

# **RULES**

## **FOR THE CLASSIFICATION AND CONSTRUCTION OF FLOATING OFFSHORE OIL-AND-GAS PRODUCT UNITS**

### **PART III**

#### **EQUIPMENT, ARRANGEMENTS AND OUTFIT**

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# **RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF FLOATING OFFSHORE OIL-AND-GAS PRODUCT UNITS**

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Rules for the Classification and Construction of Floating Offshore Oil-and-Gas Product Units (FPU) of Russian Maritime Register of Shipping (RS, the Register) have been approved in accordance with the established approval procedure and come into force on 1 January 2023.

The Rules are published in the following parts:

Part I "Classification";

Part II "Hull";

Part III "Equipment, Arrangements and Outfit";

Part IV "Stability";

Part V "Subdivision";

Part VI "Fire and Explosion Protection";

Part VII "Machinery Installations";

Part VIII "Systems and Piping";

Part IX "Machinery";

Part X "Boilers, Heat Exchangers and Pressure Vessels";

Part XI "Electrical Equipment";

Part XII "Refrigerating Plants";

Part XIII "Materials";

Part XIV "Welding";

Part XV "Automation";

Part XVI "General Requirements and Safety Principles".

The Rules supplement the Rules for the Classification and Construction of Sea-Going Ships and the Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms.

**REVISION HISTORY**

(purely editorial amendments are not included in the Revision History)

For this version, there are no amendments to be included in the Revision History.

## **1 GENERAL**

### **1.1 APPLICATION**

**1.1.1** FPU are covered by the applicable requirements of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships<sup>1</sup> and Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms<sup>2</sup>, unless otherwise specified in this Part of the Rules for the Classification and Construction of Floating Offshore Oil-and-Gas Product Units<sup>3</sup>.

**1.1.2** The requirements of this Part do not apply to the following equipment, arrangements and outfit:

- industrial equipment used for drilling or associated operations;
- equipment for formation of products;
- equipment for treatment of products;
- equipment for processing of products.

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<sup>1</sup> Hereinafter referred to as "the Rules for the Classification".

<sup>2</sup> Hereinafter referred to as "the MODU/FOP Rules".

<sup>3</sup> Hereinafter referred to as "the FPU Rules".

## **1.2 DEFINITIONS AND EXPLANATIONS**

**1.2.1** Definitions and explanations, except listed below, are given in the General Regulations for the Classification and Other Activity, Part I "Classification" and Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification, Part I "Classification" and Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the MODU/FOP Rules, as well as in Part I "Classification" and Part II "Hull" of the FPU Rules.

Long bridle is the bridle that has an anchor-adjacent section, which rests on the seabed within the entire range of design loads.

Short bridle is the bridle that may lift off from the seabed over its entire length under design loads.

### 1.3 SCOPE OF TECHNICAL SUPERVISION

**1.3.1** General provisions on the technical supervision of equipment, arrangements and outfit are set forth in the General Regulations for the Classification and Other Activity and in Part I "Classification" of the Rules for the Classification, Part I "Classification" and Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the MODU/FOP Rules, as well as in Part I "Classification" of the FPU Rules.

**1.3.2** Technical supervision covers the products included into the FPU equipment, arrangements and outfit and stated in the list given in 1.3 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification to the extent which is reasonable for the particular FPU type.

**1.3.3** The items of equipment, arrangements and outfit listed in 1.3 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification shall be monitored by the Register to meet the requirements of Part XIII "Materials" and Part XIV "Welding" of the Rules for the Classification, as well as Part XIII "Materials" and Part XIV "Welding" of the FPU Rules.

**1.3.4** The equipment, arrangements and outfit listed in [Table 1.3.4](#) are subject to the Register technical supervision during the FPU construction/conversion in accordance with the requirements of relevant sections and chapters of the Rules for the Classification, MODU/FOP Rules, as well as the FPU Rules.

Table 1.3.4

Item	FPSO, FPO, FSO	SPM
Rudder and steering gear	(+)	–
Anchor arrangement	+	+
Position-keeping system	+	+
Mooring arrangement	+	+
Towing arrangement	+	+
Fendering equipment	+	+
Boarding arrangement	+	+
Signal masts	+	+
Cargo handling gear	+	+
Openings in hull, superstructures and deckhouses and their closing appliances	+	+
Arrangement and equipment of spaces	+	+
Emergency outfit	+	+
Offloading system	+	+

Note. In brackets – for FPU.

## **1.4 GENERAL REQUIREMENTS**

**1.4.1** Installation of machinery directly on the decks, being the top of cargo and fuel oil tanks, shall be performed in compliance with 1.4.1 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification.

## **1.5 MATERIALS AND WELDING**

**1.5.1** Steel structures shall comply with the requirements of Part II "Hull" and Part XIII "Materials".

**1.5.2** Welding of structural elements of equipment, arrangements and outfit shall be performed in compliance with the requirements of Part II "Hull" and Part XIV "Welding".



