The inert gas and ballast systems should allow for the blanketing of a ballast tank in the case of cargo leakage.

Alternatively, as a means of reducing volatile organic compound (VOC) emissions on FPSOs, hydrocarbon gas blanketing may be considered in lieu of inert gas for controlling tank pressure and oxygen ingress and maintaining a non-explosive atmosphere in cargo tanks during normal operation.

17.2.6.2 Piping system

The piping system shall be designed to serve the following functions:

— transport of inert gas flow from the inert gas generating system via a central inert gas main and branch lines to each individual cargo tank;

— prevention of back flow from the inert gas main to the inert gas generating system by a deck seal arrangement or other suitable means of isolation;

— connection to a pressure/vacuum breaker to maintain the required design pressure in the tanks during normal operation;

— in some configurations, connection to the high and low pressure/vacuum breaker valves in a central stack to prevent the building of rapid overpressure;

— transport of purge gas from the inert gas generator via a main line and branch lines to a selected tank;

— connection to a ventilation stack with flame arrestor to release excess purge gas.

17.2.7 Crude oil washing system

COW systems should follow IMO requirements (see A.17.2.7).

An inert gas system shall be employed if a COW system is utilized.

17.2.8 Production vent/flare systems

Various vent system designs should be considered early in the floating structure's design stage. Since these systems can have significant effects on weight, wind actions and centre of gravity, it is important to establish realistic relief rates and the system's sizing criteria in the initial design phase.

Flaring from a floating structure, particularly one that provides oil storage, requires the following special considerations:

— The flare structures, vent stacks and booms should be designed for dynamic loading.

— Flaring can provide an ignition source in close proximity to a large volume of crude oil and/or hydrocarbon vapour.

— Export tanker loading operations can result in venting of hydrocarbon vapours relatively close to the flare.

— For weathervaning structures, the orientation of the floating structure is dependent on the combined wind and current actions, whereas only the wind affects dispersion of gas from a vent. Gas dispersion from a vent should be analyzed for a range of possible floating structure orientations.

Safety concerns resulting from flaring near stored crude or export tanker are amplified by the limited egress opportunities for personnel. When the flare tower is also used to support the inert gas venting system for hull tanks, careful selection should be made of the venting point with respect to the possible flare ignition source.

17.2.9 Electrical systems

Electrical systems for marine systems of a floating production structure should conform to RCS rules and national/international standards.

17.3 Import and export systems

17.3.1 General

In general, a floating structure imports produced fluids from subsea wells, surface wells, and/or other nearby structures, and exports produced fluids into a fixed or mobile transportation medium, such as a pipeline or tanker. In addition, solid and liquid materials, parts and supplies can be transported to/from the structure.

The type, size, scope, and limitations of a system designed to export produced hydrocarbons from a floating production structure generally depends upon the following basic considerations or parameters:

— floating structure size, type, production and discharge rate;

— type of export and transportation system;

— water depth and site-specific metocean and ice conditions;

— hydrocarbon characteristics and operating pressure;

— scope and arrangement of other field facilities;

— space available and manoeuvring room at site;

— applicable regulations, codes and standards.

Operating philosophy generally drives the selection of the type of export system.

17.3.2 Riser functions

Risers are fluid conduits between sea floor equipment and surface facilities. Riser system integrity includes both fluid and pressure containment as well as structural and global stability.

Risers usually perform one or more of the following specific functions:

— conveyance of fluids between the wells and the surface structure (i.e. production, injection or circulated fluids);

— import, export or circulation of fluids between the surface structure and remote equipment or pipeline systems;

— guidance of drilling or workover tools and tubulars to and into the wells;

— support of auxiliary lines and umbilicals;

— other specialized functions such as well bore annulus access for monitoring of fluids injection.

Risers on floating structures cover the full range of production, injection, drilling, completion, workover and exporting operations. Floating structures riser systems have additional requirements associated with operating multiple risers of potentially different types in close proximity.

Design of the riser system itself is outside the scope of this document. See A.17.3.2 for a list of references to standards and guidelines for riser system design.

