with the Special Survey.

(2) In case of special circumstances deemed necessary by the Society, the extension of the inspection interval may be considered.

(3) If approved by the Society, it may be substituted with 3. In-rwater Survey instead of Docking Survey.

2. Requirements of survey

(1) Barge type

(A) All sea connections and overboard discharge valves and cocks, including their attachments to the hull or sea chests, are to be externally examined. All nonmetallic expansion pieces in the sea-water cooling and circulating systems are to be examined both externally and internally. The stern bearing clearance or weardown and rudder bearing clearances are to be ascertained and reported on.

(B) In conjunction with Docking Surveys(or equivalent), the following ballast spaces are to be internally examined, thickness gauged, placed in satisfactory condition as found necessary, and reported upon. If such examination reveals no visible structural defects, the examination may be limited to a verification that the corrosion prevention arrangements remain effective.

(2) Column-stabilized or semi-submersible type

(A) External surfaces of the upper hull or platform, footings, pontoons or lower hulls, underwater areas of columns, bracing and their connections, sea chests, and propulsion units as applicable, are to be selectively cleaned and examined to the satisfaction of the attending Surveyor.

(B) Non-destructive testing may be required of areas considered to be critical by the Society or found to be suspect by the Surveyor.

(C) In conjunction with Docking Surveys(or equivalent In-water Surveys), the following ballast tanks are to be internally examined, and the effectiveness of coatings or corrosion control arrangements are to be verified either visual inspection or by thickness gauging(as considered necessary), placed in satisfactory condition, as found necessary, and reported upon:

(a) Representative ballast tanks in footings, lower hulls or free-flooding compartments, as accessible

(b) At least two ballast tanks in columns or upper hull, if applicable

(3) Corrosion prevention system - underwater body

In addition to the above (1) and (2) requirements, the following are to be to be performed during all of the Docking Surveys(or equivalent In-water Surveys):

(A) Cathodic potential readings are to be taken from representative positions on the entire underwater body and evaluated to confirm that the cathodic protection system is operating within design limits.

(B) Sacrificial anodes are to be examined for depletion and placed in satisfactory condition, as considered necessary.

(C) Impressed current system anodes and cathodes are to be checked for damage, fouling by marine growth and carbonate deposits. The current and voltage demands of the system are to also be checked to ensure the system is functioning properly.

(D) Additional examinations are to be performed on the wind and water areas of the structures where coating breaks are evident. Thickness measurements in these areas may be required if found necessary by the attending Surveyor.

(4) Mooring system

For mooring systems, the following are to be cleaned and examined, where applicable:

(A) The mooring anchor chain or cable tensions are to be measured and the end connections of these components are to be examined. All mooring chains are to be generally examined for their entire lengths.

(B) Anchors, cables and their respective handling means are to be examined.

(C) The buoyancy tanks are to be cleaned and examined, if applicable.

(D) Chain and stopper assemblies are to be cleaned, examined and NDE performed, as considered necessary by the Surveyor.

(E) Areas of high stress or low fatigue life are to be preselected, cleaned and NDE performed, if considered necessary.
(F) Scour in way of anchors or anchor piles is to be examined.
(G) Cathodic potential readings are to be taken from representative positions on the entire underwater structure of the mooring system to confirm that the cathodic protection system is operating within design limits.
(H) Highly stressed, high wear and tear areas of the mooring chain are to be closely examined and nondestructively tested, if considered necessary by the Surveyor. These include areas in way of the stoppers and sea bed touchdown areas.

3. In-water Survey

The requirements relating In-water Survey are to be in accordance with **Ch 2, 309.** of **Rules for the Classification of Mobile Offshore Units.**

305. Occasional Surveys

The requirements relating Occasional Survey are to be in accordance with **Ch 2, 308.** of **Rules for the Classification of Mobile Offshore Units.**

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CHAPTER 3 DESIGN CONDITIONS

Section 1 General

101. General

1. The design environment conditions of FOWT should consider the most severe load conditions in the combination of wind, wave, current, and tidal waves based on meteorological and sea state data.

2. The design life of the floating substructure and the station keeping system for wind power generation is at least 20 years, and it is based on unmanned operation under the environmental conditions corresponding to the 50-years return period. However, the operational limitations of FOWT shall be determined by the designer in consideration of the ability of the station keeping system and the operating conditions of the power generation system in the combination of wind, wave and currents based on the weather and sea condition data in the operating area.

Section 2 Design Principles

201. Design principles

1. Safety of floating substurcture and station keeping system can be demonstrated by addressing the potential structural failure mode(s) when the unit is subjected to loads scenarios encountered during transit and operation.

2. Structural requirements are based on a consistent set of loads that represent typical worst possible loading scenarios.

3. Floating substurcture and station keeping system are to be designed so as to have inherent redundancy. The structure works in a hierarchical manner and as such, failure of structural elements lower down in the hierarchy should not result in immediate consequential failure of elements higher up in the hierarchy.

4. Structural continuity is ensured. The floating substurcture, tower interface parts and station keeping system interface parts should have uniform ductility.

5. The structure is to be designed for inspection, maintenance and repair during its design life.

6. As for the design method, the following methods can be applied.
   (1) Load-resistance factor design (hereinafter referred to as LRFD) or working stress design (hereinafter referred to as WSD)
   (2) Design through direct calculation and model testing
   (3) Risk-based design

   LRFD or WSD is a method of establishing a safety factor for each load or stress component. In the case of verifying the design by LRFD or WSD and the case when designing a novel concept for FOWT, it is necessary to apply direct calculations and model tests to examine the effects of various load components combined. In the case of impact on structural safety and environment due to damage, it is recommended to conduct risk-based design in parallel. In particular, when aerodynamic, hydrodynamic and geotechnical considerations are required at the same time, it is necessary to perform design through direct calculation and model testing.

202. Limit states

1. Serviceability limit state is not applied in this Guidelines

2. Ultimate limit state

   Ultimate limit state, which corresponds to the maximum load-carrying capacity or the maximum applicable strain or deformation, includes:
   (A) attainment of the maximum resistance capacity of sections, members or connections by rupture or excessive deformations

(B) instability of the whole structure or part of it.

3. Fatigue limit state

Fatigue limit state relate to the possibility of failure due to cyclic loads.

4. Accidental limit state

Accidental limit state is to take into account the failure of the floating substructure and the station keeping system due to accidental loading, or flooding of some compartments (flooding of any one compartment without progress of flooding into other compartments). In addition, the case where the position of the floating substructure is changed due to some damage to the station keeping system should be considered. In this case, the influence of connected electrical cable and shared anchor points with adjacent floating substructures should be considered.

Section 3 Corrosion Control Means and Corrosion Margins

301. General

Corrosion control means for units are to be provided in accordance with the relevant provisions specified in **Pt 3** of **Rules for the Classification of Steel Ships** and taking design service life, maintenance, corrosive environment, etc. into account.

302. Corrosion margin

1. When corrosion protection measures deemed appropriate by the Society have been applied to the structure, the corrosion allowance specified in **Par 2** may be appropriately reduced as recognized by the Society.

2. In case that corrosion protection measures are not taken or the Society considers it to be inappropriate, an appropriate corrosion allowance is to be added to the scantlings determined by the analysis method and allowable stress specified in this Guidelines. In this case, in principle, the corrosion margin should be 2.5 mm or more, and it should be determined in consideration of the method and degree of anti-corrosion measures and the repair method. In addition, when the requirements of **Rules for the Classification of Steel Ships** or the **Rules for Steel Barges** are applied, they are to be more than those specified in the relevant rules.

Section 4 Design Loads

401. Environmental loads

1. General

The environmental load that affects structural damage is a load caused by natural phenomena, and the following environmental conditions should be considered for the FOWT:
(1) current loads
(2) wind loads
(3) wave induced loads
(4) tide and sea water level
(5) snow, ice accumulation and drift ice
(6) air/sea temperature and atmospheric pressure
(7) sea salt degree
(8) marine growth
(9) seism
(10) scour

2. current loads

(1) Current loads are to be included the changes according to the speed, direction and depth of the installation site. It is assumed that the direction of the current load is the same as the direction of the wind load in order to consider the effect of the current near the water surface caused by the wind. However, if the direction of the current according to the depth is different from the direction of the current near the water surface, this should be considered.

(2) Current loads acting on underwater structures, mooring lines, electrical cable and other underwater objects connected to FOWT are to be considered for the interaction of waves. If necessary, the velocity of the current and the velocity of the wave particle should be calculated by adding them as vectors. The combined velocity should be used to estimate the load due to currents and waves.

(3) Current loads are classified as follows.

(A) NCM: Normal Current Model means the current corresponding to the wind speed of the normal wind model defined in Par 3. Tidal-generated seafloor currents are not included.

(B) ECM: Extreme Current Model is defined according to the return period (eg, 1 year or 50 years) specified by the designer. ECM should be applied in combination with the extreme wind model defined in Par 3, the extreme sea conditions defined in Par 4 and the extreme water level model defined in Par 6.

(4) Vortex induced motion and Vortex induced vibration occurring in the structure due to the interference of the floating substructure and the current are to be considered.

3. Wind loads

(1) Changes according to wind speed and height should be based on the analysis and the interpretation of statistical data measured in the operating area.

(2) Wind load is to be determined by the model defined as follows according to IEC 61400-1, IEC 61400-3-1 and IEC TS 61400-3-2. However, it may be adjusted with the approval of the Society depending on the operating area.

(A) NWP: Normal Wind Profile Model is based on the 10-minute average wind speed at the hub height of RNA.

(B) EWM: The extreme wind speed model is based on the 10-minute average wind speed corresponding to a 1-year or 50-year return period.

(C) NTM: Normal Tubulance Mode

(D) ETM: Extreme Tubulance Model

(E) EOG: Extreme Operating Gust is used to check whether the FOWT is resonant.

(F) EDC: Extreme Direction Change

(G) ECD: Extreme Coherent Gust with Drection Change

(H) EWS : Extreme wind shear is to be considered as an individual load.

4. Wave induced loads

(1) The standard of design wave should be explained by design wave energy spectra or deterministic design waves with appropriate shape and size. The design wave height used in the calculation of wave load is to be the value designated by the owner with approval of the Society, and the frequency of the design wave is to be the one that has the greatest influence on the structure.

(2) Wave loads used in structural analysis are to include the effects of flooding, inclination, and acceleration due to motion.

(3) In the calculation of wave load, the followings are to be considered.

(A) The wave load is to be calculated according to the appropriate wave theory with the approval of the Society for the planned water depth in the operating area. However, the wave load may be obtained by the water tank test deemed appropriate by the Society.

(B) Waves in all directions are to be considered.

(C) The wave load acting on the deck, the load acting directly on the member below the water surface, the load occurring by the inclined state or the motion of the structure, etc. are to be considered.

(D) Vibrations caused by waves are to be considered.

(4) Wave loads are classified as follows.

(A) NSS: Normal Sea State is defined by the significant wave height, peak spectrum period, and wave direction corresponding to the NWP.

(B) SSS: Severe Sea State is defined by the significant wave height, peak spectral period, and wave direction corresponding to the 50-year return period. However, a sea state corresponding to the maximum wind speed at which wind power generation is possible may be used.

(C) ESS: Extreme Sea State refers to the sea state that is the most unfavorable to FOWT under the condition corresponding to the return period of 1 year or 50 years.

(5) Since the deck of the floating substructure is exposed to the green wave load, the drainage and structural strength must be taken to ensure. In the ballast tank other than the fixed ballast, the sloshing load effect is to be considered. In addition, the possibility of slamming of structures lo-

cated below the waterline is to be included.

5. Tides

(1) Tides can be classified into astronomical tides and storm surges caused by the difference in atmospheric pressure. Astronomical tide changes are determined by the highest astronomical tide (HAT) and the lowest astronomical tide (LAT), and storm surges use statistical or mathematical modeling values.

(2) The water depth of the FOWT site is determined by HSWL (Highest Sea Water Level), which is the MSL (Mean Water Level) added by sum of HAT and positive storm surge heights, and LSWL (Lowest Sea Water Level), which is the MSL subtracted by LAT and negative storm surge heights.

(3) The sea level is essential for the calculation of wave and current loads, and is also used to determine the height of the air gap, boat landing, anti-collision fenders and splash area extent.

(4) Sea level ranges are classified as follows.

(A) NWLR: Normal Water Level Range is based on the return period of 1 year.

(B) EWLR: Extreme Water Level Range is based on the repturn period of 50 years.

6. Other environmental conditions

(1) Since the weight increases due to ice and snow and the changes in effective projected area and surface roughness affect the aerodynamic and hydrodynamic loads. ice and snow should be considered when the influence of those is large in specified site.

