



ACS (Asia Classification Society)

Rules for Building and Classing Single Point Moorings (SPM Rules)

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ACS

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PART

1

Conditions of Classification

(Supplement to the ACS Generic Rules for Conditions of Classification – Offshore Units and Structures)

Part	1	Conditions of Classification
Chapter	1	Scope and Conditions of Classification
Section	1	Classification

Chapter 1 Scope and Conditions of Classification

SECTION 1 Classification

1 General

The requirements for conditions of classification are contained in the separate, ACS Generic Rules for Conditions of Classification – Offshore Units and Structures (Part 1).

Additional requirements specific to single point moorings are contained in the following Sections of this Part.

2 Application of Rules

These Rules are applicable to unmanned SPM's as defined in 3-1-1 and are generally intended for temporary moored vessels.

These Rules are applicable to those features of the system that are permanent in nature and can be verified by plan review, calculation, physical survey or other appropriate means. Any statement in the Rules regarding other features is to be considered as guidance to the designer, builder, owner, etc.

Part	1	Conditions of Classification
Chapter	1	Scope and Conditions of Classification
Section	2	Classification Symbols and Notations

SECTION 2 Classification Symbols and Notations

1 General

List of Classification Symbols and Notations for Single Point Moorings is available from ACS Generic Rules for Conditions of Classification – Offshore Units and Structures (Part 1).

2 Single Point Moorings Built Under Survey

SPM's which have been built under the supervision of the ACS Surveyors to the requirements of these Rules or to their equivalent, where approved by the Classification Committee, will be classed and distinguished in the Record by the symbols **⊛ A1, Single Point Mooring**. This document is mainly applicable to SPM systems which are designed for temporarily moored vessels. For vessels which will be permanently moored to an SPM, the ACS Rules for Building and Classing Floating Production Installations (FPI Rules) applies.

3 Single Point Moorings Not Built Under Survey

SPM's which have not been built under the supervision of the ACS Surveyors, but which are submitted for classification, will be subject to a special classification survey. Where found satisfactory, and thereafter approved by the Classification Committee, they will be classed and distinguished in the Record, but the mark **⊛** signifying the survey during construction will be omitted.

For SPM's which have been built under survey and according to the rules of any IACS member, the mark **⊛** will be assigned.

4 Single Point Mooring as a Part of a Floating Production System

SPM's built under survey for use as part of the mooring system for a classed floating production system do not require a separate classification under these Rules. Requirements for mooring systems of floating production systems are found in the FPI Rules.

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Chapter	1	Scope and Conditions of Classification
Section	2	Classification Symbols and Notations

5 Classification Data

Data on single point moorings will be published in the Record as to the latitude and longitude of the location of the mooring, the length overall and displacement of the ship it is designed to moor, the depth of water at the site, maximum hawser tension where applicable, and general types of cargo and other fluids which the mooring is designed to handle.

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Chapter	1	Scope and Conditions of Classification
Section	3	Plans and Design Data to be Submitted

SECTION 3 Plans and Design Data to be Submitted

1 Plans

Plans showing the scantlings, arrangements, and details of the principal parts of the structure, associated piping and equipment of each SPM to be built under survey are to be submitted for review and approved before construction is commenced. These plans are to clearly indicate the scantlings, joint details and welding, or other methods of connection. The number of copies to be submitted is to be in accordance with 1-1-3/6 and 1-1-3/7. In general, plans are to include the following where applicable:

- General arrangement
- An arrangement plan of watertight compartmentation, including the location, type and disposition of watertight and weathertight closures
- Structural arrangement showing shell plating, framing, bulkheads, flats, main and bracing members, joint details, as applicable
- Details of watertight doors and hatches
- Welding details and procedures
- Corrosion control arrangement
- Type, location and amount of permanent ballast, if any
- Bilge, sounding and venting arrangements
- Hazardous areas
- Electrical system one line diagrams
- Location of fire safety equipment
- Mooring arrangement

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- Mooring components including anchor leg, associated hardware, hawser and hawser loaded-deflection characteristics
- Foundations for mooring components, industrial equipment, etc. showing attachments to hull structure
- Anchoring system showing the size of anchor, holding capacity of piles, pile sizes, and capacity, etc.
- PLEM (Pipe Line End Manifold)
- SPM Main Bearing
- Cargo or product swivel including swivel driving mechanism, swivel bearing, electrical swivel details
- Product or cargo system piping, schematic drawing with bill of materials
- Design data of equipment, piping, and related components including min. and max. designing pressure and temperature
- Ancillary piping system schematic drawing with bills of material
- Floating and underbuoys hoses/flexible risers
- Telemetry/Control system
- Navigation aids
- Methods and locations for NDT
- Plans for conducting underwater inspections in lieu of drydocking (UWILD)
- Test and inspection plan for all major load carrying or pressure retaining components including cargo or product swivel, electrical swivel, bearings
- Test procedures

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2 Site Chart

To demonstrate that navigational considerations have been taken into account in establishing the mooring location, a site chart of mooring is to be submitted in accordance with 3-1-2 which shows as follows:

- (1) Location of the mooring
- (2) Potential navigation hazard
- (3) Existing & planned navigation aids
- (4) Bottom contour elevations
- (5) Maneuvering area
- (6) Swing circle

3 Site Condition Reports

To demonstrate that site conditions have been ascertained and taken into consideration in establishing design criteria, reports on subjects including the following are to be submitted in accordance with 3-1-2:

- (i) Environmental conditions of wind, waves, current, seiche, tide, visibility, temperature, and ice.
- (ii) Water depth, at berth and throughout the maneuvering area, bottom soil conditions, and subsurface hazards.