Risers for importing produced fluids and/or exporting to pipelines are usually connected to some point on the hull structure or turret (typical of ship-shaped structures), or to the deck (typical of semi-submersibles and spars). Risers impose actions on the hull structure and can require local structures with receptacles for moment-reducing and/or tensioning devices. Local structures should be designed for the maximum static and dynamic actions and action combinations as specified by the riser system designer (see 9.8.6).

17.3.3 Export systems

17.3.3.1 General

Floating structure export systems generally comprise one, or a combination, of

— pipeline export system, and/or

— tanker transfer export system.

If no storage is provided on the floating structure, the export system generally consists of one or more cargo pumps and a metering system. In the case of storage, the tanks are often manifolded to a central pump room or, alternatively, individual pumps are provided within each tank (see 17.2.5). Consideration should be given to pump and metering locations and provision of an adequate structural foundation to support such equipment.

17.3.3.2 Pipeline export

Pipeline export systems can consist of a pipeline either to a remote facility or to a nearby offloading point. In the latter case, hydrocarbons are offloaded under low pressure from the floating structure to an export tanker through a separate mooring and offloading system (normally a single point mooring) connected to the floating structure via risers and subsea pipelines. The offloading system shall be located at a suitable azimuth and at a sufficient distance away from the floating structure to allow for safe approach, departure and weathervaning of the export tanker when moored. A risk assessment shall be conducted to consider suitable mitigation measures to avoid collision between the export tanker and floating structure.

A separate offloading mooring system is used where separation between the floating structure and the export tanker is important for safety reasons or in areas where space is too limited to allow safe tandem transfer.

Unless the fluids are first transmitted to nearby booster pumping stations or compression and treatment structures, the floating structure should have high pressure gas compression, gas and water treatment and high-pressure pumping facilities, to condition the produced fluids for export.

For a turret-moored, weathervaning floating structure, a high-pressure swivel (sealed, rotatable joint or coupling) or wrap-around hose system should be specified. If the swivel or wrap-around hose is already planned for the incoming production stream, it can be equipped with multiple paths to also accommodate the outgoing export risers.

17.3.3.3 Tanker export

17.3.3.3.1 General

Hydrocarbons can be transferred from the floating structure directly into trading tankers of opportunity or into dedicated shuttle tankers and barges, for export or shuttling to onshore or offshore terminals. Transfer can also be effected through a transfer line from the floating structure to an unmanned buoy for subsequent transfer to the terminal by tanker.

Floating structure-to-tanker transfer can be accomplished using any one, or a combination, of the following transfer schemes:

— alongside transfer (side-by-side) (see 17.3.3.3.3);

— tandem transfer (see 17.3.3.3.4);

— direct transfer (see 17.3.3.3.5).

These transfer schemes can use a flexible offloading hose arrangement, an above-water hose boom, or a hard pipe swivel joint boom to transfer fluids to the offloading tanker. The flexible offloading hose can be left floating in the water or stored on a reel or any similar arrangement when not in use. The method of hose storage depends on the metocean conditions at a given location.

A dripless valve should be included as part of the system such that if quick disconnect is required no resulting pollution should occur.

Automatic valves should be set-up to close at a speed that minimizes the dynamic shock to the system. Also, it is important that good procedures and communications are developed between the offloading structure and the tanker to prevent inadvertent closing of valves.

17.3.3.3.2 Tanker stationkeeping systems

Key aspects of hydrocarbon offloading systems are the stationkeeping system to be used by the export tankers, and the offloading system to export the hydrocarbons from the floating structure to the tanker. Several options exist, to suit the various combinations of metocean and ice conditions and operating limitations (see A.17.3.3.3.2).

17.3.3.3.3 Alongside transfer

An alongside (side-by-side) transfer system consists of mooring equipment to secure the tanker alongside, fendering to prevent contact between the two hulls and a fluid transfer system using hoses or mechanical loading arms. Consideration shall be given to location of this equipment and associated local actions imposed on the hull. Limiting conditions for safe operation shall be specified in the MOM.

Excessive wave induced motions are a major cause of downtime for alongside transfer. The wave height limitation to allow safe mooring of a tanker alongside a floating structure can vary, depending upon the following factors:

— type of floating production structure;

— differences between floating production structure and export tanker sizes and hull shapes;

— relative wind, wave and current direction, speed and characteristics;

— weathervaning capability of the floating structure;

— adequacy of fenders and mooring equipment;

— transfer equipment design;

— manoeuvrability of the export tanker;

— limiting sea state for assisting tug operations.