## **1.6 DESIGN ACCELERATIONS DUE TO HEAVE AT SEA**

**1.6.1** The dimensionless accelerations due to heave at sea shall be applied when determining the load upon arrangements and equipment on the ship- or pontoon-shaped FPU of the unrestricted service and those restricted area of navigation **R1** given in 1.7 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification.

**1.6.2** With regard to non-ship-shaped FPU of other areas of navigation, accelerations may be applied different from those required herein which shall be substantiated by calculations approved by the Register.

## **2 RUDDER AND STEERING GEAR**

**2.1** The rudder and steering gear and the active means of the FPU steering shall meet the requirements of Section 2 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification.

### **3 ANCHOR ARRANGEMENT**

#### **3.1 GENERAL**

**3.1.1** The anchor arrangement on self-propelled FPU shall meet the requirements of Section 3 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification as applied to transport ships.

**3.1.2** The anchor arrangement on manned FSPM shall meet the requirements of Section 3 of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the MODU/FOP Rules.

**3.1.3** The anchor arrangement on SSPM or unmanned FSPM may be of a temporary nature.

Taking into account the personnel, machinery and power source, the temporary anchor arrangement shall provide:

FPU anchorage during its fitting-out afloat (loading of solid ballast, systems testing);

FPU position-keeping (additionally to the tug service) while holding anchorage in transit under conditions which severity is in excess of the permissible ones;

FPU positioning and position-keeping during installation on the seabed.

**3.1.4** Chain lockers and chain pipes shall be located outside the hazardous area. If such arrangement is impracticable, these structures shall be protected from gas penetration.

### 3.2 TEMPORARY ANCHOR ARRANGEMENT

#### 3.2.1 General requirements.

**3.2.1.1** The anchor arrangement may be fitted not only on the FPU hull, but on the temporary overhang (exposed) platforms, and the individual items of the anchor arrangement (hawse pipes, chocks, connecting shackles, etc.) may be located to be used for other arrangements (towing, mooring, etc.) taking into account the possibility of their further application in the FPU transit to the new operational area or for utilization.

**3.2.1.2** The development and use of temporary anchor arrangement are allowed, provided the following is submitted:

data on the seabed, seismic activity and prevailing hydrometeorological conditions in the specific area;

necessary data and calculations defining the operation conditions of all the anchor arrangement elements;

arrangement plans indicating temporary anchor arrangement location including anchors, anchor lines comprising chains, wire, synthetic fibre ropes or their combination, machinery and any other elements;

design calculation of anchor arrangements during the performance of particular operations.

#### 3.2.2 Calculation principles for temporary anchor arrangement.

**3.2.2.1** The FPU anchor equipment shall be determined by special calculations based on the environmental conditions and corresponding loads during performance of specific operations, having regard for the FPU additional position-keeping and positioning provided by auxiliary tow order vessels.

The anchor equipment may be selected according to 3.1.5 and 3.1.6 of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the MODU/FOP Rules by the equipment number  $N_e$  determined by the formula

$$N_e = K_1 K_2 \Delta^{2/3} + K_3 A, \quad (3.2.2.1)$$

where  $K_1, K_2, K_3$  = coefficients accounting for the hull shape, wave effect and wind conditions at the anchorage, respectively;

$\Delta$  = displacement volume of FPU during operation, in m<sup>3</sup>;

$A$  = total windage projected area of the structures above the waterline on the plane normal to the horizontal projection of an anchor line, in m<sup>2</sup>.

The coefficient  $K_1$  is recommended to obtain from the ratio  $R/R'$ , where  $R'$  and  $R$  are resistances of the submerged part of a conventional ship and FPU with the same displacements and towing speed, respectively.

The coefficients  $K_2$  and  $K_3$  shall be taken in compliance with Table 3.2.2 of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the MODU/FOP Rules.

The Register may accept other values of coefficients, provided it is proved that the proposed values are in agreement with the actual construction, service and repair conditions.

**3.2.2.2** The anchor arrangement elements shall be designed taking into account 4.3.3 of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the MODU/FOP Rules.

**3.2.2.3** Safety factors for each particular element of the anchor arrangement are recommended to obtain similarly to anchor arrangements in accordance with 3.1.5 and 3.3.4 of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the MODU/FOP Rules.

The rated forces for the particular elements of the anchor arrangement are determined based on the breaking load value for anchor lines meeting the requirements of 3.6 of Part III "Equipment, Arrangements and Outfit" and 6.3 of Part IX "Machinery" of the Rules for the Classification.

**3.2.3 Temporary anchor arrangement structure.**

**3.2.3.1** FPU is recommended to be provided with at least two anchors.

Temporary anchor arrangement shall generally include:

bower anchors;

anchor lines;

devices for securing and releasing the inboard end of the chain cable (senhouse slips, etc.);

machinery for dropping and hoisting bower anchors and the FPU positioning with the dropped anchors (where the anchor arrangement is used for the FPU positioning);

stoppers ensuring the FPU riding at anchors;

chain lockers or platforms for storage of anchor ropes and chain cables, and other special equipment necessary for a specific marine operation.