(2) Since the scour or earthquake affects the station keeping, anchor type and anchor point should be selected based on seabed soil and geotechnical data.

(3) Since marine growth increases the weight of mooring lines, electrical cables and floating substructure and the hydrodynamic diameter and surface roughness, marin growth effect should be considered in the load calculation.

(4) In case of weight increase by sticking and collision due to drift ice in the winter season, this condition should be considered.

(5) If wind and current load are changed according to the air and sea water temperature of the operating area, these temperature's effect should be included in load calculation. If there is a change in wind load due to atmospheric pressure difference, this should be reflected.

(6) The salinity of seawater is an important parameter in the design of a cathodic protection system and affects the buoyancy of the floating substructure. It should be considered as an environmental condition.

(6) Protection against lightning is to be considered in accordance with IEC 61400-24.

402. Fixed load

The fixed loads of FOWT are generally as follows. The partial safety factor for the fixed load is 1.1 for ultimate limit state and 1.0 for accidental limit state.

- RNA and tower weight
- weight of the hull and equipment of the floating substructure (fender, ship anchorage, corrosion protection, etc.)
- weight of station keeping system
- weight of machines, equipment and systems permanently installed on floating substructure
- fixed ballast weight, if applicable
- hydrostatic pressure
- pre-tension of mooring line
- undersea earth pressure
- pre-tension of electrical cable

403. Functional load

The functional loads are usually as follows. The partial safety factor for the fixed load is 1.1 for ultimate limit state and 1.0 for accidental limit state.

- loads caused by loading and unloading of maintenance and repair facilities
- impact load generally occurred by service vessels anchored to the structure
- load transferred to floating substructure due to RNA's normal operation or emergency stop
- thermal deformations or soil displacements acting on floating substructure and station keeping system
- variable ballast weight to ensure stability, if applicable
- helicopter-related loads, if applicable

404. Fatigue load

The range of stresses contributing to fatigue damage of structures should be considered. In general, the stress range due to wind and wave loads should be analyzed in the time domain in order to consider the motion characteristics of the floating body and its interaction with the control system (refer to 502. for detailed instructions). The environmental condition related wind and wave is to be divided into a number of individual conditions. Each condition should be consisted of a reference sea state characterized by wave (direction, significant wave height, peak period, etc), current velocity, wind direction, average wind speed and standard deviation of wind speed must be specified with the probability of occurrence. Typically 8 to 12 wave directions and 10 to 50 wave cycles are used in wave condition. Frequency domain analysis results should be performed based on previous model tests or time domain analysis and should be limited to application only in the initial design stage.

405. Accidental load

Accidental loads of FOWT are as follows and correspond to design load conditions 8.1, 8.4, 9. and 10. in Table 3.

- collision by service vessels or drift ice
- failure of the ballast water control system
- damage to mooring line
- structural damage caused by falling objects
- fire
- accidental immersion.

406. Design Load Case (DLC)

1. The design load case of FOWT is to be considered all possible design load conditions according to IEC 61400-3-1 and IEC TS 61400-3-2. If there is a possibility to change the load condition of the floating substructure and the station keeping system due to the failure or malfunction of the wind turbine control system, it should be considered in addition to the design load case. For example, if an active stability control system is installed and the load conditions are likely to change due to failure of this system, it should be included in the design load case. Among the other environmental conditions in 401. 6., the conditions with a small influence may not be included in the design load case under the approval of the Society.

2. For the floating substructure and the station keeping system, the design load case as shown in Table 3 must be considered and the fixed loads and functional loads of 402. and 403. are to be included in the design load case. Partial safety factors in Table 3 should be applied only to environmental loads. In the case where RNA and tower are not registered to th Society, 1.1 of design load case in Table 3 does not need to be applied.

3. In extreme environmental conditions where the rotor blades are stopped, the maximum angle of misalignment in the wind and wave directions is to be considered up to 90°.

4. In case that the environmental conditions are changed or the vibration and motion due to vortex are large due to the influence of the adjacent FOWT, new design load case is to be added under the approval of the Society.

5. In Table 3, if the strength evaluation by any design load case can be overlapped or offset according to the strength evaluation by other design load case, this case may be omitted under the approval f the Society.

Table 3 Design load case

Cond.	DLC	Wind	Wave	Wind & Wave Direction	Current	Water level	Other cond.	Type	Partial safety factor
power production	1.1	NTM, V[1]	NSS, H_s[4]	COD[9], UNI[10]	NCM	MSL	[13]	U[27]	1.25
	1.2	NTM, V	NSS, [5]	MIS[11], MUL[12]	-	NWLR≥MSL	-	F[28]	[29]
	1.3	ETM, V	NSS, H_s	COD, UNI	NCM	MSL	-	U	1.35
	1.4	ECD, V_r[2]	NSS, H_s	MIS, MUL	NCM	MSL	-	U	1.35
	1.5	EWS, V	NSS, H_s	COD, UNI	NCM	MSL	-	U	1.35
	1.6	NTM, V	SSS, $H_{s,SSS}$[6]	COD, UNI	NCM	NWLR	-	U	1.35
power production + occurence of fault	2.1	NTM, V	NSS, H_s	COD, UNI	NCM	MSL	[14]	U	1.35
	2.2	NTM, V	NSS, H_s	COD, UNI	NCM	MSL	[15]	U	1.1
	2.3	EOG, V_r & V_{out}[1]	NSS, H_s	COD, UNI	NCM	MSL	[16]	U	1.1
	2.4	NTM, V	NSS, H_s	COD, UNI	-	NWLR≥MSL	[17]	F	[29]
	2.5	NWP, V	NSS, H_s	COD, UNI	NCM	NWLR	[18]	U	1.35
	2.6	NTM, V	SSS, $H_{s,SSS}$	MIS, MUL	NCM	NWLR	[19]	U	1.1
start up	3.1	NWP, V	NSS, H_s	COD, UNI	-	NWLR≥MSL	-	F	[29]
	3.2	EOG, V_{in}[1], V_r & V_{out}	NSS, H_s	COD, UNI	NCM	MSL	-	U	1.35
	3.3	EDC, V_{in}, V_r & V_{out}	NSS, H_s	MIS	NCM	MSL	-	U	1.35
normal shutdown	4.1	NTM, V	NSS, H_s	COS, UNI	-	NWLR≥MSL	-	F	[29]
	4.2	EOG, V_r & V_{out}	NSS, H_s	COD, UNI	NCM	MSL	-	U	1.35
	4.3	NTM, V	SSS, $H_{s,SSS}$	MIS, MUL	NCM	MSL	[20]	U	1.35
emergency stop	5.1	NTM, V_r & V_{out}	NSS, H_s	COD, UNI	NCM	MSL	-	U	1.35
parked or idling	6.1	EWM, V_r	ESS, H_{s50}[7]	MIS, MUL	ECM	EWLR	-	U	1.35
	6.2	EWM, V_r	ESS, H_{s50}	MIS, MUL	ECM	EWLR	[21]	U	1.1
	6.3	EWM, V_1[3]	ESS, H_{s1}[8]	MIS, MUL	ECM	NWLR	[22]	U	1.35
	6.4	NTM, V_{out}〈V_{hub}[1]〈$0.7V_{ref}$[2]	NSS, [5]	COD, MUL	-	NWLR≥MSL	-	F	[29]
parked & fault	7.1	EWM, V_1	ESS, H_{s1}	MIS, MUL	ECM	NWLR	-	U	1.1
	7.2	NTM, V_{hub} 〈 V_{out}	NSS, [5]	COD, MUL	-	NWLR≥MSL	-	F	[29]
transit install repair	8.1	load specified by designer						U	1.35
	8.2	EWM, V_1	ESS, H_{s1}	COD, UNI	ECM	NWLR	-	U	1.1
	8.3	NTM, V_{hub} 〈 $0.7V_{ref}$	NSS, [5]	MIS, MUL	-	NWLR≥MSL	[23]	F	[29]
	8.4	load specified by designer						F	[29]
powerprodu-tion	9.1	NTM, V	NSS, H_s	MIS, MUL	NCM	MSL	[24]	U	1.1
	9.2	NTM, V	NSS, H_s	MIS, MUL	NCM	MSL	[25]	U	1.1
	9.3	NTM, V	NSS, H_s	MIS, MUL	NCM	MSL	[26]	U	1.1
parked or idling	10.1	EWM, V_{ref}	ESS, H_{s50}	MIS, MUL	ECM	EWLR	[24]	U	1.1
	10.2	EWM, V_{ref}	ESS, H_{s50}	MIS, MUL	ECM	EWLR	[25]	U	1.1
	10.3	EWM, V_{ref}	ESS, H_{s1}	MIS, MUL	ECM	NWLR	[26]	U	1.1

〈Note〉

(1) V : $V_{in} \leq V_{hub} \leq V_{out}$

V_{hub} : 10-minute average wind speed at hub height

V_{in} : 10-minute average minimum wind speed at hub height in power generation

V_{out} : 10-minute average maximum wind speed at hub height in power generation

(2) V_r : V_{ref} ± 2 m/s, the sensitivity to all wind speeds in the range shall be analysed

V_{ref} : reference wind speed of the 10-minute average wind speed

(3) V_1 : 10-minute average wind speed at hub height with a return period of 1 year

(4) H_s : Significant wave height
(5) Joint prob. distribution of H_s, T_p (Wave period) and V_{hub}
(6) $H_{s,SSS}$: significant wave height of the severe sea state
(7) H_{s50} : Significant wave height with a return period of 50 years
(8) H_{s1} : Significant wave height with a return period of 1 year
(9) COD : when wave and wind direction are the same
(10) UNI : uni-direction
(11) MIS : in case that wind and wave directions are different due to yaw misalignment of RNA, the most unfavorable angle in all directions of 360° should be selected, and the angular spacing for the direction is designated by the designer under the approval of the Society
(12) MUL : multi-direction
(13) For extrapolation of extreme loads on the rotor-nacelle assembly
(14) Normal control system fault or loss of electrical network or primary layer control function fault
(15) Abnormal control system fault or secondary layer protection function related fault
(16) External or internal electrical fault including loss of electrical network
(17) Control system fault, electrical fault or loss of electrical network
(18) Low voltage ride through
(19) Fault of seastate limit protection system
(20) Maximum operating sea state limit
(21) Loss of electrical network
(22) Extreme yaw misalignment
(23) No grid during installation period
(24) Transient condition between intact and redundancy check condition
(25) Redundancy check condition
(26) Leakage (damage stability)
(27) F : fatigue strength
(28) U : ultimate strength
(29) See Table 4, 6 and 8

Section 5 Load Calculation

501. General

1. The designer must be obtained the approval of the Society for the load calculation method proven to be sufficiently accurate and submit the analysis model, calculation results and model test results.

2. Wind load Calculation

(1) After calculating the wind load according to IEC 61400-1, it is to be verified through a certified software or wind tunnel test. Static and dynamic wind load effects according to FOWT characteristics should be considered.

(2) The aerodynamic load induced by the airflow through the rotor is determined by the interrelation effect such as average wind speed and turbulence across the rotor plane, rotor rotation speed, air density and aerodynamic shape of the wind turbine components, as well as air elasticity and rotation. The FOWT installed in the wind farm should consider the shadow effect and wake effect of the adjacent FOWT. In general, the range of the wake effect is 10 times the rotor diameter (refer to IEC 61400-1).

(3) Since rotor thrust and wind force generate heeling moment that affects the stability of FOWT, RNA and tower designers or manufacturers must submit accurate rotor thrust and wind force calculation results using a certified calculation method using international standards.

(4) Vibration caused by vortex can generate resonance in RNA and tower and affect the fatigue strength of tower and floating substructure connection, therefore it should be included in wind load calculation.

3. Calculate the wave load

(1) The wave load acting on a FOWT can be determined using certified hydrodynamic computational

software. The empirical equations such as Morrison's equation can be used for slender structure that do not change the wavelength. In contrast, the wave force calculation shall be based on incident wave (e.g. Froude-Krylov) and diffraction of incident wave for structural features that significantly change the wavelength.

(2) For semi-submersible floating substructures with columns and bracings, wave loads can be calculated using a combination of diffraction and Morison equations and verified through model tests. If the installation site is a shallow water with a depth-to-wavelength ratio of less than 0.25, the nonlinear effect of waves should be considered.

(3) Slamming loads are to be considered for structural members subjected to slamming loads during towing and operation at installation site. Slamming loads due to breaking waves should also be considered, where applicable. For guidance on slamming loads, see IEC 61400-3-1 Annex C. If there is a liquid ballast tank, the sloshing load in the tank is to be included, and the green-water effect, which may occur in extreme environmental conditions, is to be considered.