Fenders used for alongside offloading should preferably be of a rubber, floating type filled with air or foam. Fender handling equipment should be designed for the largest size and heaviest type fender to be used. Floating structure hull strength in the fender area should be checked with respect to local buckling and yielding. Both the floating structure and its stationkeeping system should be designed to absorb the maximum mooring and impact actions caused by the export vessel, and at the same time, allow the export vessel to safely clear all mooring lines.

Consideration should be given to making both the stationkeeping and fluid transfer systems capable of rapid, remote safe disconnection in an emergency.

17.3.3.3.4 Tandem transfer

Tandem transfer consists of a mooring hawser arrangement and a floating or suspended transfer hose system. Mooring hawsers should be of suitable material and construction for the intended service and should be manufactured and tested in accordance with appropriate standards (see A.17.3.3.3.4).

The maximum peak mooring force anticipated in service shall be used to size the hawser. The maximum peak mooring force and set of metocean and ice conditions likely to cause such a force shall be clearly specified in the MOM. An appropriate means of monitoring the hawser force should be provided in the control room, along with a readout and warning of a high hawser force.

A suitable hawser termination and supporting structure shall be provided. The strength of the hawser termination and its supporting structure shall be greater than the breaking strength of the hawser.

Provision shall be made for supporting the hose termination and any associated hose storage equipment, such as a hose reel or horizontal storage tray.

The actual limiting wave height for mooring and loading operations depends upon the following:

— distance between floating structure and export vessel;

— size of export vessel and floating structure;

— crosswind and current conditions;

— floating structure stationkeeping system configuration and stationkeeping capabilities (fishtailing, surge control);

— manoeuvring space at the site;

— export tanker stationkeeping capabilities;

— stationkeeping support vessel bollard pull;

— degree of automation in the hawser and offloading connection;

— location of manifold hose connection;

— ability of operations personnel to safely access connection/disconnection areas.

17.3.3.3.5 Direct transfer

Direct transfer of hydrocarbons to DP shuttle tankers is effected by using a long loading hose without a mooring hawser between the shuttle tanker and the storage structure. The DP system on the shuttle tankers ensures stationkeeping within a pre-defined sector during transfer operations. During operation, tanker heading is normally not directly towards the storage structure.

17.3.4 Material handling

Material handling systems include provisions for supply vessels to moor against the floating structure's hull and/or DP adjacent to the structure, as well as lifting and transfer systems to transfer material to and from the structure and onboard the structure.

Due consideration shall be given to provision of mooring points and fendering arrangements for safe and efficient loading and unloading of material from supply vessels.

In arranging critical equipment, the risks posed by dropped objects shall be considered.

Material handling on a floating structure is inherently more dangerous than on land or on a fixed platform, due to the structure's accelerations/movements. This additional risk shall be considered when planning transport routes and designing lifting and transport equipment. Accelerations/movements of the platform shall be taken into consideration in all transportation of objects and in the design of transport equipment. Operational restrictions should also be considered depending on the type of platform, its motion characteristics, handling means involved and actual weather conditions.

Material handling below deck is complicated by transport routes through bulkheads and decks which are parts of the floating structure's watertight compartmentation. This shall be borne in mind when transport routes are being designed.

17.3.5 Lifting appliances

Lifting appliances can be split into two main groups:

a) offshore cranes used for material handling between the floating structure and another vessel, as well as internally on the floating structure;

b) other lifting appliances used solely for lifts internally on the floating structure.

The following considerations apply:

— lifting appliances should be designed to RCS rules or other recognized standards for offshore lifting appliances (see A.17.3.5);

— area layout shall be designed to allow the use of relevant handling equipment/facilities;

— all transport equipment shall have adequate brakes or other facilities to stop inadvertent motion;

— transport routes should lead to a lay-down area or at least to a point where pick-up by a deck crane is possible;

— lay-down areas shall have adequate fenders to stop swinging lifts causing damage.