The number of separate anchor arrangement elements is determined by calculations.

**3.2.3.2** The following types of anchors may be used as bower anchors: Hall's or Gruson's and admiralty stocked anchors.

**3.2.3.3** Chains of various strength grades are recommended to be used as anchor lines.

If justified with due regard to the short-term nature of operations, the chains may be replaced with wire and synthetic fibre ropes of adequate strength.

**3.2.3.4** The anchor lines characteristics shall be determined on the basis of special calculations on the assumption that they will ensure the required holding power and anchor loading under specific conditions at the design environmental effects. Anchor lines and their complete set shall meet the requirements of Section 7 of Part XIII "Materials" of the Rules for the Classification. Where combination anchor lines are used, which include chain and rope inserts, the complete set shall ensure the continuous rope tension (due to the weight of chain sections) to preclude formation of sheepshank knots on the rope inserts.

**3.2.3.5** Each bower-anchor chain cable and rope shall be provided with a stopper intended for the FPU riding at anchor. Where the length of the anchor lines is fixed and there is no need for position mooring the stopper may be replaced with the device for securing and releasing the inboard end of the chain cable.

The stoppers shall be supplemented with the devices for securing and releasing the inboard ends of the anchor chain cables and ropes where the FPU position mooring is necessary for its installation.

**3.2.3.6** Laying of anchor lines shall provide for their free run when dropping or hoisting the anchors in compliance with the requirements of 3.6.3 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification.

Chain lockers shall meet the requirements of 3.6.4 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification.

The platforms for stowing chain cables or ropes shall be dimensioned and located so that they ensure the free stowage of the specified length of anchor chain cables using the FPU cargo handling gear, the free lead of chain cables through the chain pipes and their free veering away when dropping the anchors.

**3.2.3.7** If fitted with the proper equipment, the carriage, dropping and hoisting the anchors and anchor chain cables or ropes may be provided by the auxiliary tow order vessels.

**3.2.3.8** Anchor machinery shall be fitted for dropping and hoisting the bower anchors, and also for position mooring during the FPU installation. If there is no need for the FPU position mooring, as well as where the carriage, dropping and hoisting of anchors are provided by the auxiliary tow order vessels, FPU may be not equipped with anchor machinery.

The power of anchor machinery shall be determined based on the actual mass and overall characteristics of anchor equipment, the requirements for the FPU positioning, the conditions during operations performance etc.

Where FPU is provided with the anchor machinery, or the winches available on FPU are used for anchor and chain cable handling operations, these machinery shall meet the requirements of the Rules for the Classification and MODU/FOP Rules. Where the auxiliary tow order vessels machinery is used for anchor handling operations, it shall be verified for compliance with the MODU/FOP Rules considering the characteristics of the FPU anchor arrangement. Anchor machinery shall be designed to meet the requirements of 6.3 of Part IX "Machinery" of the Rules for the Classification.

**3.2.3.9** A spare set of anchor equipment (anchor, anchor line and joining devices) is recommended to be provided on board FPU for the prolonged (more than a week) tows at sea.

## **4 POSITION-KEEPING SYSTEMS**

### **4.1 GENERAL**

**4.1.1** The requirements of this Section apply to the systems intended for position-keeping of FPU at a certain location with restriction of shiftings within the prescribed limits and ensuring normal conditions to perform technological processes at a site.

**4.1.2** The requirements cover the following:

- .1** anchoring systems which include anchors and flexible anchor lines;
- .2** anchoring systems which include anchors and tension anchor lines;
- .3** dynamic positioning systems;
- .4** thruster assisted position mooring systems.

**4.1.3** The position-keeping system including winches and chain stoppers shall be located on the open deck within non-hazardous areas, unless special measures are provided to avoid risk of ignition during normal operations and accidental disconnection.

## **4.2 POSITION MOORING SYSTEM**

**4.2.1** The FPU position mooring system shall provide their position-keeping:  
under operation conditions at the design external loads and with a tied up transport ship (TS) (including condition with one anchor line broken at reduced safety factors meeting the requirements of 4.3.10 and 4.3.11 of Part III "Equipment, Arrangements and Outfit" of the MODU/FOP Rules);

under extreme conditions without a tied up transport ship and at the stormy weather potential once in 100 years (including condition with one anchor line broken at reduced safety factors).

**4.2.2** Position mooring system shall ensure the limitation of the FPU horizontal movements at design conditions.

**4.2.3** The laying out of anchor lines for the FPU position-keeping shall not result in the limitations on the TS maneuvering and draught.

**4.2.4** Position mooring system are divided by the way of position-keeping into two types:  
type I: positioned with the anchor lines which ensure position-keeping above the specified seabed location being exposed to horizontal loads;

type II: positioned with the tension anchor lines which ensure both the position-keeping above the specified seabed location and the minimum changes of the distance from the structure bottom to the seabed being exposed to horizontal and vertical loads at the maximum depression (lowering) of sea level (due to waves, ebb-tide, natural level depression).