4. Current load calculation

(1) Current load on hull, mooring line, electrical cable, etc. below the waterline is to be determined by certified calculation method, model test or measurement. The current velocity should be vectorally added to the water particle velocity If the current and wave overlap. The change in the current according to the water depth should be included in the load calculation. It can be calculated using the Morison equation.

(2) When the vortex by the interference of the structure and the current causes vibration, the effect on fatigue strength are to be considered.

5. Calculation of other loads

(1) In the location where ice and snow accumulate, the increase of effective area and weight of the structure is to be included in the wind load calculation and stability verification.

(2) Where applicable, acoustic shock waves from earthquakes, subsea erosion, tsunamis and seismic events will cause an acceleration of hydrodynamic additional mass to induce soil liquefaction and shear failure. These events shall be taking into account the impact on the anchor performance of station keeping system.

(3) The effect of marine growth increases the hydrodynamic diameter, surface roughness and inertia force of the fixed load, therefore, it should be included in the load calculation.

(4) Calculation of impact load due to drift ice is to be in accordance with ISO 19906 and API RP 2N.

502. Coupling Analysis

1. The coupling analysis should be performed to determine the following variables affecting the RNA, tower, floating substructure, station keeping system and electrical cables of the FOWT.

(1) 6-DOF motion of floating substructure
(2) mximum tension and fatigue load on mooring lines and electrical cables
(3) loads acting on the tower and floating substructure connections
(4) the inertial force of the tower for RNA design or selection
(5) fluid dynamic load acting on floating substructure, hull girder load, design wave height and period
(6) acceleration for determination of inertia load
(7) air gap
(8) resonance period

2. For guidance on coupling analysis of FOWT, refer to IEC TS 61400-3-2. If necessary, the following should be considered.

(1) Sufficient data on the simultaneous occurrence of wind, wave, current and tidal conditions in the installed site
(2) Dynamic interactions between RNA, towers, floating substructures, station keeping system and electrical cables
(3) RNA and stabilization system control
(4) time scale difference between wind speed (typically a 10-minute average) and wave (typically 3 hours)
(5) Sufficient simulation time and number to collect statistically converged responses.

3. Analysis method

(1) Coupling analysis is a method to analyze simultaneously for FOWT's all systems. As an alter-

native method, it is possible to apply the partial coupling analysis method of using the dynamic analysis result for the station keeping system and electrical cable as the boundary condition of the floating substructure.

(2) Frequency domain analysis is a method for calculating the dynamic response of FOWT with combined dynamic properties of aerodynamic, hydrodynamic and control system in the frequency domain. However, this analysis cannot derive non-linear dynamic interactions between the components of FOWT and consider nonlinear aerodynamic and hydrodynamic loading effects. This analysis should be used to derive the hydrodynamic coefficients that are generally used as inputs to the time domain analysis.

(3) Time domain analysis provides a means to model nonlinear and transient effects. This method is possible to model the nonlinear effects including hydrodynamic drag force, finite wave amplitude effect, nonlinear righting force in the mooring state and the effect of motion control equipment such as a heave plate.

(4) For statistical convergence of nonlinear interactions between components of FOWT, the sufficient simulation period and number of iterations should be applied for time domain analysis. Two models that are related to wind condition based on 10-minute average and sea condition based on 1 to 6 hours should be combined in a reasonable way. A certified technique should be applied for statistical convergence to derive the maximum response of time domain analysis for each design load condition. For detailed guidance on the time domain analysis method, IEC TS 61400-3-2, 7.5 and ISO 19904-1 can be referred to.

(5) The analysis software should be demonstrated to consider properly the interaction between the components of the FOWT based on comparing with the model test results. Also, this software should be able to reflect all the environmental conditions in 401.

(6) Frequency domain or time domain analysis results can be converted into quasi-static loads corresponding to individual design load conditions and used for direct analysis to determine the dimensions of floating substructures.

4. Model test

(1) Model test is to be performed in accordance with IEC TS 61400-3-2, App K. The size of the model for the FOWT model test should be appropriate to consider both aerodynamic and hydrodynamic effects.

(2) In the case of designing a new concept of FOWT, a model test should be performed and compared with the numerical analysis results. ⚓

CHAPTER 4 MATERIALS AND WELDING

Section 1 General

101. Application

1. The materials used for important structural members are to be in accordance with **Pt 2, Ch 1** of **Rules for the Classification of Steel Ships**. The steel used for parts supporting heavy loads such as plant facilities, etc. and those parts under tensile loads in the direction across the plate thickness are to be in accordance with **Pt 2, Ch 1, 308.** of **Rules for the Classification of Steel Ships**.
2. Underdeck and hull interface plating or bracket structures attached to the deck or hull should have the same or compatible material grade as the deck or hull structure, respectively.
3. Mooring system chains, chain parts, wire ropes, fiber ropes, and anchors as well as the windows provided for accommodation spaces are to be in accordance with **Pt 4** of **Rules for the Classification of Steel Ships**, or standards deemed appropriate by the Society.

Section 2 Welding

201. General

The welding procedures employed during construction should be to a recognized international standard. Welders should be qualified in the welding processes and procedures utilized. The selection of welds for testing and the methods utilized should meet the requirements of the society.

202. Welding structure

1. Welded joints of crossing parts at the ends of columns and bracings are, as a rule, to be of full-penetration type.
2. Size of fillet welds applied to respective internal structural members of columns and bracings is to be F1 specified in Pt 3, Ch 1, Table 3.1.11 of Rules for the Classification of Steel Ships.
3. For welded joints other than specified in Par 1 and 2, welding is to be in accordance with the requirements in Pt 3, Ch 1, Sec 5 of Rules for the Classification of Steel Ships.
4. Welding is to be carried out by the personnel qualified by the Society in accordance with the approved welding specification.

203. Joints of special design

In case of welded joints of special design, the Society may require tests to check the strength of the joints and any defects.

204. Underwater welding

Welders to be engaged in underwater welding are to be those who have been accepted through the qualification test approved by the Society. ⚓

CHAPTER 5 FLOATING SUBSTRUCTURE

Section 1 General

101. General

1. The design and construction of FOWT are to be based on the applicable requirements of design considerations of this guide and not specified in this guide are to be in accordance with the Rules.
2. Design Considerations of this chapter reflects the different structural performance and demands expected for an installation transiting and being positioned at a particular site on a long-term basis.
3. This chapter applies to floating substructures using steel. When concrete is used as a structural member of a floating substructure, it is to comply with laws and/or international standards recognized by the Society.

102. Load line

1. A mark designating the maximum allowable draught is to be located in easily visible positions on units as deemed appropriate by the Society.
2. The designation of load lines is to comply with the requirements given in the **"International Convention on Load Lines, 1996"** unless specified otherwise by the relevant flag states or coastal states.

103. Loading manual, stability information and instruction for operation

1. In order to avoid the occurrence of unacceptable stress in FOWT structures for all ballast loading conditions and wind turbine layout and to adjust the loading of ballast, floating substructure is to be provided with loading manuals approved by the Society. Such loading manuals are to at least include the following (1) to (4) items as well as relevant provisions given in **Pt 3, Ch 3** of **Rules for the Classification of Steel Ships**.
   (1) The loading conditions on which the design of a unit has been based, including the permissible limits of longitudinal still water bending moments and still water shearing forces.
   (2) The calculation results of longitudinal still water bending moments and still water shearing forces corresponding to the loading conditions.
   (3) The allowable limits of local loads applied to structural members, in cases where deemed necessary by the Society.
   (4) The limit values of the loads of mooring lines.
2. In addition to **Par 1** above, a loading computer that is capable of readily computing longitudinal still water bending moments and still water shearing forces corresponding to all ballast loading conditions and the operation manual for such a computer is to be provided on board and onshore control place.
3. The capability of the loading computer specified in **Par 2** above to function as specified in the location where it is installed is to be confirmed.
4. A stability information booklet approved by the Society is to be provided on board and onshore control place in accordance with **Pt 1, Annex 1-2** of **Rules for the Classification of Steel Ships**. This booklet is to include the results of stability evaluations in representative operating conditions and assumed damage conditions as well as the damage condition of any mooring system equipment as necessary.
5. Instructions for the loading and unloading, and transfer and offloading operations of ballast are to be provided on board and onshore control place.

Section 2 Structural and Fatigue Strength

201. Global Analysis

1. The load partial safety factor corresponding to each design load case specified in Ch 3 is to be applied in the structural analysis in accordance with the method recognized as appropriate for the floating substructure, connection part with the tower and the interface equipment of the station keeping system.

2. According to the load-resistance factor design (LRFD) method, 1.0 of the partial resistance safety factor must apply for the ultimate limit state in Ch 3, 202. 1.3 of the partial resistance safety factor must apply in the case of structural members made of joints other than full penetration welding. The partial resistance safety factor for the fatigue limit state shall be applied as shown in Table 4. The partial resistance safety factor for the interface equipment of the position maintenance system is in accordance with Sec 4.

3. Wave load in Ch 3 is defined as a regular wave giving a response level equal to the maximum design response of a specific response variable. This maximum design response variable or dominant load parameter is determined for the return period. The wind loads in Ch 3 may be converted into quasi-static loads.

Table 4 Partial resistance safety factor for fatigue strength of floating substructure

	Inspection or repair available	inspection or repair is not possible
Structural damage does not compromise the overall integrity of the structure.	2.0	3.0
Structural damage violates the overall integrity of the structure.	3.0	5.0

4. Structures such as deck transverse webs, longitudinal beams, longitudinals and transverse bulkheads of tower connections and floating substructures are to be evaluated for the reaction forces at the tower connections and the most unfavorable combination of loads acting on the floating substructure. The scope of the finite element model should be large enough to minimize cutout boundary effects. Openings and cutouts around critical areas, should be included in the finite element model to determine their effects. Special attention should be paid to cutouts in the transverse web near the tower connections.

5. When the mooring structure is within the scope of the finite element model, the mooring line static weight can be expressed as a gravitational and dynamic acceleration mass that can be calculated and added to the finite element method model. The result of the dynamic load should be compared with the result of the mooring analysis to confirm that the dynamic effect is evaluated conservatively in the finite element analysis.

202. Combination of stresses

1. In obtaining local stresses of the structural members, all the stress components concerned are to be calculated. In this case, the effect of circumferential stress due to external pressure is to be considered for tubular members.

2. The scantlings are to be determined on the basis of criteria which combine, in a rational manner deemed appropriate by the Society, the individual stress components acting on the respective structural members.

203. Equivalent stress

For plate structures, members may be designed according to the equivalent stress criterion, where the equivalent stress is obtained from the following formula.

$\sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3\tau_{xy}^2}$

σ_x , σ_y : Stress in the x and y axis directions at the centre of thickness of the plate, respectively($\mathrm{N/mm^2}$).

τ_{xy} : Shearing stress in the x-y plane($\mathrm{N/mm^2}$).

204. Scantlings of Structural Members

1. General

(1) For the primary structural members which contribute to the overall strength, the scantlings are to be determined in accordance with the requirements in **Par 2** and **3.**

(2) For the structural members subjected to local loads only, the requirements in **Rules for the Classification of Steel Ships** may be applied under the approval of the Society.

2. Thickness of plating of hull structure

The thickness of plating of the primary hull structure such as shell plating which contributes to the overall strength, subjected to distributed loads, is not to be less than obtained from the following formulae, whichever is the greater.

$$75.2S\sqrt{\frac{h_s}{K_e}} + C \quad (\mathrm{mm}), \qquad 60.8S\sqrt{\frac{h_c}{K_p}} + C \quad (\mathrm{mm})$$

S : Spacing of transverse or longitudinal frames(m).

h_s : Head of water in static loading (m).

h_c : Head of water in combined loading as well as static load plus dynamic load (m).

K_e : As given by the following formulae, whichever is the smaller.

$$\frac{235 - k\sigma_{s1}}{k}, \quad 1.45\left(\frac{235 - k\sigma_{s2}}{k}\right)$$

K_p : As given in (a) or (b) below.

(a) Where $\sigma_{c1} \times \sigma_{c2} > 0$, the value given by the following formulae, whichever is the smaller.

$$\frac{5750 - k^2\sigma_{c1}^2}{235k}, \quad 2\left(\frac{235 - k|\sigma_{c2}|}{k}\right)$$

(b) Where $\sigma_{c1} \times \sigma_{c2} < 0$, the value given by the following formulae, whichever is the smaller.

$$\frac{5750 - k^2\sigma_{c1}^2}{235k}, \quad 2\left(\frac{235 - k|\sigma_{c1}| - k|\sigma_{c2}|}{k}\right)$$

σ_{s1}, σ_{s2} and σ_{c1}, σ_{c2} : Axial stresses acting on the plating in static loading and combined loading, respectively ($\mathrm{N/mm^2}$). (See **Fig 2**)

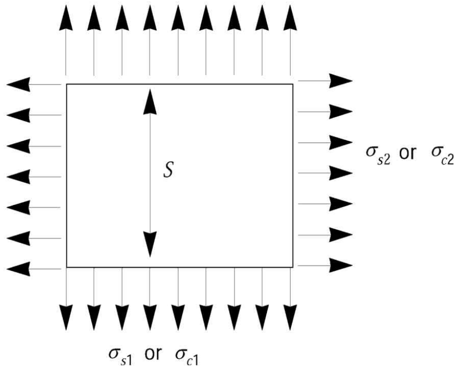

Fig 2 Axial stress σ_{s1}, σ_{s2} ,σ_{c1}, σ_{c2}

k : Material factor, as given in the following.