For further information on lifting, reference can be made to ISO 19902 and ISO 19901-6.

17.4 Fire protection systems

17.4.1 General

Fire protection measures on a floating structure consist of structural fire protection, firewater systems, fixed fire-extinguishing systems and alarms.

Fire protection requirements are usually specified in national standards. Reference can also be made to ISO 13702 and RCS rules.

17.4.2 Structural fire protection systems

Systems for structural fire protection are either active (e.g. water spray) or passive (e.g. insulation or intumescent coatings). In selecting a system, the following points shall be considered:

— active systems can increase water system capacity requirements and require provisions for drainage for firewater runoff;

— passive systems provide protection but need not represent a minimum weight solution;

— requirements for access to structural components under passive coating system for inspection;

— testing requirements for active systems.

17.4.3 Firewater systems

All floating structures shall have a firewater system that supplies hose stations throughout the structure. The system shall have sufficient redundancy so that a fire in any space or open area would not render the system inoperative.

A minimum of two pumps, each capable of supplying 100 % firewater design capacity, with separate sources of power should be provided, supplying a fire main fitted with isolation valves so that, if a section fails, the failure can be isolated and the remainder of the system remains operational.

Other fire protection systems that can be supplied from the fire main include, but are not limited to

— foam systems, typically installed to protect produced hydrocarbon storage areas and helicopter decks,

— a process deluge system, and

— active structural fire protection (water spray) systems.

When sizing the firewater system, all high-consequence fire risk scenarios shall be considered and the system shall be sized to be capable of supplying all systems that would be required to operate simultaneously in any single fire risk scenario.

17.4.4 Fixed fire-extinguishing systems

Fixed fire-extinguishing systems are usually installed in machinery spaces, electrical equipment rooms and control stations. These systems include gaseous systems, sprinkler systems, water mist systems, foam systems and dry chemical systems, and can be manually actuated or automatically actuated by a fire detection system.

RCS rules and applicable national/international standards should be consulted for fixed fire-extinguishing systems for protection of the marine component of a floating structure.

Fixed fire-extinguishing systems for the industrial component of a floating structure (process facilities) shall be provided to address hazards associated with the process facilities in enclosed spaces containing process equipment, process-related machinery, hydrocarbon storage areas, electrical equipment rooms and other areas or spaces constituting a fire hazard.

17.4.5 Alarms

Flag and national administrations often have specific requirements for general alarm systems. In the absence of specific requirements in RCS rules or equivalent, IMO requirements should be conformed to (see A.17.4.5).

18 Stationkeeping systems

18.1 General

A floating structure shall be provided with suitable means of keeping its position at the specific site of intended operation. These means typically consist of a stationkeeping system connecting the floating structure physically to the seabed, or a DP system whereby the floating structure is kept in position by means of thrusters, or a combination of both.

The design of stationkeeping systems shall be in accordance with ISO 19901-7.

The type of stationkeeping equipment involved depends upon the type of floating structure and the chosen system solution.

18.2 Mooring equipment

18.2.1 Winches

Most floating structures use mooring winches of the same type. Alternatives for mooring winching equipment are covered in ISO 19901-7. One winch per mooring line should be used if the mooring system is to be continuously adjustable. An alternative is to have a group of mooring lines served by one common winch. This alternative should only be used if continuous adjustability is not required.

The winch pulling power should be specified when designing the mooring system, based on the worst allowable installation and/or adjustment weather conditions.

Mooring systems with fairleads should be capable of moving the chain/wire system sufficiently to make critical inspection of the moorings at the fairleads. Sufficient capability in terms of chain lockers or alternative means to secure the chain should be provided for this possibility.

The chain-bearing surfaces (e.g. winch chain wheel or chain jack latches) should be formed to suit the chain to be used.

18.2.2 Fairleads and chain stoppers

Chain stoppers on each mooring line shall lock the mooring line to the mooring attachment point once the required installation tension is reached.

Various types of fairleads or bending shoes should be considered and employed for routing of the mooring lines from the winches to the point where they leave the floating structure. Intermediate fairleads should be direction-fixed and the last fairlead before the line leaves the structure should be rotatable in at least one plane.