**4.2.5** Multi-anchor (distributed) and single-anchor type I systems are recommended for position-keeping of the FPU in question.

**4.2.6** Position mooring system shall be designed in compliance with Section 4 of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the MODU/FOP Rules.

**4.2.7** Position mooring system parameters are recommended to be determined using the step-by-step approach as follows:

determine the laying out, mass and number of anchors (anchor lines), the length, diameter and strength grade of bridles with the use of analogues taking into account the level of external loads due to natural factors and the distribution of sea depths at the position mooring system location;

determine the mass of anchors and the forces of anchor lines pretension;

calculate the maximum forces in bridles exposed to external loads due to the natural factors potential once in 100 years;

determine safety factors and compare them with the standard ones;

make the corrections of position mooring system parameters according to the comparison results and repeat the calculation if needed;

calculations shall be continued until the satisfactory precision of values of acting and permissible forces is reached.

**4.2.8** When performing calculations for position mooring system, the software having Type Approval Certificate issued by the Register shall be used.

**4.2.9** The documentation meeting the requirements of 4.2.2 and 4.2.3 of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the MODU/FOP Rules shall be submitted to the Register.

**4.2.10** System design shall meet the requirements of 4.3 of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the MODU/FOP Rules.

**4.2.11** System equipment (winches, tensioning devices, fairleads and guiding devices) and system control stations shall meet the requirements of 4.4 and 4.8 of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the MODU/FOP Rules, respectively.



### **4.3 ANCHORS**

**4.3.1** Depending on the seabed, pile, plate, suction, gravity, shot-driven and explosive-driven anchors, as well as ship anchors may be used for the FPU position-keeping.

**4.3.1.1** Pile anchors are capable to withstand vertical and horizontal loads and are installed (embedded) using hammers, drilling and washout with a water jet under pressure.

**4.3.1.2** Plate anchors are manufactured by welding of plate components, and they have high holding power in clay and silt seabed.

**4.3.1.3** Suction anchors are caissons used in soft and medium hard soils, and are embedded by pumping out water from the caisson.

**4.3.1.4** Gravity anchors are reinforced concrete/steel and concrete structures which holding power is equal to its weight in water along all directions.

**4.3.1.5** Explosive-driven anchors are used in shallow water, and embedded into the seabed by a shot or a series of explosions and turned around by the anchor line tension towards the position corresponding to the maximum resistance to loading.

**4.3.1.6** Ship anchors embedded during dragging are used for the grounds other than the hard ones.

**4.3.2** Anchors are subdivided subject to the following:

direction of operation (all-around and directional);

operating principle (gravity, pile and circular);

material (steel and reinforced concrete);

design (solid, combined, pontoons, frames and composite).

Gravity anchors are subdivided subject to the following:

shape of cross-section (pyramid-shaped, segment, mushroom-shaped, plate-type and a "frog" with one or two knives);

mass: small (< 50 t), medium (> 50 t, but < 100 t), large (> 100 t, but < 300 t) and very large (> 300 t, but < 900 t).

**4.3.3** Characteristics of anchors shall be selected subject to the load applied, soil properties, safety factors for shear (1,05 – 1,3) and capsizing (1,1 – 1,4). In this case, anchor displacements while in operation shall be prevented and the requirements for the accuracy of anchor installation (normally 5 % of the sea depth unless the additional requirements for the installation accuracy are specified) shall be considered.

When selecting the anchor type, the characteristics of the facilities, which may be used during the anchor transportation and installation, shall also be considered.

**4.3.4** The anchor mass shall be defined by the holding power value with due regard to a safety factor, which is assumed according to normative documents, and depends on the anchor type and shape, soil characteristics and effective loads.

**4.3.5** Anchor holding power shall ensure its resistance to displacements and rotations exposed to external forces due to its design and the scheme of transmitting bridle-to-anchor forces.

**4.3.6** The load transmitted to an anchor is defined by the value of a rated force on the bridle at the seabed level and the angle of its approach to the seabed surface which shall be determined by calculating the FPU position-keeping system.

#### **4.4 BRIDLES**

**4.4.1** Bridles intended for transmitting load to an anchor may consist of a chain cable, a wire rope, synthetic ropes or combinations thereof. Chain bridles, sometimes with the wire rope inserts, are generally used for position-keeping of large FPU.

**4.4.2** For chain bridles the chain cables of categories 1, 2, 3, as well as R3, R3S, R4, R4S and R5 according to Section 7 of Part XIII "Materials" of the Rules for the Classification may be used.