Mild steels ------------------------ 1.00
High tensile steels
A 32, *DH 32*, *EH 32* -------- 0.78
AH 36, *DH 36*, *EH 36* -------- 0.72
For other high tensile steels, the value of k is to be dedicated at the discretion of the Society.

C : Corrosion allowance specified in **Ch 3, 302.**

3. Section modulus of transverse or longitudinal frames

The section modulus of transverse or longitudinal frames which support the panels prescribed in **Par 2** is to be obtained from the following formula.

$$1079C\left(\frac{kSh_c l^2}{235-k\sigma_{c0}}\right) \quad (\mathrm{cm}^3)$$

C : Coefficient given below.
1.0 for both ends fixed
1.5 for both ends simply supported

l : Span of frames (m).

σ_{c0} : Axial stress in combined loading ($\mathrm{N/mm^2}$).

S, h_c, k : As specified in **Par 2.**

4. Local buckling of cylindrical shells

Unstiffened or ring-stiffened cylindrical shells subjected to axial compression, or compression due to bending, and having proportions which satisfy the following relationship are to be checked for local buckling.

$$D/t > E/9\,\sigma_y$$

D : Diameter of cylindrical shell
t : Thickness of shell plating
(D and t expressed in the same units.)

σ_y : Specified minimum yield stress of the material
E : Modulus of elasticity of the material
(σ_y and E expressed in the same unit system.)

205. Helicopter Deck

1. Design loads

Plans showing the arrangement, scantlings and details of the helicopter deck are to be submitted. The arrangement plan is to show the overall size of the helicopter deck and the designated landing area. The design load in determining the scantlings of the members of helicopter deck is to be in accordance with following (1) to (3).

(1) Helicopter landing impact loading
  (A) As for the deck loads in the range where a helicopter takes off or lands, a load of 75 % of the helicopter maximum take-off weight is to be taken on each of two square areas, 0.3 m × 0.3 m.
  (B) For girders, stanchions, etc., the structural weight of the helicopter deck is to be considered in addition to the helicopter impact loading specified in (A).
  (C) Where the upper deck of a structure or deck house is used as a helicopter deck and the spaces below are normally manned, the impact loading specified in (A) is to be multiplied by a factor of 1.15.
(2) Stowed helicopter loading
  (A) The deck loads in the space where a helicopter is stowed are to be taken as wheel loadings at maximum take-off weight. In this case, the dynamical effect due to the motion of the unit is also to be taken into account.
  (B) In addition to (A), a uniformly distributed loading of 0.5 kN/m^2, representing wet snow or ice is to be considered, if necessary.
  (C) For girders, stanchions, etc., the structural weight of the helicopter deck is to be considered in addition to the loads specified in (A).
(3) Minimum deck load
  The minimum deck load for helicopter deck is to be taken as 2 kN/m^2.

2. Allowable stresses

Allowable stresses of the structural members of the helicopter deck are not to exceed the values in **Table 5** in association with the design loads prescribed in **Par 1.**

Table 5 Allowable Stresses

Design loads \ Structural members	Deck plating	Deck beams	Girders, stanchions, truss supports, etc.
Helicopter landing impact load	*	σ_y	0.9 × σ_y'
Stowed helicopter load	σ_y	0.9 × σ_y	0.8 × σ_y'
Overall distributed load	0.6 × σ_y	0.6 × σ_y	0.6 × σ_y'

* : At the discretion of the Society.
σ_y : As specified in **310. 2.** (N/mm^2).
σ_y' : For members subjected to axial compression, σ_y or critical buckling stress, whichever is the smaller(N/mm^2).

3. Minimum thickness

The minimum thickness of helicopter deck plating is not to be less than 6 mm.

4. Landing appliances other than wheels

In case where a helicopter is provided with any other landing appliances other than wheels, the design loads are to be at the discretion of the Society.

5. Loadings on helicopter deck

Wind loadings and possible wave impact loadings on helicopter decks are to be considered. Where in this case, those loadings are in accordance with the discretion of the Society.

206. Stress concentration

1. The effect of local stress concentrations is to be considered for notches in members or discontinuous parts of structure.

2. Where the tensile stresses acting on the thickness direction of plating, plate material with suitable through-thickness properties is required in accordance with Pt 2, Ch 1 of Rules for the Classification of Steel Ships.

207. Fatigue Analysis

1. General

   FOWT is exposed to complex loading conditions related to environmental conditions and operating of control systems. The fatigue analysis method proposed in this Guidelines assumes that the structural response of a floating support structure can be reasonably expressed with three components of intrinsic frequency.
   (1) low-frequency components, mainly including responses to low-frequency motion caused by waves and wind;
   (2) Wave frequency components due to direct wave loading or wave-induced motion in the frequency range associated with most wave energy.
   (3) High-frequency components due to secondary and higher-order wave loads and aerodynamic responses of wind turbine RNA

2. Fatigue analysis in the low frequency range

   The low-frequency motion caused by wind and waves depends on the natural frequency of the rigid body motion of the floating substructure. The frequency range of low-frequency motion should be distinguished from the lowest major wave frequency, which should be used as the upper frequency limit of the low-pass filter. The time increment used in the coupling analysis should be appropriately selected so that the peak of the motion response can be identified. The natural frequencies of rolling and pitching are generally less than the main wave frequency. Low frequency pitching and rolling can induce significant structural loads on the following hull structural components:
   (1) Bracing member and connection
   (2) A member connecting the column and the pontoon

   Low-frequency pitching and rolling may cause significant structural loads on the tower. The pitching and rolling derived from the time domain analysis can be expressed as a spectral function, which is additionally applied to the stress transfer functions to obtain a stress spectrum in the low frequency range. Finite element analysis can be performed in which quasi-static pitching and rolling actuate the structure to derive the stress transfer function. The heeling angle can be obtained by applying wind load to the tower and current load to the hull structure. Therefore, in addition to gravity and buoyancy loads, low frequency loads are assumed currents and wind loads, gravity loads due to heeling, mooring line and electrical cable tensions of floating substructures. An appropriate stress concentration factor must be incorporated into the stress transfer function.

3. Fatigue analysis in the wave frequency range

   The wave frequency response of floating substructures affected by waves is generally the main cause of fatigue damage in hull structures. Waves for floating body can be obtained using diffraction/radiation analysis. Additional drag and inertia loads for slender bracing members can be calculated by Morison Equations and should be appropriately considered in the motion analysis. The 6-DOF rigid body motion response amplitude operator (Response of Amplitude Operator, hereinafter referred as RAO) can be obtained from the frequency domain or time domain motion analysis. RAOs of cross-sectional loads and moments that are important for structural design can also be derived. The spectral fatigue analysis method can be used for hull structures in the wave frequency range. The stress transfer function should be determined through finite element analysis of the floating substructure related to the amplitude, period and direction of the unit wave.

4. Fatigue analysis in the high frequency range

   In general, time-domain motion analysis should be performed to identify the frequency range of the high-frequency response distinct from the highest principal wave frequency, which is used as the lower-limit frequency of the high-pass filter. High-frequency loads can arise from a variety of sources, such as high-frequency wave loads, high-frequency aerodynamic loads transferred from towers, and vortex-induced vibration loads transferred from mooring lines. The rigid motion of floating substructures due to high-frequency loads can be neglected for semi-submersible or spar-type structures.

5. Calculation of fatigue damage under broadband spectral loading

Floating offshore wind turbines typically have a broadband response that does not follow a Rayleigh distribution. After obtaining the stress response spectra for three distinct frequency ranges from the load/motion spectrum and the stress transfer function, the fatigue damage can be calculated in various ways. It is recommended to calculate the fatigue damage of floating substructures using Dirlik's method.

6. Time domain fatigue analysis for heave plates and towers

Time domain fatigue analysis is recommended for FOWT's towers because of the nonlinear aerodynamic loading and the combined effects of wind and waves. After calculating the motion and load of tower top and base through time domain motion analysis of FOWT, The structural dynamic analysis of the tower can be performed in the time domain by using it as a boundary condition. The main load on the heave plate is the hydrodynamic pressure induced by the waves and motion of the hull. Significant nonlinear hydrodynamic loads are applied to the heave plate due to nonlinear viscous drag and relative hull motion. When a heave plate is connected to hull structure through a bracing member, the overall deformation of the bracing member due to bending and shearing can significantly affect the heave plate design. The hydrodynamic pressure distribution acting on the heave plate can be obtained through time domain motion analysis, and this pressure distribution is used for structural analysis. Heave plates should generally consist of detailed divided panels.

Section 3 Structural Strength for Semi-submersible Type

301. Application

The requirements in this Section apply to the semi-submersible type FOWT.

302. Overall strength

1. The overall strength of the unit is to be in accordance with the requirements in **201.**

2. For units of this type, the highest stresses may be associated with less severe environmental conditions than the maxima specified by the owner or designer. Particular attention is to be given to such a case.

303. Strength of structure in way of mooring system

Local structure in way of fairleads, winches, etc., forming a part of the position mooring system, is to be designed to the breaking strength of the mooring line or chain.

304. Upper structure

Unless deck structures are designed for wave impact, a clearance acceptable to the Society should be maintained between passing wave crests and the deck structure. The Administration should be provided with model test data, reports on past operating experience with similar configurations or by calculations showing that adequate provision is made to maintain this clearance.

305. Column and lower hulls

1. Where columns, lower hulls or footings are of stiffened shell construction, the scantlings of plating, stiffeners, girders, etc. are not to be less than determined by the requirements in **206. 2** and **3.** In this case, h_s and h_c are to be in accordance with the requirements in the followings.

(1) Where an internal space is loaded with liquid, h_s is the vertical distance in metres from the load line to the tank top and h_c is the vertical distance in metres from the tank top to the top of overflow pipes. Where, however, the specific gravity of the liquid is greater than that of sea water, h_s and h_c are to be modified taking account of specific gravity.
(2) Where an internal space is a void compartment, the top of h_s is at the load line and the top of h_c is 0.6 times the design wave height in the severe storm condition above the water level at the design water depth.
(3) The minimum values of h_s and h_c are not to be less than 6 metres for areas subject to wave immersion and 3.4 metres for other areas.

2. Where columns or lower hulls are designed as shells either unstiffened or ring stiffened, the scantlings of shell plating and ring stiffeners are to be determined to satisfy the strength requirements in **Sec 2** in response to the design heads, h_s and h_c, specified in **Par 1.**

3. The scantlings of deep tank bulkheads and their stiffeners provided in columns, lower hulls or footings are not to be less than determined by the requirements in **Pt 3, Ch 15** of **Rules for the Classification of Steel Ships**.

4. When column or lower hull is an effective member for the overall strength of the unit, the stress resulting from the overall strength is to be added by the stress.

5. Where a column or lower hull is a part of the overall structural frame of hull, consideration should also be given to stresses resulting from deflections due to the applicable combined loading.

6. Particular consideration is to be given to structural details, reinforcement, etc., in areas subject to high local loadings indicated in the followings ;

(1) Areas subject to bottom bearing loads, where applicable,
(2) Bulkheads of partially filled tanks, etc.,
(3) Areas liable to sustain external damages,
(4) Jointed parts between columns or lower hulls,
(5) Areas subject to wave impact.

306. Bracing members

1. Bracing members are to be designed to transmit loadings and to make the hull structure effective against environmental forces, and when the unit is supported by the sea bed, against the possibility of uneven bearing loads.

2. Bracing members are to have sufficient strength for buoyancy, wave and current forces and wave impact.

3. When bracing members are of tubular section, ring frames may be required to maintain stiffness and roundness of shape.

4. When bracings are watertight, they are to be suitably designed to prevent collapse from external hydrostatic pressure.

5. Underwater bracing members are to be provided with a leak detection system make it possible to detect fatigue cracks at an early stage.

6. The hull structure should be able to withstand the loss of any slender bracing member without causing overall collapse when exposed to environmental loading corresponding to a one-year return period for the intended area of operation.