4 Model Tests

When model tests are used to determine the design loads or to demonstrate that the established design loads have been based on the results of physical dynamic model tests, a report is to be submitted describing the design loads, calculations, description of model test facilities and procedures, and a summary of the results. It is recommended that the designer consult with ACS concerning model testing, procedures, methods and data analysis to ensure the investigation is adequate.

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Chapter	1	Scope and Conditions of Classification
Section	3	Plans and Design Data to be Submitted

5 Calculations

In general, where applicable, the following calculations are to be submitted:

- (i) Structural design in accordance with 3-2-2
- (ii) Stability calculations in accordance with 3-2-2
- (iii) Mooring and anchorage in accordance with 3-4-1
- (iv) Piping in accordance with Part 4, Chapters 1 and 2
- (v) Calculations for all pressure retaining and load bearing components in accordance with Part 4
- (vi) Swivel stack static and dynamic analysis in accordance with Part 4

Calculations when submitted are to be footnoted indicating references.

6 Additional Plans

Where certification under the other regulations described in 1-1-5 of the ACS Generic Rules for Conditions of Classification – Offshore Units and Structures (Part 1) is requested, submission of additional plans and calculations may be required.

7 Submissions

Plans should generally be submitted electronically to ACS. However, hard copies will also be accepted.

Additional copies may be required when the required attendance of the Surveyor is anticipated at multiple locations.

All plan submissions originating from manufacturers are understood to have been made with the cognizance of the builder.

SECTION 4 Information Booklet and Maintenance Manual

1 General

For each SPM, a document is to be submitted. This document is to include recommendations regarding operation and maintenance of the SPM facility, the design criteria for the SPM, information regarding the mooring area, and the components of the SPM.

2 Items Included in Information Booklet and Maintenance Manual

The document is to include the following information:

- (1) Site chart as described in 1-1-3/2 .
- (2) Design vessel data, including deadweight, length, draft and distance from bow to manifold.
- (3) Environmental design criteria with various sizes of vessels, including the operating wind, wave, current and tides.
- (4) Design cargo transfer criteria, including type of cargo and design maximum working pressure, temperature, flow rate, and minimum valve closing times including the vessel's manifold valves.
- (5) Plans showing the general arrangement of the single point mooring components and details of those components required to be handled during operation or inspected during maintenance, including details of access to these components.
- (6) Description of navigation aids and safety features.
- (7) Recommended procedure for the mooring and disconnecting a vessel at the SPM.
- (8) Recommended procedure for connecting and disconnecting floating hose to a tanker's manifold.

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Chapter	1	Scope and Conditions of Classification
Section	4	Information Booklet and Maintenance Manual

(9) Recommended maintenance schedule and procedures for the SPM facilities, including a check list of items recommended for periodic inspection. Where applicable, procedures for adjusting anchor leg tension, removal and reinstallation of hoses, inspection of flexible risers, adjustment of buoyancy tanks, and replacement of seals in the cargo swivel are to be included.

(10) Recommended cargo system pressure testing.

3

The Information Booklet and Maintenance Manual is to be submitted for review by ACS solely to ensure the presence of the above information which is to be consistent with the design information and limitations considered in the SPM's classification. ACS is not responsible for the operation of the SPM.

The Information Booklet and Maintenance Manual required by these Rules may contain information required by flag and coastal Administrations. These Administrations may require that additional information be included in the Operation and Maintenance Manual.

PART

2

Materials and Welding

Chapter 1 Materials

SECTION 1 Manufacture, Survey and Certification

1 General

1.1

Materials used for the construction or repair of the SPM's which are classed or intended to be classed with ACS, are to be manufactured, tested and inspected in accordance with the requirements of this Part of SPM Rules and Part 2 of ACS Rules for Classification of Vessels.

1.2

Materials complying with recognized national or international standards with specifications equivalent to above may also be accepted

1.3

Where it is intended to use materials of different process, manufacture or of different properties, the use of such materials will be specially considered.

1.4

Consideration is to be given to the minimization of hazardous substances used in the construction of the SPM and is to facilitate recycling and removal of hazardous materials.

1.5

Materials containing asbestos are not permitted.

SECTION 2 Material Selection

1 General

1.1

Materials are to be used based on type and level of stresses, temperatures, corrosive and erosive conditions and failure probabilities during installation, operation and maintenance.

1.2

Materials are to have adequate strength and ductility for the intended purpose and corrosion resistance. Appropriate corrosion protection may be applied where materials are not corrosion resistant.