**4.4.3** Bridle diameter is determined considering the maximum design load on FPU.

**4.4.4** Long and short bridles may be used in the position mooring system.

**4.4.5** For gravity reinforced concrete anchors, angle between the bridle and the horizontal plane at the point of its securing to the anchor  $\alpha \leq 15 - 20^\circ$ . In this case, the vertical component of the force transmitted to the anchor and the corresponding reduction of its holding power shall be considered.

**4.4.6** Suspended weight may be used for reducing the angle  $\alpha$  and for increasing the damping properties of the bridle.

**4.4.7** The bridle rigidity is defined as the ratio of the horizontal force increment to the initiated displacement of its top end. The rigidity depends on the location depth, bridle length, initial tension of the bridle and its linear weight.

## 4.5 DESIGN LOADS

**4.5.1** Design external loads for the position mooring system design shall be determined in accordance with Section 3 of Part II "Hull".

**4.5.2** The FPU response to external effects may be conventionally divided into four frequency ranges:

quasi-static or a zero frequency range determined by the sea level, averaged wind and current;

slowly varying (low-frequency) range induced by gust wind and second order wave loads (drift loads), and by current;

medium-frequency range determined by first order wave loads and diffraction;

high-frequency range (including heave, pitch and roll resonances) associated with higher order wave effects and resulted in the longitudinal and transverse vibrations of lines.

The first two may be conventionally considered as the static ones, while the rest two as the dynamic ones. When using the static approach, it is assumed that the line tension depends on the co-ordinates of the line ends only, while the dynamic one additionally considers the speed and accelerations thereof.

**4.5.3** The following parameters are critical for FPU:

maximum and minimum tensions of lines;

the FPU horizontal, vertical and angular displacements and its accelerations due to wind, current and wave;

displacements of the FPU movable joint of the main pipeline;

parameters affecting fatigue strength of the lines (moments of zero-, second- and fourth-order displacement spectra).

**4.5.4** For prolonged holding of the bend and rotation angle of the bottom flexible assembly of the rigid pipe within  $1 - 2^\circ$ , it is recommended to ensure at first approximation the horizontal mean displacement (statics + drift) equal to 2 — 4 % of the sea depth under the FPU bottom (the lesser figure refers to depths of 600 — 1000 m, the greater one, to depths under 100 m; the values for depths of 100 — 600 m are obtained by linear interpolation).

It is recommended to ensure at first approximation the maximum horizontal displacement (dynamics) under the bottom equal to 8 — 12 % of the sea depth with the same depth ratios in order to be within the limits for the angles of deformations of pipe slip joints due to surging, swaying and heaving motions, and also in order to ensure the angular oscillation amplitudes for flexible ground joint within  $4,5 - 6^\circ$ .

Where a flexible pipe is available, the permissible horizontal displacements are as follows (per cent of the depth under the bottom with the same depth ratios):

mean: 3 — 5 and 5 — 10;

maximum: 10 — 15 and 15 — 30.

**4.5.5** In addition to the factors and external loads specified in Part II "Hull", the temperature of water and air, fouling, as well as all types of the FPU motions, and FSPM-FPU motions (heave, roll, pitch, sway, surge, yaw) shall be considered.

**4.5.6** Various loading conditions of FPU (different amount of product and liquid ballast) shall be additionally considered for FSPM-FPU, and limiting mooring and offloading conditions, i.e. TS position-keeping conditions shall be calculated.

**4.5.7** Considering the position mooring system particular response to resonance oscillations on the environmental effect frequencies, special attention shall be paid to the evaluation of the resonance oscillations in determining design loads, in particular:

sway and yaw motions of the moored TS;

surge motions of TS;

pitch motions of the hull, and FSPM-FPU which may cause the formation of "snakes" in slack chains;

heave motions of FSPM with the moored TS (or without it) which causes the change of the anchor line tension;

yaw of FSPM with the moored TS (or without it) including instantaneous loads on a tension anchor line.

In addition, the secondary factors which may initiate the resonance shall be considered:

head sea impact in calculating wave loads within a coastal strip in an splash zone (FSPM is fully in the splash zone);

change of the water particle velocities direction at the joint action of current and waves;

dynamic effects due to the vortex shedding at high current velocities.

**4.5.8** Due to the complicated development of theoretical methods for such calculations, it is recommended to determine the motions and loading by model tests together with design methods. In doing so, the following shall be considered:

reduced effect of field dampening compared to the model test;

effect of fouling on wave resistance and inertia forces;

effect of resonance on anchor lines sagging.

**4.5.9** Position mooring system shall be designed so that the sudden failure of any anchor line will not cause progressive failure of the remaining anchor lines and position-keeping system as a whole.

**4.5.10** The position mooring system elements shall be designed with due regard to the corresponding safety factors using the procedures which allow to identify extreme loading conditions for each element.

Safety factors shall be obtained in compliance with the modes and conditions specified in 1.2.2 and 1.2.3 of Part IV "Stability" of the MODU/FOP Rules.

Safety factors given in Tables 4.3.10 and 4.3.11 of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the MODU/FOP Rules, which may be reduced considering the operational conditions, FPU purpose and anchor line type, may be used as a first approximation.