7. Consideration should be given to the need for ring frames to maintain stiffness and shape in tubular bracing members.

307. Wave clearance

Unless deck structures are designed either in accordance with the requirements in 304. 1 or by considering wave impact, to the satisfaction of the Society, reasonable clearance between the lower surface of deck structure and the wave crest is to be ensured for all afloat modes of operation, taking into account the predicted motion of the unit relative to the surface of the sea.

Section 4 Mooring System Interface

401. Structural strength

1. The basic scantlings in way of the hull interface structure is to be designed based on the first principle approach and meet the requirements of strength criteria in **Rules for the Classification of Mobile Offshore Units** or equivalent national industry standards recognized and accepted, such as API Standards. Welding design of hull interface structure connections is to be developed based on **Pt 13, Ch 7 of Rules** for the Classification of Steel Ships or a direct calculation approach.
2. Structural strength evaluation is carried out for each design load case in **Ch 3 Sec 4**. For the interface between the floating substructure and the station keeping system such as fairleads, chain jacks, winches, etc., the partial resistance partial safety factor of 1.25 applies. When one mooring line is damaged and the remaining mooring line is required to maintain its position, the reinforced partial resistance safety factor (e.g: 1.67) specified by the Society may be applied.

402. Fatigue calculations

1. The fatigue calculations are to be carried out for the intended design operating life of the installation. Where the external interface connections are subjected to water immersion, the S-N curves in seawater with (CP) Cathodic Protection or (FC) Free Corrosion are to be used, as applicable. If the simplified fatigue calculation approach is to be used and the long-term Weibull distribution parameter is not available for the hull interface, then a Weibull parameter is to be developed for the specific location under consideration. The safety factors for fatigue life for hull interface connections are to be in accordance with **Table 6** shown below.

Table 6 Partial resistance safety factor for fatigue strength of mooring system interface

	Inspection or repair available	inspection or repair is not possible
Structural damage does not compromise the overall integrity of the structure.	3.0	5.0
Structural damage violates the overall integrity of the structure.	5.0	10.0

2. Position Mooring Hull Interface

   Structural members in way of the turret structure or other mooring structure are to be effectively connected to the adjacent structure in such a manner as to avoid hard spots, notches and other harmful stress concentrations. Special attention is to be given to cutouts, bracket toes and abrupt changes of structural sections. These areas are considered to be critical to the vessel and are to be free of cracks. The effects of stress risers in these areas are to be determined and minimized. The FE model used to perform the turret/hull integration strength analysis may also be used for the fatigue screening evaluation of the turret/hull interface structure to identify the critical fatigue details using the F or F2 Class S-N curves and appropriate safety factors. The fatigue cyclic loads are to correspond to the worst-case tank dynamic loads, seakeeping loads, inertia loads due to the vessel motion, and mooring and riser dynamic loads, where applicable. Different wave headings and vessel tank loading patterns should be considered and the fraction of the total time for each base wave heading and each tank loading pattern can be used directly. The frequency difference between wave frequency stress response and low frequency stress response imposed by mooring lines and risers should be considered. Although the low frequency stress response has negligible effects on most hull structural details, it becomes significant and may have the dominant contribution to the fatigue damage of structural components in the mooring system, risers and their interface with the hull. When the wave frequency and low frequency stress responses are obtained separately, the method of simple summation of fatigue damages from the two frequency stress responses does not account for the coupling effects (i.e., the augmentation of the low frequency response by the wave frequency response is non-conservative and therefore should not be used). There is an alternative method, which is both conservative and easy to use, that is known as the combined spectrum method. In this method, the stress spectra for the two frequency bands are combined. The RMS and the mean up-crossing frequency of the combined stress process are given, respectively, as follows.

$$\sigma_c = (\sigma_w^2 + \sigma_l^2)^{\frac{1}{2}}$$

$$f_{0c} = (f_{0w}^2\, \sigma_w^2 + f_{0l}^2 \sigma_l^2)^{\frac{1/2}{\sigma_c}}$$

Where,

σ_w = RMS of the wave-frequency stress component
σ_l = RMS of the low-frequency stress component
f_{0w} = mean up-crossing frequency of the wave-frequency stress component
f_{0l} = mean up-crossing frequency of the low-frequency stress component

However, if both frequency components of stress range are significant, the above-mentioned combination method may be too conservative since the wave-frequency contribution is expected to dominate, thus controlling the mean up-crossing frequency of the combined stress process. To eliminate the conservatism, a correction factor given below can be applied to the calculated fatigue damage of the sea state.

$$\frac{f_{0p}}{f_{0c}}\left[\lambda_l^{(\frac{m}{2})+1}\left(1-\sqrt{\frac{\lambda_w}{\lambda_l}}\right)+\sqrt{\pi\lambda_l\lambda_w}\frac{m\Gamma(\frac{m}{2}+\frac{1}{2})}{\Gamma(\frac{m}{2}+1)}\right]+\left(\frac{f_{0w}}{f_{0c}}\right)\lambda_w^{m/2}$$

Where,

λ_l = σ_l^2 / σ_c^2
λ_w = σ_w^2 / σ_c^2
f_{op} = $(\lambda_l^2 f_{ol}^2 + \lambda_l \lambda_w f_{ow}^2\, \delta_w^2\,)^{1/2}$ with $\delta_w = 0.1$
m = slope parameter of the S-N curve
$\Gamma()$ = complete gamma function

Section 5 Hull Equipment and Towing Arrangements

501. Guardrails, fenders

1. The guardrails or bulwarks specified in **Pt 4** of **Rules for the Classification of Steel Ships** are to be provided on weather decks. In cases where guardrails will become hindrances to the taking-off and landing of helicopters, means to prevent falling such as wire nets, etc. are to be provided.

2. Suitable fenders fore contact with the gunwales of other ships such as support ships, tug boats, shuttle tankers, etc. are to be provided.

3. Freeing arrangements, cargo ports and other similar openings, side scuttles, rectangular windows, ventilators and gangways are to be in accordance with the requirements for tankers specified in **Pt 4** of **Rules for the Classification of Steel Ships**.

4. Ladders, steps, etc. are to be provided inside compartments for safety examinations as deemed appropriate by the Society.

502. Towing

1. The design and arrangement of towing fittings should have regard to both normal and emergency conditions.

2. Equipments and fittings provided in accordance with **Par 1** should meet the appropriate requirements of recognized standards acceptable to the Society(KS, JIS etc.) and arrangements are to be submitted to the Society for the approval.(Refer to the **Guidelines for safe ocean towing (MSC/Circ.884)**).

3. Each fitting or item of equipment provided under this regulation should be clearly marked with any restrictions associated with its safe operation, taking into account the strength of its attachment to the unit's structure.

Section 6 Ice Strengthening

601. Reinforcement

1. Units designed to be located in areas where ice strengthening may be necessary will be specially considered and, provided that the unit is reinforced as necessary for operation in the specified ice conditions to the satisfaction of the Society, and an appropriate Additional Special Feature Notations may be added to the Class Notation by the Society.

2. Ice strengthening for surface type units is to be in accordance with **Pt 3, Ch 20** of **Rules for the Classification of Steel Ships.**

Section 7 Corrosion Control

701. General

All steelworks are to be coated with a paint of good quality or to be corrosion controlled with an effect equivalent to or more than paint. Where, however, the requirements in **Ch 2, 304.** are applied, special considerations are to be paid to the prevention of corrosion.

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CHAPTER 6 STATION KEEPING SYSTEMS

Section 1 General

101. General

1. The FOWT is to be provided with a station keeping system satisfying the requirements given in this chapter. The station keeping maintenance system consists of a mooring system and a system that controls the movement of the upper part of the floating substructure (tower and RNA) to maintain the position.
2. Mooring systems are to be sufficiently capable of positioning at a specific location against all of the design loading cases in Ch 3.
3. In the case of mooring systems operated in sea areas where low temperature, freezing, ice formation, etc. are predicted, the effects of such things are to be taken into consideration or appropriate countermeasures are to be provided.
4. For general mooring systems, see Ch 1, Sec 2 for definitions. The use of a new concept station keeping system not covered by this chapter or other existing industry standards is to be determined by the Society.
5. Mooring system with redundancy means a system that can maintain the position required by the operation manual of FOWT even when one mooring line is damaged. A mooring system without redundancy means that cannot maintain the position required by the FOWT's operating instructions when one mooring line is damaged.

102. Conditions to be considered for mooring system analysis

The various conditions of a Floating Installation which are important for the designer to consider are as follows.

1. A condition with all components of the system intact and exposed to an environment as described by the design load case.
2. If any one mooring line is damaged, the FOWT is assumed to move to a new location. When mooring lines are under maximum load in undamaged extreme conditions, the mooring system with redundancy should ensure that damage to one mooring line does not cause the worst mooring system damage. Mooring analysis is to be performed according to the design load cases in Ch 3. If damage to one mooring line causes a load concentration on the other mooring lines, the effect on the mooring line interface structure of the floating substructure should be evaluated. A mooring system without redundancy and devices associated with the SALM are not relevant if one mooring line is damaged. If partial damage to the SALM structure causes a loss of buoyancy, the ability to retain position should be analyzed. If a thruster is present in the positioning system, loss of thruster power or mechanical damage associated with the thruster is considered separately.
3. If one mooring line is damaged, the FOWT may over-exercise before being placed in a new equilibrium position. Movement conditions can be an important consideration to maintain adequate spacing between mooring facilities and nearby FOWTs. An analysis of this state is required under the design load case. The effect of increased tension due to damage to one mooring line should also be considered.

Section 2 Mooring Analysis

201. General

1. FOWT is a dynamic system that is continuously exposed to changes in wind, current, wave and draft, etc., and the calculation of the maximum load acting on the station keeping system should consider the environmental conditions of the installation area. It should be determined through the coupling analysis described in Ch 3.

2. In case of mooring systems using mooring lines, analysis is to be carried out under the awareness that there is no harmful excessive bend of any lines in way of the contact points between mooring lines and mooring equipment (fairleaders, etc.) fitted on board Units.

3. The mooring systems and the seabed mooring points (anchors, sinkers, piles, etc.) of any periphery facilities for positioning are not to be slid, uplifted, overturned, etc. against any envisioned force from the mooring lines. In cases where scouring effects are not considered to be negligible, appropriate consideration is to be taken such as the modification of burial depth, protection against the flow around seabed mooring points, etc.

4. The maximum offset of FOWT and maximum tension of a mooring line is to be calculated.

5. In the mooring analysis, the load, stiffness, damping, etc. of the electrical cable should be considered, and attention should be paid to the interaction between the structure and the electrical cable.

202. 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 following formula is to be adopted as the standard for calculating maximum offset. In the following formula, mean offset and significant single amplitude or maximum amplitude of the maximum offset obtained from model tests or analysis methods deemed appropriate by the Society are used.

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

or

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

whichever is greater.

where

S_{mean} : Mean offset of the Units due to wind, current and mean drift

$S_{lf(sig)}$: Significant single amplitude low frequency motion

$S_{wf(sig)}$: Significant single amplitude wave frequency motion

3. The maximum values of low frequency motion $S_{lf(\max)}$ and wave frequency motion $S_{wf(\max)}$ may be calculated by multiplying the significant amplitude values to the factor C, which is to be calculated as follows:

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

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

T : Hypothetical storm duration (seconds), minimum 10,800 (i.e. 3 hours). In the case of areas with longer storm durations (monsoon areas), T needs to be a higher value.

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

4. In the case of low frequency components, T_a may be taken as the natural period T_n of a Units with a mooring system. T_n can be calculated as follows using the mass of the Units m (including added mass, etc.) and the stiffness of the mooring system k for horizontal motion (port-starboard, fwd-aft, yaw motion) at the Units s mean position and equilibrium heading as follows:

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

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 the Society for reference.

5. In order to assess the motion of Units in waves in relatively shallow water, shallow water effects are to be taken into account. In cases where the changes in tidal levels in shallow waters are relatively large, the tidal difference affecting Units motion and the tension acting on mooring lines is to be considered.

203. Calculation of mooring line tensions, etc.

1. In order to calculate the maximum tension acting on the mooring lines, the severest combination of wind, waves and current is to be considered together with a sufficient number of angles of incidence. Although this severest condition generally corresponds to cases where all of the wind, wave and current directions are consistent, in the case of specific sea areas, the combination of wind, waves and current in different directions which are likely to create a higher tension are to be taken into account as needed.

2. When the quasi-static analysis procedure is followed in the calculation of the tension acting on the mooring line, the following (1) to (3) are to be considered. The maximum tension of the mooring line calculated by the procedure for quasi-static analysis or dynamic analysis shall have the appropriate safety factor specified in Table 7.

(1) Static tension of mooring lines due to net weight and buoyancy.

(2) Steady tension of mooring lines due to a steady horizontal offset of Units induced by wind, waves and current.