The chain-bearing surfaces (e.g. guide roller in wheel-type fairleads or chain-stopper latches) should be formed to suit the chain to be used.

Chain stoppers and fairleads and their supporting structures should be designed for a force equivalent to the minimum breaking strength of the mooring line (see also ISO 19901-7).

18.2.3 Monitoring and control equipment

Monitoring of mooring line tension or line angle shall be performed to detect line failure, for example, by instrumentation.

Local winch and chain-stopper control shall be specified, and can involve remote control and monitoring of winch, chain stopper and line parameters.

18.3 Turret

18.3.1 General

A turret mooring system allows a ship-shaped structure to rotate or weathervane around a geostationary turret that is physically moored to the seabed with a multi-line spread mooring system. A suitable bearing system shall be provided at the interface between the floating structure and the turret. A means for locking the turret to the hull and controlling the relative rotation should be considered, if relevant.

Turret moored structures can fall into two groups: freely weathervaning or those with heading control.

Some freely weathervaning structures have a locked turret, which either unlocks by active intervention or starts rotating when a pre-set yaw moment is attained.

Structures with heading control try to keep the bow into the waves to minimize the roll motion. An important aspect of these structures is the need for redundancy in the thruster system.

18.3.2 Turret structure

The turret structures supporting the mooring lines shall be designed for the maximum combined actions to which they can be subjected during service. The various situations to which mooring systems can be subjected are described in ISO 19901-7.

Fatigue damage due to repetitive actions shall be assessed.

Wave slamming effects shall be considered, where appropriate.

Suitable inspection methods shall be provided to allow inspection and maintenance of the turret structure during its design service life.

18.3.3 Bearing system

18.3.3.1 General

The function of the bearing system is to transfer the forces between the turret and the hull. The working conditions of the bearing system depend on the type of system, but unless the turret is of the disconnectable type, the system shall be designed for actions resulting from the ULS and ALS design situations, exposure to salt water and to ambient temperatures. If roller bearings are used, the bearing shall be adequately protected from seawater ingress by a suitable sealing arrangement and suitable lubrication arrangements. Contamination of the grease with dust should be expected.

18.3.3.2 Forces on the bearing system

The forces on a turret bearing system include, but are not limited to, the following action effects:

— mooring line and riser actions;

— buoyancy of the turret (varying with draught);

— inertia of the turret due to floating structure accelerations;

— weight of the turret (inclination due to roll and pitch to be considered);

— global deformation of the structure;

— friction-induced bearing and swivel torques;

— hog/sag structure deflections resulting in moonpool ovalization;

— effects due to entrapped water and added mass;

— effects induced by assembly tolerances and fabrication tolerances.

The bearing should be designed for the maximum combination of such actions as expected in service.

Local support structure shall be designed for maximum action effects and allowable deflections as specified by the bearing manufacturer.

Fatigue damage to bearings and local support structure due to repetitive actions shall be assessed.

Bearings shall be designed according to an internationally recognized standard (see A.18.3.3).

18.3.3.3 Alternative bearing designs

A number of different bearing types are used. The most common are

a) roller bearings based on rollers in sealed grease-filled units,

b) roller systems based on rails and large-diameter steel “bogie” wheels,

c) sliding bearings based on low-friction pads on spring supports sliding against a machined stainless steel surface.

On some turret systems, all the force is transmitted by one bearing while, on others, there are two, an upper and a lower bearing, with the lower bearing typically transmitting horizontal forces only. In some cases, the lower bearing, typically a rubber fender, is installed as a back-up for the mooring forces experienced in extreme conditions.

Where self-lubricating sliding bearings are used, expected wear rates and maximum total wear over the design service life shall be assessed using appropriate test data.

18.3.3.4 Inspection, maintenance and repair

The bearing system is vital for the safety and functionality of a turret-moored floating structure. Therefore, the bearing function shall be maintained during the life of the structure. Where possible, access for inspection and maintenance shall be built into the systems. Alternatively, a monitoring system shall be specified. In harsh metocean and ice conditions, the bearing system should be designed with redundancy to secure the function of the turret (force transfer and structure rotation) in any weather conditions. The system should be designed to facilitate inspection, maintenance and repair activities at location, with a minimum of downtime.