Safety factors for bridles shall be taken in reference to the rated static breaking strength. Safety factors for anchors shall be taken in reference to their holding power.

**4.5.11** The maximum tension  $T_{max}$  at the safety factor  $SF$  value shall be determined by the formula

$$SF = PB/T_{max} \quad (4.5.11-1)$$

where  $PB$  = minimum rated breaking strength of the anchor line.

The FPU maximum movements shall meet the condition

$$x_{ult}/x \geq k \quad (4.5.11-2)$$

where  $x_{ult}$  = ultimate values of the FPU movements established by the requirements for design and by the equipment operating manuals;

$x$  = maximum rated movements for the rated operating mode under consideration;

$k$  = safety factor the value of which may be taken equal to 1,15 when the quasi-static method is used, and equal to 1,05 when the dynamic method is used.

**4.5.12** The fatigue endurance level of anchor lines, determined by the calculation, shall not be less than thrice the rated service life of the position mooring system.

**4.5.13** The total forces due to wind, current and wave shall be calculated at various angles between them and taking into account the dynamic effect of waves. The angular displacements of the hull and the horizontal displacements of FPU and TS in motions, as well as the deviations of the horizontal force acting on the bridle shall be calculated according to the procedure and the program recognized and certified by the Register, respectively.

**4.5.14** In addition to the above loads, the initial tension of anchor lines shall be considered.

**4.5.15** The diameter of an anchor chain cable, which safety factor is assumed at least 1,5, shall be selected taking into account the effect of the maximum total loads due to initial tension, wind, wave and current on the bridle.

**4.5.16** Strength for the position mooring system securing elements (chain locker pipes and chain stoppers) on FPU shall exceed the strength of the weakest link of an anchor line by 30 %.

**4.5.17** The calculation of the unit high-frequency oscillations shall take into account the position mooring system rigidity at depths below 70 m and the dynamic calculation of the position mooring system behaviour shall be carried out at depths exceeding 450 m. In particular cases, such a calculation may be required for the lesser water depths as well.

The position mooring system rigidity characteristic shall be determined according to the procedure approved by the Register, and computer program shall be approved by the Register.

#### **4.6 DYNAMIC POSITIONING SYSTEM**

**4.6.1** The dynamic positioning system shall meet the requirements of 4.9 of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the MODU/FOP Rules.

#### **4.7 MOORING SWIVEL**

**4.7.1** The mooring swivel shall provide the FPU free rotation about the vertical axis and monitor the movement of the tied up TS.

**4.7.2** The mooring swivel structure shall withstand the following loads:  
mooring line;  
its own weight;  
dynamic loads due to the FPU motions, wind and current.

**4.7.3** The bearings of the mooring swivel/turret shall have sufficient rigidity to prevent impermissible displacements.

**4.7.4** When designing bearings the following factors shall be taken into consideration:  
plastic deformation of rolling components and raceways (bearing capacity);  
fatigue in critical local sections of the outer and inner races;  
bolts fatigue;  
carrying capacity of the bearings on the whole, determined by the bearing capacity of the bolts and cross sections of the races, taking into account the rigidity of structures supporting the races (fixed and rotating).

**4.7.5** Carrying capacity of the bearing shall be determined taking into account the balance of forces acting on the rolling elements and the following loads on the race components:

forces caused by securing bolts including possible shear forces;  
possible pressure at connection point of the component in question with the structure supporting the race;  
forces in the cross section of the race (i.e. on end surfaces of the component in question).

**4.7.6** The safety factor for the bearing races shall be not less than:  
1,7 by the maximum bearing capacity of the race and bolts;  
1,5 by the fatigue strength (90 % probability) at the load factor of 0,7.

**4.7.7** The bolt tightness force shall be 65 — 80 % of their yield strength.

**4.7.8** For bolts subject to strong tension account shall be taken of cracking due to stress-actuated corrosion.

**4.7.9** Pressure bolts shall be as far as possible equally spaced over a circle.

#### 4.8 TURRET

**4.8.1** The turret shall provide the FPU free rotation about the vertical axis, securing of a number of anchor lines and reliable connection of the fixed and moving parts of cargo pipeline (refer to 4.7.1).

**4.8.2** In addition to the loads mentioned in 4.7.5, account shall be taken of the forces caused by the most adverse operating conditions of the anchor lines. Particular emphasis shall be placed on design tolerances and stresses during transfer of critical load.

The support of leading blocks shall be designed for a load equal to minimum strength in case of anchor line being broken. The nominal equivalent stress in the support structure shall not exceed 0,8 the yield strength of the material.

Strength calculations and finite element analysis (FEA) made for unfavourable load acting on the anchor lines shall be submitted.

**4.8.3** The turret essential machinery shall be considered as main one. Components and systems shall be chosen with a margin so that failure of a single component cannot result in loss of operability of the turret.

The turret machinery in case of the blackout accident shall be supplied from the emergency source of power within 18 h.