(3) Quasi-static varying tension of mooring lines due to Units motion induced by waves.

Table 7 Safety factors for chain and wire rope

Condition			Safety factor
Intact	mooring system with redundancy	Dynamic analysis	1.67
		Quasi-static analysis	2.00
	mooring system without redundancy	-	2.00
One broken mooring line (at new equilibrium position)	mooring system with redundancy	Dynamic analysis	1.05
		Quasi-static analysis	1.43
	mooring system without redundancy	-	1.43
One broken mooring line (transient condition)	mooring system with redundancy	Dynamic analysis	1.05
		Quasi-static analysis	1.18
	mooring system without redundancy	-	1.58

3. The maximum tension in a mooring line $T_{\max}$ is to be determined as follows:

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

or

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

whichever is greater

where

T_{mean} : Mean mooring line tension due to wind, current and mean steady drift

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

$T_{wf(sig)}$: Significant amplitude of wave frequency tension

The maximum values of low frequency tension $T_{lf(\max)}$ and wave frequency tension $T_{wf(\max)}$ are to be calculated by the same procedure as that used for obtaining the motions at low frequency and wave frequency described in **202. 2** above.

4. Mooring systems are to be designed so that the failure of any one mooring line does not cause the progressive failure of the remaining mooring lines.

5. Followings are to be taken into account;

(1) Dynamic tension in mooring lines due to damping forces and inertia forces acting on each mooring line in cases where they are generally used in deep water.

(2) Quasi-static low-frequency varying tension of mooring lines due to the low-frequency motion of Units in irregular waves in cases where they are used in a sufficiently slack condition. (in cases where the natural period of motion of a Units in a horizontal plane is sufficiently longer than the period of ordinary waves)

204. Fatigue analysis

1. The fatigue life of mooring lines is to be assessed in consideration of the changing tension range, T and the number of cycles, n. The fatigue life of mooring lines is to be evaluated by estimating the fatigue damage ratio, Di in accordance with Miner's law using a curve relating the changing tension range to the number of cycles to failure.

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

n_i : Number of cycles within the tension range interval, i, for a given sea state.

N_i : Number of cycles to failure at changing tension range, Ti.

The cumulative fatigue damage, D for all expected number of sea states NN (identified in a wave scatter diagram) is to be calculated as follows:

$$D = \sum_{i=1}^{NN} Di$$

The value of D divided by the usage factor (η) specified in **Table 8** is not to be greater than 1. In such cases, the usage factors for the underwater parts of the mooring lines are, in principle, to be taken to be that of an inaccessible and critical area.

2. The fatigue life of each mooring line component is to be considered. $T-N$ curves for various line components are to be based on fatigue test data and regression analysis.

3. Special consideration is to be given to the fatigue strength of the connections between the mooring lines and hull structures of Units, the connections between the mooring lines and seabed mooring points, and the connections between the mooring lines and other mooring lines.

Table 8 Usage Factor

	Accessibility	Usage Factor
mooring system with redundancy	High	1.0
	Low	0.5
mooring system without redundancy	High	0.33
	Low	0.1[*1]

Section 3 Mooring Equipment

301. Components of mooring

1. The strength of connecting shackles, links, etc. used at the connecting points between the mooring lines and hull structures and between mooring lines and seabed mooring points are, in principle, to have safety factors against the breaking loads of such mooring lines or the ultimate strength of structures not less than those indicated in the **Table 7.**
2. When the chain is used for mooring lines, the standard length of the contact point between the chain and the fairlead is not to be less than 7 times the diameter of the chain.
3. In the case where it is used for wire rope mooring line, the standard length of the part where the wire rope and the fairlead are in contact is not to be less than 14 times the diameter of the wire rope.
4. For the arrangement that does not satisfy the criteria in Par 1 and 2, a detailed analysis is to be carried out considering the effect of the bending load acting on the mooring line.
5. Chains, wire ropes or fibre ropes used for mooring systems are to comply with the requirements given in **Pt 4, Ch 8, Sec 4 and Sec 5** of **Rules for the Classification of Steel Ships** or any standards deemed appropriate by the Society. In cases where the Grade R4 chains specified in **Pt 4, Ch 8** of **Rules for the Classification of Steel Ships** or stronger chains are used, special care is to be taken because repairs by welding for any defects, loose studs and corrosion by welding is, in principle, prohibited for such chains.
6. Intermediate sinkers, intermediate buoys and anchors, sinkers, piles, etc. for seabed mooring points are to be as deemed appropriate by the Society.
7. Chain stoppers used for mooring systems are to have sufficient strength against the breaking strength of the mooring line as deemed appropriate by the Society. The prototypes of chain stoppers are to be verified to have sufficient strength against the breaking strength of the mooring line. It is to be verified that the stress calculated by structural analysis under the awareness that the mooring line is subjected to design maximum loads does not exceed the specified proof stress of the chain stoppers.
8. In the case of catenary mooring systems, mooring lines are to be sufficiently long so that no up-lifting forces act on the parts of the mooring line around the mooring point on the seabed under design conditions.

302. holding power of seabed mooring points

1. Information verifying that the holding power of seabed mooring points is sufficient against the expected tension from the mooring lines in accordance with **203.** is to be submitted to the Society for reference.

2. In the case of seabed mooring points which rely on friction with the seabed surface, if the submerged unit weight of mooring lines is constant, the maximum load at the seabed mooring point F_{anchor} can be calculated as follow:

$$F_{anchor} = P_{line} - W_{sub}WD - F_{friction}$$

$$F_{friction} = f_{sl}L_{bed}W_{sub}$$

P_{line}: Maximum mooring line tension

WD : Water depth

f_{sl} : Friction coefficient of mooring line on seabed at sliding which is to be determined in consideration of soil conditions, the type of mooring line, etc. In the case of soft mud, sand, and clay, the values of f_{sl}, and the coefficient of friction at the start f_{st}, indicated in the **Table 9** may be used.

L_{bed} : Length of mooring line on seabed at design storm conditions, not to exceed 20% of the total length of a mooring line.

W_{sub} : Submerged unit weight of mooring line

In cases where submerged mooring lines are not a single line, or those cases where using intermediate sinkers/buoys, the above equation is to be applied in consideration of such effects.

3. The safety factors for the horizontal holding power capacity of the seabed mooring points of catenary mooring systems and taut mooring systems are, in principle, to be in accordance with **Table 10.** However, the above may not be complied with in cases where required ultimate holding capacity is to be determined based on mooring loads derived from dynamic analysis taking into account mooring line dynamics.

6. The safety factors for the vertical holding power capacity of the seabed mooring points of taut mooring systems are, in principle, to be in accordance with **Table 11.**

Table 9 Coefficient of Friction f

	Starting (f_{st})	Sliding (f_{sl})
Chain	1.00	0.70
Wire rope	0.60	0.25

Table 10 Safety Factor for the Horizontal Holding Capacity of the Seabed Mooring Points of Catenary Mooring Systems and Taut Mooring Systems

Safety factor	
Intact	1.50
One broken mooring line	1.00

Table 11 Safety Factor for the Vertical Holding Capacity of the Seabed Mooring Points of Taut Mooring Systems

Safety factor	
Intact	1.20
One broken mooring line	1.00

Section 4 Anchor Holding Power

401. Generals

Different types of foundation systems used for floating installations are drag anchors, pile anchors, vertically loaded anchors (VLA) and suction piles. Gravity boxes, grouted piles, templates, etc., may also be used and are considered to be within the scope of classification.

402. Drag anchor

1. For a mooring system with drag anchors, the mooring line length should be sufficiently long such that there is no angle between the mooring line and the seabed at any design condition.
2. For soft clay (in Gulf of Mexico) condition, a small angle for the damaged case with one broken line are to be as deemed appropriate by the Society.
3. Drag anchor holding power depends on the anchor type, as well as the condition of the anchor deployed in regard to penetration of the flukes, opening of the flukes, depth of burial, stability of the anchor during dragging, soil behavior of the flukes, etc.
4. The designer should submit to the Society the performance data for the specific anchor type and the site-specific soil conditions for the estimation of the ultimate holding capacity (UHC) of an anchor design. Because of uncertainties and the wide variation of anchor characteristics, exact holding power is to be determined after the anchor is deployed and test loaded.
5. The maximum load at anchor, F_{anchor} is to be calculated, in consistent units, as follows **302. 2**

403. Conventional pile

1. Conventional pile anchors are capable of withstanding uplift and lateral forces at the same time.
2. Analysis of the pile as a beam column on an elastic foundation is to be submitted to the Society for review.
3. The analyses for different kinds of soil using representative soil resistance and deflection (p-y) curves are described in the API RP 2A and API RP 2T, as applicable. The fatigue analysis of the pile should be submitted for review.

404. Vertically loaded drag anchors (VLA)

1. VLAs can be used in a taut leg mooring system with approximately a 35° to 45° angle between the seabed and the mooring lines.
2. These anchors are designed to withstand both the vertical and horizontal loads imposed by the mooring line.
3. The structural and geotechnical holding capacity design of the VLA are to be submitted for review. This is to include the ultimate holding capacity and the anchor's burial depth beneath the seabed. Additionally, the fatigue analysis of the anchor and the connectors joining the VLA to the mooring line should be submitted for review.
4. The safety factors of VLA anchors' holding capacity are specified in **Table 12.**

Table 12 Factor of Safety for Anchor Holding Capacities

Condition			Safety factor
mooring system with redundancy	drag anchors	intact	1.50
		One broken mooring line	1.00
	Vertically loaded drag anchors (VLAs)	intact	2.00
		One broken mooring line	1.50
	pile anchors	-	API RP 2T or API RP 2SK
	suction piles	intact	1.5 ~ 2.0
		One broken mooring line	1.2 ~ 1.5
In case of mooring system without redundancy, the safety factor should be applied 120% 새 the above factor.			

405. Suction piles

1. Suction pile anchors are caisson foundations that are penetrated to the target depth by pumping out the water inside of the pile to create underpressure within the pile.
2. They may typically consist of a stiffened cylindrical shell with a cover plate at the top and an open-bottom and generally have larger diameters and are shorter in length than conventional piles.
3. These piles can be designed to have a permanent top or a retrievable top depending on the required vertical holding capacity.
4. The pad eye for the mooring line connection can be at the top or at an intermediate level depending on the application of the suction pile. Suction pile anchors are capable of withstanding uplift and lateral forces.
5. Due to the geometry of the suction piles, the failure modes of the soils maybe different than what are applicable for long slender conventional piles.
6. The safety factors for the suction piles' holding capacity are specified in **Table 12.** Geotechnical holding capacity and structural analyses for the suction piles are to be submitted to verify the adequacy of the suction piles to withstand the in-service and installation loads.
7. Additionally, fatigue analysis of the suction piles are to be submitted to verify the adequacy of the fatigue life of the critical locations. Installation analyses are to be submitted to verify that the suction piles can be penetrated to the design penetration and that the suction piles can be retrieved, if necessary.
8. It is suggested that a ratio of at least 1.5 between the force that would cause uplift of the soil-plug inside of the pile and the effective pile installation force be considered in the penetration analysis. ⚓

CHAPTER 7 STABILITY and WATER/WEATHERTIGHT

Section 1 General

101. Application

1. The requirements of this chapter apply to floating substructures in relation to the stability of the FOWT.

2. The floating substructure shall have a positive metacentric height (GM) under average conditions of calm waters before and during the operational phase. It is assumed that no mooring system is present in all floating substructure stability reviews except for the TLP type. However, if it adversely affects the stability, it should be considered. The metacentric height should be specified for each operating mode and the guidelines for metacenter or allowable center of gravity height.should be included in the operating manual.

102. General

1. When moving for installation after building, the intact stability should be considered in consideration of the environmental conditions during transition. In addition, during the installation or trial operation period, the intact stability should be reviewed in consideration of the environmental conditions reflecting the 50-years return period.

2. The stability at the operational stage is to be considered the following.
   (1) environmental conditions such as wind, waves, currents, and accumulation of snow and ice
   (2) applicable damage scenarios
   (3) motion of floating substructure
   (4) effect of RNA operating conditions
   (5) effect of station keeping system
   (6) free surface effect of ballast tank

3. Alternative stability criteria may be considered by the Society, provided an equivalent level of safety is maintained and if they are demonstrated to afford adequate positive initial stability. In determining the acceptability of such criteria, the Society should consider at least the following and take into account as appropriate:
   (1) environmental conditions representing realistic winds (including gusts) and waves appropriate for service in various modes of operation;
   (2) dynamic response of a unit. Analysis should include the results of wind tunnel tests, wave tank model tests, and non-linear simulation, where appropriate. Any wind and wave spectra used should cover sufficient frequency ranges to ensure that critical motion responses are obtained;
   (3) potential for flooding taking into account dynamic responses in a seaway;
   (4) susceptibility to capsizing considering the unit's restoration energy and the static inclination due to the mean wind speed and the maximum dynamic response;
   (5) an adequate safety margin to account for uncertainties.