18.3.4 Turning and locking systems

Some turrets have a turning system for controlling the rotational position of the turret relative to the floating structure. For naturally weathervaning structures with roller bearing systems, the turning system is usually omitted. Generally, systems based on sliding bearings have a turret-turning system to avoid twisting the mooring lines and risers as the structure rotates to minimize the weather exposure. The system can be based on hydraulic cylinders and grippers, a rack and pinion system, etc.

The system performance is characterized by a turning force and a rotating velocity. The necessary force is determined as the maximum calculated turning resistance plus a safety factor. The necessity for a redundant system should be evaluated.

The necessary turning velocity depends on the maximum required rotational speed of the structure. This is a function of the expected heading change rate of the metocean actions or ice actions. Normally, a full rotation (360°) in one hour should be sufficient, but this shall be determined for each structure based on a site-specific analysis.

18.4 Disconnectable structures

18.4.1 General

Disconnectable structures (see 5.3.8) are a particular class of floating structures. In normal operations, their behaviour is similar to that of permanently moored structures. However, upon occurrence of a threshold event, a disconnectable floating structure is capable of rapid disconnection from its ancillary components (risers, moorings, etc.).

The rapid disconnection allows the floating structure to move to a location where the metocean or ice conditions are less severe than those existing or forecast at the original location, protecting the structure and/or other components (moorings, risers, etc.) from the extreme actions that would be experienced, if the platform remained connected.

18.4.2 Categorization

A structure shall not be categorized as disconnectable unless

a) a reliable forecast or identification of the threshold event is technically and operationally feasible,

b) disconnection is part of the operating philosophy, and the process is clearly defined in the platform's MOM, and

c) sufficient time and resources exist to safely disconnect the platform after the occurrence or detection of a threshold event.

18.4.3 Threshold events

Threshold events are the following:

a) the approach of a hazard (e.g. a tropical cyclonic storm, iceberg) whose intensity or magnitude exceeds predefined limits, and which might result in unacceptable consequences on one or more platform components (moorings, risers, structure, etc.);

b) the measured value of one or more response parameters (motions, accelerations, tensions, etc.) for the platform or for a key component (e.g. production riser) exceeds a predefined limit.

Basing the disconnection decision on a specific type of threshold event depends heavily on the operating philosophy adopted. In practice, type a) threshold events, with the exception of sudden hurricanes, can be systematically tracked with sufficient advanced warning.

Disconnection based on type b) threshold events can originate, for instance, from the desire to avoid exposing risers to winter storms, which are not easily detected and tracked. Another example would be failure of the stationkeeping system to maintain the excursions of the structure within prescribed limits.

In more general terms, the criteria for disconnection should represent a reasonable balance between setting the event limiting value too low (less onerous design situation but frequent disconnections) or too high (more onerous design situation but less frequent disconnections).

18.4.4 Operational mode

There are two distinct modes of operation:

— connected mode (see 18.4.5);

— disconnected mode (see 18.4.6).

Disconnection can involve complete disconnection of the structure from the riser system and from the mooring system, where applicable, creating two independent systems. The dependability of the disconnection process is critical to ensure that the floating structure does not experience actions exceeding pre-set limits. A safe and reliable operating procedure based on a risk assessment should be documented in the MOM. This procedure should be periodically tested and witnessed to ensure continuous safety and reliability of the system.

18.4.5 Connected mode

18.4.5.1 General

In the connected mode, the actions used in the design of the structure and other platform components should be derived from metocean and/or ice parameters at least as severe as those that characterize the threshold event. Threshold event data should include directionality information.

The operating procedure should ensure disconnection so that the threshold actions are not exceeded.

Production operations should be timely suspended ahead of the disconnection sequence to minimize environmental risk.

The details of the production suspension process should be included in the disconnection procedure.

18.4.5.2 Design criteria

For type a) threshold events, a watch circle should be defined that allows sufficient time to react to approaching hazards. The actions to be taken to disconnect (planned or emergency) should be based on the amount of time available to react to changing conditions. Recurring risk analyses during operation should be performed to ensure possible scenarios regarding the impact of an event are considered. In this case, the structure and other platform systems (risers, moorings, etc.) shall be designed for the