Emergency shutdown system shall be activated automatically when a fire is detected and the maximum permissible concentration of hydrocarbon gas is up to 50 % of the permissible level in way of the turret.

**4.8.4** To monitor and control the machinery of the turret or float-free buoy for STL, it is necessary to submit documentation given in Table 4.8.4.

Table 4.8.4

Name	Turret machinery	STL machinery
Description of functions	+	+
Block diagrams of system (T)	–	+
System diagram	–	+
Location of power supply source (T)	+	+
Arrangement plan (T)	+	+
List of devices and equipment (T)	+	+
Tables of data on the environment	+	+
Test program for software used by manufacturer (T)	+	+
Operating Manual <sup>1</sup>	–	+
Schematic diagrams of input and output circuits	–	+

<sup>1</sup> A copy shall be submitted for information only.  
Notes. T – is also required for typical approved diagrams.



## **5 MOORING ARRANGEMENT**

### **5.1 GENERAL**

**5.1.1** The mooring arrangement on self-propelled FPU shall meet the requirements of Section 4 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification.

**5.1.2** TS mooring shall be as follows:

stern mooring with flexible mooring lines;

side mooring with flexible mooring lines.

**5.1.3** Each FPU shall be provided with the mooring arrangement which ensures TS warping and its maintaining at a certain distance.

**5.1.4** In determining the mooring arrangement characteristics it is recommended to consider the following conditions:

complex solution of the problems associated with mooring and cargo handling operations (approach, TS position-keeping near FPU, limits for movements during cargo handling operations);

monitoring of mooring and cargo handling operations taking into account the dynamic effects of external forces;

simplicity, workability and repairability of the structure, availability of a "weak link";

dimensions and position of the mooring arrangement shall provide transmission of the loads carried to the FPU hull structure;

relative position of the mooring arrangement components shall contribute to the safer system "FPU-TS", including the attending personnel injury risk reduction.

**5.1.5** The type and location of the mooring arrangement, the loads applied shall be determined, considering the TS characteristics, environmental loads, operational restrictions, structural features of FPU and vessels involved.

**5.1.6** The mooring arrangement shall ensure position-keeping of a tied up ship exposed to the following:

wind;

current;

tides;

waves;

ice;

draught changes;

negative and positive water setup.

**5.1.7** The forces caused by draught changes, tidal oscillations, and during cargo handling operations shall be balanced by the proper handling of mooring lines, in particular, by the installation of appropriate winches.

**5.1.8** The wave and ice effect is recommended to assume according to the results of model tests, in-situ measurements or computer-based calculations.

## **5.2 INITIAL CALCULATION BACKGROUND**

**5.2.1** The strength calculations of the mooring arrangement and its supporting hull structures shall be performed according to the procedure agreed with the Register.

## **6 TOWING ARRANGEMENT**

**6.1** The towing arrangement on self-propelled FPU shall meet the requirements of Section 5 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification.

**6.2** FPU shall be provided with the emergency towing arrangement in compliance with 5.7 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification.

## **7 FENDERING EQUIPMENT**

**7.1** The fendering equipment shall withstand glancing blow of TS in the fully loaded condition or in ballast and ensure the absence of sparking on impact.

**7.2** The dimensions and arrangement of the fendering equipment shall be selected so that to ensure protection against the TS of various types considering the rise of tide.

**7.3** Where auxiliary vessels are supposed to mooring at FPU, provision shall be made for fenders to protect the FPU hull against damages.

**7.4** The characteristics, design and arrangement of the fendering equipment and fenders shall meet the requirements of 4.1.3.2 of Part XV "MODU and FOP Safety Assessment" of the MODU/FOP Rules.

**7.5** It is recommended to use the structures of high power-capacity rubber shock-absorbers of various types, e.g. axially-compressed cylindrical or specially sectioned (V-shaped, M-shaped).

**7.6** The attachment points of the fendering equipment shall include safety device ("weak link") to prevent damage to this equipment due to accidental overloading.

**7.7** The fendering equipment strength shall be determined in compliance with the provisions of [5.2](#).

**7.8** The fendering equipment parameters shall be taken considering the following:  
power-capacity, reaction force and deformation of the fendering equipment taking into account the impact energy determined according to 3.17.1 of Part II "Hull";

necessity of individual design for specific conditions;

use of slowly-restorable structures which have high power-capacity at a small reaction force and low pressure on the side of the ship being moored, as well as a capability of dissipating the ship impact energy with transmitting the loads to the unit hull structures;

low friction coefficient and stability to shear loads;

simplicity, workability and repairability;

installation of a system to monitor the ship mooring and the means to prevent damage to the ship hull due to accidental overloading.

## **8 BOARDING ARRANGEMENT**

**8.1** Each FPU shall be provided with a boarding arrangement ensuring access to FPU and its abandonment at any time with due regard to the relevant restrictions (wave height, wind velocity, etc.).