Section 2 Intact Stability Criteria

201. Righting and Heeling Moment Curves

1. The heeling moment curve due to wind is to be determined according to the wind load (F) obtained from the formula specified in Ch 4, Sec 2, 201.3. of the Rules for Mobile Offshore Drilling Units.

2. Righting and heeling moment curves due to wind should be drawn up for all ranges of draft for the floating state, and should be drawn up for the most affected axial direction. If the floating substructure has liquid tanks, the free surface effect is to be included. In this case, it is assumed that the structure floats without receiving mooring resistance.

3. The heeling moment due to wind load is to be calculated considering the characteristics of RNA (the thrust of the rotor, operating conditions and control system operation). The arm of heeling moment means the vertical distance from the center of hydrodynamic pressure of the underwater hull

or 1/2 of the mean draft to the center of wind pressure. It is also possible to obtain gradient force and center of pressure in wind tunnel tests using floating substructure and RNA model. When the current increases the heeling moment, this should be taken into account.

4. In the case of FOWT using a thruster to maintain position, the thrust of the thruster is to be included in the calculation of the heeling moment. The heeling moment due to snow and ice accumulation and other adverse environmental influences such as green waves and adverse effects of the positioning system should be properly considered.

5. In general, the minimum wind speed in the normal operating condition should be 36m/s (70 knots), and the minimum wind speed in the extreme sea condition should be 51.5m/s (100 knots) or more.

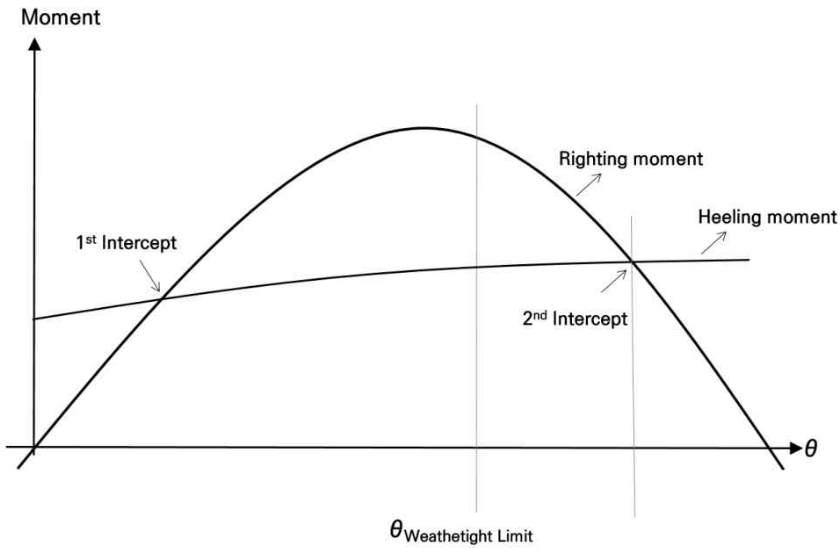

Fig 2 Righting and heeling moment curves

202. Intact Stability Criteria

1. Intact stability of floating substructure should satisfy the criteria for intact stability or dynamic response-based intact stability.

2. Floating substructure should have sufficient stability to withstand the same heeling moment generated under the load cases indicated by U under the design load cases in Ch 3, Sec 4 Table 3 or in the sea conditions specified in 201.4. and the following conditions are to be considered.
   (1) Considering that the plane of the rotor is perpendicular to the wind as shown in Fig. 2, the effect of changing the heeling moment according to the minimum wind speed in the extreme sea conditions specified in 201.5 should be reflected. However, if the actual environmental conditions in some operating conditions are worse than the specified extreme sea conditions, it should be calculated taking this into account.
   (2) As shown in Fig. 2, in order to secure the stability according to the wind direction, the effect of changing the heeling moment between 0 and 360 degrees in the wind direction should be reflected. However, the calculations are made assuming the minimum wind speed in the normal operating conditions specified in 201.5.

3. For barge type floating substructure, as shown in Fig 2, the righting moment shall be calculated as the area up to the smaller of the angle of seawater inflow due to the unprotected opening or the angle of second intersection between heeling and righting moment. and should not be less than 140% of the area of the inclination moment at that angle.

4. For semi-submersible floating substructure, as shown in Fig 2, the righting moment shall be calculated as the area up to the smaller of the angle of seawater inflow due to the unprotected opening

or the angle of second intersection between heeling and righting moment. and should not be less than 130% of the area of the inclination moment at that angle. At all angles, the righting moment diagram should have a positive (+) value.

5. The standard for undamaged stability of Spar and TLP-type floating substructures is to be in accordance with the separate standards determined by the Society.

6. Changes in the center of gravity should be considered in all operating procedures for RNA. Where applicable, heeling angle limits imposed by RNA and tower or the design requirements of the positioning system shall be added.

203. Dynamic response-based intact stability criteria

1. As an alternative to the intact stability criterion specified in 202., the dynamic response-based intact stability criterion can incorporate the dynamic response characteristics of floating substructures into the stability criterion to provide a reasonable safety margin against heeling and flooding.

2. Dynamic motion analysis is to be performed for wind-dominated and wave-dominated loading cases, including extreme storm conditions and other related environmental conditions. Dynamic motion analysis to evaluate the heeling and flooding for the condition where the mooring system is excluded is in accordance with Ch 3, Sec 5. The dynamic response required as an input for the evaluation of intact stability is as follows.
   (1) The maximum angle of heeling of the floating substructure to evaluate the heeling criterion.
   (2) Decreased flooding distance due to the heeling angle and wave motion of the floating substructure for evaluating the flooding criteria

3. For all direction, the area under the righting moment curve measured between the maximum heeling angle and the heeling angle corresponding to the second intersection of the righting and heeling moment curves should be at least 110% of the area under the righting moment curve measured between the maximum heeling angle and the heeling angle corresponding to the first intersection of the righting and heeling moment curves.

4. When the model test results are reflected in the dynamic response analysis, the following items among the model test results are to be submitted to the Society.
   (1) Description of model construction, scaling method, RNA model control plan and measurement plan
   (2) Description of the input and measured wind and wave spectra
   (3) Description of turbine operating conditions considered in the model test
   (4) Response spectrum and response amplitude operators (RAO) presented in tabular form over a suitable range of periods (or frequencies)
   (5) Model test results including mean, maximum, square mean and effective values for motion in 6 degrees of freedom and relative motion to at least 4 reference points of the hull and tension of mooring line corresponding to the motion

Section 3 Damage Stability Criteria

301. Damage Range

1. The following compartments are to be regarded as independently flooded regardless of the cause of flooding.
   (1) Compartment where ballast water pump or cooling system equipment is installed
   (2) Compartments provided with locking openings below the waterline
   (3) Compartments adjacent to seawater.

2. To evaluate damage stability, the heeling moment applied to the floating substructure, tower and RNA in design load cases 9.3 and 10.3 in Table 3 or under environmental conditions with a minimum wind speed of 25.8 m/s (50 knots) is to be considered. Final waterline of damaged floating substructure are to be as follows.
   (1) Not to exceed the lowest point of the hull deck or the top of the hull below the waterline, whichever is the lower.
   (2) 1.5 m below the unprotected opening

3. In assessing the damage stability of barge type, the following extent of damage should be assumed to occur between effective watertight bulkheads:

(1) horizontal penetration: 1.5 m; and

(2) vertical extent: from the base line upwards without limit.

The distance between effective watertight bulkheads or their nearest stepped portions which are positioned within the assumed extent of horizontal penetration should be not less than 3 m; where there is a lesser distance, one or more of the adjacent bulkheads should be disregarded. Where damage of a lesser extent than in Par 1 results in a more severe condition, such lesser extent should be assumed. All piping, ventilation systems, trunks, etc., within the extent of damage referred to in Par 1 should be assumed to be damaged. Positive means of closure should be provided at watertight boundaries to preclude the progressive flooding of other spaces which are intended to be intact.

4. In assessing the damage stability of column-stabilized units, the following extent of damage should be assumed:

(1) Only those columns, underwater hulls and braces on the periphery of the unit should be assumed to be damaged and the damage should be assumed in the exposed portions of the columns, underwater hulls and braces.

(2) Columns and braces should be assumed to be flooded by damage having a vertical extent of 3 m occurring at any level between 5 m above and 3 m below the draughts specified in the operating manual. Where a watertight flat is located within this region, the damage should be assumed to have occurred in both compartments above and below the watertight flat in question. Lesser distances above or below the draughts may be applied to the satisfaction of the Society, taking into account the actual operating conditions. However, the required damage region should extend at least 1.5 m above and below the draught specified in the operating manual.

(3) No vertical bulkhead should be assumed to be damaged, except where bulkheads are spaced closer than a distance of one eighth of the column perimeter at the draught under consideration, measured at the periphery, in which case one or more of the bulkheads should be disregarded.

(4) If damage of a lesser extent than specified in (1) to (3) results in a more severe damage equilibrium condition, such a lesser extent is to be assumed.

(5) All piping, ventilation systems, trunks, etc., within the extent of damage should be assumed to be damaged. Positive means of closure should be provided at watertight boundaries to preclude the progressive flooding of other spaces which are intended to be intact.

302. Damage stability criteria

1. The ability to reduce angles of inclination by pumping out or ballasting compartments or application of mooring forces, etc., should not be considered as justifying any relaxation of these provisions. Alternative subdivision and damage stability criteria may be considered for approval by the Society provided an equivalent level of safety is maintained.

2. In the case of a barge type structure, it is to be divided into watertight decks and watertight bulkheads to have sufficient buoyancy, and it is to have sufficient residual stability suitable for the following conditions against the heeling moment caused by the wind.

(1) Even after damage, the opening below the final waterline is to be watertight.

3. For semi-submersible type, the floating substructure should be subdivided by means of watertight decks and bulkheads to provide sufficient buoyancy and the stability under following conditions shall be secured for heeling moment by wind:

(1) Any opening below the final waterline should be made watertight.

(2) The righting moment curve, after the damage set out above, should have, from the first intercept with the wind heeling moment to the lesser of the extent of weathertight integrity and the second intercept, a range of at least 7°. (See **Fig 3**)

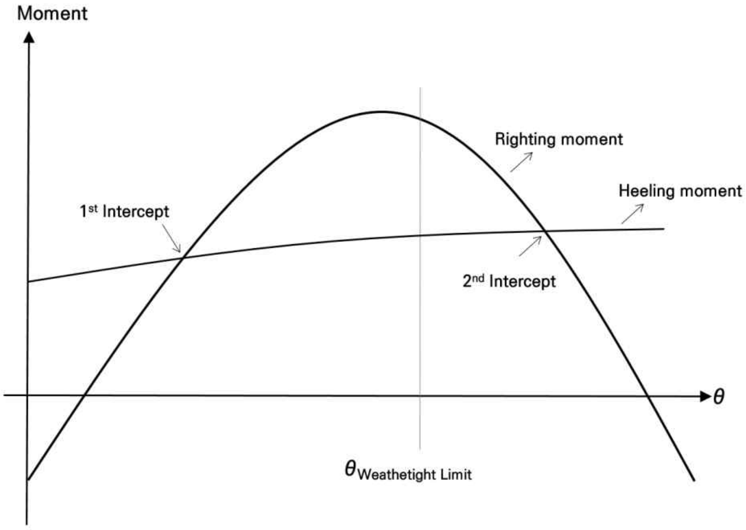

Fig 3 Righting and heeling moment diagram after damage

Section 4 Inclining Test

401. General

1. An incline test or equivalent measurement procedure is to be performed to determine the weight and center of gravity position of the FOWT including the hull light weight, permanent ballast and major components. When inclination testing is not possible due to the FOWT characteristics, the center of gravity should be determined by accurate weighing of all components and precise weight calculation. A certified load cell must be used for weighing.

2. An inclining test should be required for the first unit of a design, when the unit is as near to completion as possible, to determine accurately the light ship data (weight and position of centre of gravity).

3. For successive units which are identical by design, the light ship data of the first unit of the series may be accepted by the Society in lieu of an inclining test, provided the difference in light ship displacement or position of centre of gravity due to weight changes for minor differences in machinery, outfitting or equipment, confirmed by the results of a lightweight survey, is less than 1% of the values of the light ship displacement and principal horizontal dimensions as determined for the first of the series. Extra care should be given to the detailed weight calculation and comparison with the original unit of a series of column-stabilized, semisubmersible types as these, even though identical by design, are recognized as being unlikely to attain an acceptable similarity of weight or centre of gravity to warrant a waiver of the inclining test.

4. The results of the inclining test, or those of the lightweight survey together with the inclining test results for the first unit should be indicated in the operating manual.

5. A record of all changes to machinery, structure, outfitting and equipment that affect the light ship data should be maintained in a light ship data alterations log and be taken into account in daily operations.

6. For column-stabilized units:
   (1) A lightweight survey or inclining test should be conducted at the first renewal survey. If a lightweight survey is conducted and it indicates a change from the calculated light ship displacement in excess of 1% of the operating displacement, an inclining test should be conducted, or the difference in weight should be placed in an indisputably conservative vertical centre of gravity and approved by the Society.
   (2) If the survey or test at the first renewal survey demonstrated that the unit was maintaining an effective weight control programme, and at succeeding renewal surveys this is confirmed by the

records under Par 4, light ship displacement may be verified in operation by comparison of the calculated and observed draught. Where the difference between the expected displacement and the actual displacement based upon draught readings exceed 1% of the operating displacement, a lightweight survey should be completed in accordance with paragraph (1).

7. The inclining test or lightweight survey should be carried out in the presence of the Surveyor.

Section 5 Watertight/Weathertight Integrity

501. Watertight and weathertight

1. A plan identifying the placement (open or closed) of all passive closure devices and the location of all watertight and weathertight closures, and unprotected openings, shall be submitted for review.
2. All exterior openings below the level at which weathertight integrity is to be maintained shall have a weathertight closing device. Openings equipped with closure devices shall effectively block the ingress of water due to intermittent flooding of closure devices.
3. Appropriate closures shall be installed to achieve watertight integrity for all interior and exterior openings with edges lower than the level at which watertight integrity must be maintained for both intact and damaged conditions.

502. Watertight Bulkheads

1. All units are to be provided with watertight bulkheads in accordance with the requirements in **Pt 3, Ch 14 of Rules for the Classification of Steel Ships** and **Ch 14 of Rules for the Classification of Steel Barges**. In the case of column-stabilized units, the scantlings of watertight flats and bulkheads are to be made of effective to that point necessary to meet the requirements of damage stability.

2. Tank boundaries

(1) Tight divisions and boundary bulkheads of all tanks are to be constructed in accordance with the requirements in **Pt 3, Ch 15** of **Rules for the Classification of Steel Ships**.
(2) Tanks for fresh water or fuel oil, or any other tanks which are not intended to be kept entirely filled in service, are to have divisions or deep swashes as may be required to minimize the dynamic stress on the structure.
(3) The arrangement of all tanks, together with their intended service and the height of the overflow pipes, is to be clearly indicated on the plans submitted for approval.
(4) Each tank is to be tested in accordance with **Table 3.1.1** in **Pt 3, Ch 1** of **Rules for the Classification of Steel Ships**.

3. Boundary penetrations

(1) The number of openings in watertight subdivisions should be kept to a minimum compatible with the design and safe operation of the unit. Where watertight boundaries are required for damage stability, they are to be made watertight, including piping, ventilation, shafting, electrical penetrations, and so on.
(2) Watertight doors should be designed to withstand water pressure to a head up to the bulkhead deck or freeboard deck respectively. A prototype pressure test should be conducted for each type and size of door to be installed on the unit at a test pressure corresponding to at least the head required for the intended location. The prototype test should be carried out before the door is fitted. The installation method and procedure for fitting the door on board should correspond to that of the prototype test. When fitted on board, each door should be checked for proper seating between the bulkhead, the frame and the door. Large doors or hatches of a design and size that would make pressure testing impracticable may be exempted from the prototype pressure test, provided that it is demonstrated by calculations that the doors or hatches maintain watertightness at the design pressure, with a proper margin of resistance. After installation, every such door, hatch or ramp should be tested by means of a hose test or equivalent.

503. Closing Appliances

1. General

The construction and closing appliances of openings through which the sea water is likely to flow in are to be in accordance with the requirements in **Pt 4, Ch 3, Sec 3** of **Rules for the Classification of Steel Ships** and International Convention on Load Lines, except that those which are provided in column-stabilized units, which are not located within areas of calculated immersion and for which special considerations are given, are to be at the discretion of the Society.

2. General requirements related to watertight integrity.

(1) External openings, such as air pipes (regardless of closing appliances), ventilators, ventilation intakes and outlets, non-watertight hatches and weathertight doors, which are used during operation of the unit while afloat, are not to submerge when the unit is inclined to the first intercept of the righting moment and wind heeling moment curves in any intact or damaged condition. Openings, such as side scuttles of the non-opening type, manholes and small hatches, which are fitted with appliances to ensure watertight integrity, may be submerged.(Such openings are not allowed to be fitted in the column of stabilized units.) Such openings are not to be regarded as emergency exits. Where flooding of chain lockers or other buoyant volumes may occur, the openings to these spaces should be considered as downflooding points.

(2) External openings fitted with appliances to ensure watertight integrity, which are kept permanently closed while afloat, are to comply with the requirements of (5).

(3) Internal openings fitted with appliances to ensure watertight integrity are normally closed while the unit is afloat but these openings may be of the quick acting type door in column-stabilized and surface units. The closing appliances are to have strength, packing and means for securing which are sufficient to maintain watertightness under the design water pressure of the watertight boundary under consideration.

(4) Internal openings fitted with appliances to ensure watertight integrity, which are to be kept permanently closed while afloat, are to comply with the following:

(A) A signboard to the effect that the opening is always to be kept closed while afloat is to be fitted on the closing appliance in question.

(B) Opening and closing of such closure devices should be noted in the unit's logbook, or equivalent.

(C) Manholes fitted with bolted covers need not be dealt with as under (A).

(D) The closing appliances are to have strength, packing and means for securing which are sufficient to maintain watertightness under the design water pressure of the watertight boundary under consideration.

3. General requirements related to weathertight integrity.

(1) Any opening, such as an air pipe, ventilator, ventilation intake or outlet, non-watertight side-scuttle, small hatch, door, etc., having its lower edge submerged below a waterline associated with the zones indicate in (A) or (B) below, is to be fitted with a weathertight closing appliance to ensure the weathertight integrity, when:

(A) a unit is inclined to the range between the first intercept of the right moment curve and the wind heeling moment curve and the angle necessary to comply with the requirements of **202.** during the intact condition; and

(B) The angle range suitable for 302.3 from the first intersection of the restoration moment curve and the wind-induced inclination moment curve after damage in case of semi-submersible structure (refer to Fig 4)

(2) External openings fitted with appliances to ensure weathertight integrity, which are kept permanently closed while afloat, are to comply with the requirements of **503. 2 (4).** ⚓

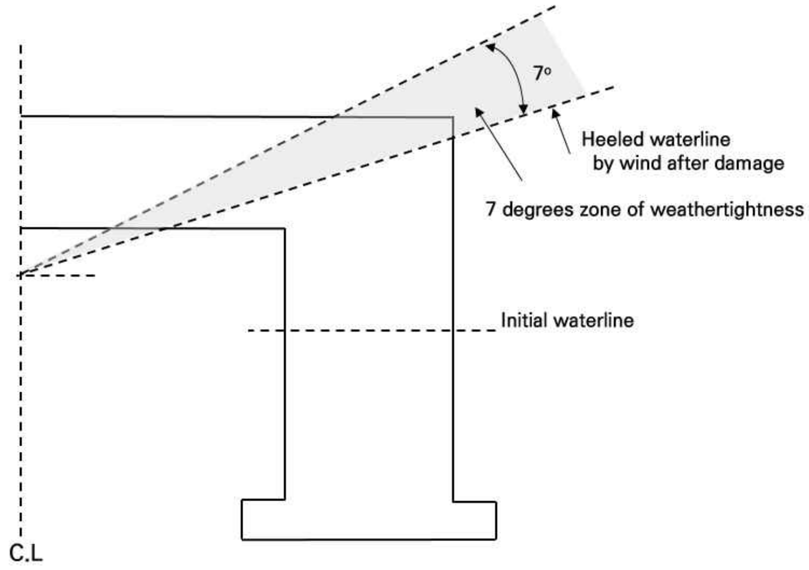

Fig 4. Minimum Requirements of weather-tightness after damage for semi-submersible type

CHAPTER 8 MACHINERY INSTALLATIONS

Section 1 General

101. General

1. In the case of items not specified in this Chapter, the requirements specified in Rules for the Classification of the Mobile Offshore Units are to be applied with reference to the fact that the FOWT is operated unmanned.

Section 2 Auxiliaries and piping arrangements

201. Bilge system

1. The bilge system is to comply with the applicable requirements in Ch 10, 104. 5 of the Rules for Mobile Offshore Units.
2. If a portable powered bilge pump is used instead of a fixed bilge system, at least two sets of pumps are to be provided in the structure or a support ship is to be able to provide it to the structure. These pumps and arrangements should be readily accessible.

202. Ballast system

1. Ballast system is to comply with the applicable requirements in Ch 10, 104. 6 of the Rules for Mobile Offshore Units.
2. All ballast tanks except permanent ballast tanks are to be equipped with a ballast system capable of injecting and discharging ballast water.
3. All ballast pumps and valves are to be equipped with means of remote actuation.
4. Normal or emergency operation of the ballast system is not to cause gradual flooding through openings such as hatches, manholes, etc. in watertight spaces.
5. The ballast system may be driven by a pump or compressed air according to:
   (1) Pump-driven ballast water system
      (A) At least two sets of ballast pumps are to be provided in the ballast system, and one of the two sets is to be permanently connected to the ballast water system. The remaining 1 set can be provided on board as a spare or replaced with a permanently connected eductor.
   (2) Ballast system driven by compressed air
      (A) The compressed air system is to be capable of supplying a sufficient amount of compressed air for ballasting at all times.
      (B) When two sets of compressors are installed, one set should be powered by an emergency power source or an independent engine, and each compressor should be capable of supplying the amount of compressed air required in (D).
      (C) When one set of compressors is installed, the compressor should be powered by an emergency power source or an independent engine, and it should be able to store and supply the amount of compressed air required in (D).
      (D) The amount of compressed air is to be capable of restoring the unit to the horizontal trim and normal operating draft from the worst flooded condition as defined in Ch 7, 301..

203. Air tubes and sounding pipes

1. Air pipes, overflow pipes and sounding pipes are to comply with the applicable requirements in Pt 5, Ch 6, Sec 2 of the Rules for the Classification of Steel Ships.
2. Tanks and compartments fitted with fixed drainage systems are to be provided with air pipes unless other ventilation is provided.

3. For specific compartments such as small watertight compartments with manholes installed in easy-to-access places on upper decks or similar decks other than tanks, air pipes and sounding pipes may be omitted if it is deemed that there is no impediment to the safety of the unit.

Section 3 Fire-fighting equipment

FOWT firefighting equipment must meet the requirements of the competent government. ⚓

CHAPTER 9 ELECTRICAL INSTALLATIONS and CONTROL SYSTEM

Section 1 General

101. General

1. In the case of items not specified in this Chapter, the requirements specified in Rules for the Classification of the Mobile Offshore Units are to be applied with reference to the fact that the FOWT is operated unmanned.

Section 2 Electrical installations

201. Electrical installations

1. The FOWT is to be equipped with a device for supplying power to the pump and control system. If a small battery is installed instead of an emergency generator, the power supply time of the battery should be greater than the maximum duration of environmental conditions in which the wind power generation is interrupted in the sea area where the FOWT is installed, and an appropriate battery charging device should be provided.
2. If the floating substructure is provided with a ballast system to trim the FOWT, failure of the ballast system or the ballast system shall not affect safety or stability.

Section 3 Control system

201. Control system

1. Where applicable, the FOWT may consist of separate or integrated systems in which motion control of floating substructure and RNA control.
2. In order to ensure that FOWT is operated stably within the design allowable range, the effective-ness of this control system should be evaluated by simulating the operation of the control system by combining with the time domain analysis of Ch 3, Sec 5.
3. The independent operation of the RNA control system according to the wind speed can reduce the kinetic stability of the floating substructure. Therefore, the RNA control system should be able to adjust the pitch angle of the blade and the thrust of the rotor to maintain stability by reflecting the motion of the floating substructure.
4. As a system for actively controlling the motion of floating substructure, a ballast water distribution control system and a position maintaining thruster can be installed. If an active control system is installed on the floating substructure, this system should be designed in conjunction with the RNA control system.
5. If the effect of emergency stop or malfunction due to total or partial failure of the control system including unmanned measurement and monitoring devices causes a new design load case that is different from the design load condition in Ch 3, Sec 4, this design load case. should be verified. ⚓

GUIDELINES FOR FLOATING OFFSHORE WIND TURBINE PLATFORM

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