**8.2** For FPU methods and equipment shall be additionally developed for emergency evacuation in accident situations.

**8.3** Two ways of carrying/evacuating the personnel shall be considered: by ships and helicopters.

**8.4** A cargo crane provided with a man-riding cage is recommended as a general means for access to FPU elevated above the water surface, and a vertical ladder for access to low FSPM.

**8.5** The transfer of people shall be assured at least under the following conditions:  
wind velocity: 8 to 12,5 m/s;  
wave height with 3 % probability  $h_{3\%}$ : 0,75 to 1,25 (force 3);  
current speed: up to 1 knot.

**8.6** The boarding arrangement shall be located on both FPU sides.

**8.7** The boarding arrangement shall provide the safe approach of ships with displacement below 2500 t at a speed of up to 1 knot, and withstand the appropriate loads produced by ships swinging foul without damage to their separate elements and the whole structure.

**8.8** The action of ice on the boarding arrangement being inoperable shall be precluded.

## **9 SIGNAL MASTS**

**9.1** Signal masts intended for carrying signal means and aerials shall be designed to meet the requirements of Section 6 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification.

## **10 CARGO HANDLING GEAR**

**10.1** Cargo handling gear of FPU shall comply with the Rules for the Cargo Handling Gear of Sea-Going Ships.

## **11 OPENINGS IN HULL, SUPERSTRUCTURES, DECKHOUSES AND THEIR CLOSING APPLIANCES**

**11.1** The requirements apply to the arrangement and closing appliances of openings located above the FPU margin line. The margin line means the line of the intersection of the upper surface of the bulkhead deck (or its continuation) with the outer surface of side shell plating at side.

**11.2** Openings in hull, superstructures and deckhouses of FPU, to which a minimum freeboard has been assigned, and their closing appliances shall meet the Register requirements specified for ships of unrestricted service given in Section 7 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and in Section 8 of Part III "Equipment, Arrangements and Outfit" of the MODU/FOP Rules to the extent that is reasonable and practicable for FPU in question.

**11.3** The coaming height of openings for doors, companion hatches, skylights, ventilation trunks and ventilators, as well as closing appliances of these openings shall be determined with regard to the requirements for the FPU intact and damage stability.

Covers of companion hatches shall be watertight and fitted with quick acting devices for securing and opening, and also with position indicators.

**11.4** Tight manholes having clear dimensions of at least 500 × 600 mm shall be fitted for access to tanks and cofferdams.

**11.5** Side scuttles in mooring and cargo control room shall have electric heating and screen wipers. In addition, the control station shall be provided with a washing system for glasses and with light filters.

**11.6** Openings in the FPU watertight subdivision bulkheads and their closing appliances shall meet the requirements of 7.12 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification.

Doors in those bulkheads shall be remotely operated from the central control station on the deck, which is above the damage waterline after flooding.

Water-and-gastight doors made of steel shall be fitted in superstructures, the doors meeting the requirements of 2.1.3.1 of Part VI "Fire Protection" of the Rules for the Classification shall be fitted in inner spaces.

The detachable panels of doors used as an emergency exit shall be dimensioned at least 400 × 500 mm.



## **12 ARRANGEMENT AND EQUIPMENT OF SPACES**

**12.1** The arrangement and equipment of spaces shall meet the requirements of Section 8 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification for cargo ships.

**12.2** Stairways shall be at least 600 mm wide (between stringers), their angle of inclination shall not exceed 55° (60° in cargo tanks), and in extraordinary cases, it may be equal to 65°. The width of vertical ladders shall not be less than 300 mm and of spar ladders, not less than 250 mm.

**12.3** The means of access to cargo tanks shall meet the requirements of 7.14.2 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification.

**12.4** Guard rails of open decks and working stations shall be four-rowed and of 1100 mm high, and in inner spaces, three-rowed and of 1000 mm high.

**12.5** Deck machinery and devices shall be provided with covers.

**12.6** Spare parts and appliances shall be taken according to the supplier's recommendations given in specifications for the supply of machinery, apparatus and other equipment, and for arrangements and systems, according to the requirements of the Register and other regulatory documents.

Spare parts and appliances shall be kept in lockers, cabinets, boxes and on shelves, and ashore as well.

**12.7** Requirements for the mooring and cargo control room, and for the main machinery control room are specified in Part VII "Machinery Installations" and Part XV "Automation".

### **13 EMERGENCY OUTFIT**

**13.1** Necessity and completion of the FPU emergency outfit shall be determined by the shipowner independently with regard to the FPU area of operation, particulars and the requirements of the national standards.

**13.2** Emergency outfit and fire fighting equipment shall be stored in specially equipped spaces with free access.

Russian Maritime Register of Shipping

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Part III  
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FAI "Russian Maritime Register of Shipping"  
8, Dvortsovaya Naberezhnaya,  
191186, St. Petersburg,  
Russian Federation  
[www.rs-class.org/en/](http://www.rs-class.org/en/)