1.3

Where materials are to be welded, good weldability properties are to be ensured.

1.4

The materials used are to be non-combustible in general. Other types of materials where used, are to be specially approved by ACS.

1.5

Materials suitable for sour service are to be of appropriate standards such as ANSI/NACE MR0175 or ISO 15156.

2 Structure

2.1

The materials for construction of the buoy are to be generally in accordance with the requirements of ACS Rules for Classification of Vessels depending on air temperature in area of operation, thickness of material and location on the structure.

2.2

For most applications, ordinary strength steel, such as, ASTM A36, is considered acceptable. Critical load carrying components in the mooring load path, such as hawsers connection, padeyes, etc are to be considered as primary application structure.

3 Mooring System

3.1

Materials used in the construction of anchors, anchor legs, associated hardware, etc. are to comply with ACS requirements. Where material requirements are not covered by ACS Rules, recognized industry standards may be applied.

The following industry standards and rules may be applied for mooring system components:

- Buoyancy Tanks : ASME Boiler and Pressure Vessel Code
- Chains: Part 2 of ACS Rules for Classification of Vessels
- Wire Ropes: API Spec 9A and RP 9B
- Anchor piles : API RP2A “Recommended practice for planning, designing and constructing fixed offshore platforms”

3.2

Where synthetic materials are used, material specifications are to be submitted for review.

4 Cargo or Product Transfer System

4.1

Materials used in the construction of cargo or product transfer system are to comply with appropriate material specifications as may be approved in connection with the application of usage.

4.2

The mechanical properties and chemical composition of materials used in the construction of cargo or product transfer systems are to comply with recognized standards as approved for the design, taking into account the operating temperature.

Materials need not be tested in the presence of the Surveyor. In general they may be accepted on the basis of a review of manufacturer’s certificates by the Surveyor.

4.3

The chemical composition, heat treatment and hardness of the materials used in cargo or product transfer systems that will be exposed to hydrogen sulfide are to be suitable to resist sulfide stress cracking. The materials are to comply with recognized standards such as NACE MR 01 75 or ISO 15156.

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Chapter	1	Materials
Section	2	Material Selection

4.4

Material selection is to consider the possibility of chloride stress cracking if chlorides are present in the cargo or product fluid.

5 Bearings

5.1

Materials used in the construction of bearing retainers are to comply with recognized standards and appropriate material specifications as may be approved in connection with a particular design.

Materials need not be tested in the presence of surveyor. In general they may be accepted on the basis of a review of manufacturer's certificates by the surveyor.

6 Bolts and Nuts

6.1

Bolts and nuts considered as essential for structural and operational safety are to conform to recognized standards (e.g. ISO 898).

6.2

For general service, the specified tensile properties are not to exceed ISO 898 property Class 10.9 when the installation is in atmospheric environment. For equipment submerged in seawater, the tensile properties are not to exceed property class 8.8 or equivalent.

7 Rails and Wheels

7.1

Materials and section of rails used in the case of wheel and rail type buoy are to be of recognized national / international standards (e.g. IS3443, DIN583).

7.2

Wheels may be manufactured from cast, forged or rolled steel according to recognized national / international standards (e.g. IS3177, ISO 16881-1).

Chapter 2 Corrosion Protection

SECTION 1 Corrosion Protection of Structures

1 General

1.1

Requirements to coatings for corrosion control (including those for any impressed current anode shields) shall be defined during design (e.g. by reference to a standard or in a project specification), including as a minimum:

- coating materials (generic type)
- surface preparation (surface roughness and cleanliness)
- thickness of individual layers
- Inspection and testing.

1.2

Coating systems are to be generally in accordance with the requirements specified in ACS Rules for Classification of Vessels, as applicable.

1.3

Steel surfaces are to be protected by a coating system proven for marine atmospheres by practical experience or relevant testing.

1.4

Corrosion monitoring is to be done where considered necessary.

SECTION 2 Corrosion Protection of Systems and Equipment

1 General

1.1

Equipment and piping are to be corrosion resistant or protected against corrosion where considered necessary for safety or operational reasons.

1.2

Dissimilar metallic materials in contact are to be avoided or adequately protected against galvanic corrosion.

1.3

External steel surfaces exposed to the marine atmosphere are to be protected by coating. Steel structures of the buoy and components submerged in sea water are to be protected by cathodic protection or a combination of cathodic protection and coating.

Sacrificial anodes are to be attached to the structure in such a way that they remain secure during service. Attachment may be made by welding of steel core, by bolting to supports which are welded to the structure or by other approved means of mechanical clamping.

1.4

Internal corrosion control is to be used if the cargo contains water or has a relative humidity of more than 50% and if the partial pressure of corrosive gases is above the following limits:

O₂ : 100 Pa

H₂S : 10 kPa

CO₂ : 20 kPa

1.5

Increased corrosivity due to combination of gases are to be considered.

Chapter 3 Welding

SECTION 1 General

1 Scope

1.1

Welding in steel hull construction of all SPM installations is to comply with the requirements of this Chapter. Welding of any other specific construction material will be specially considered.

2 Documentation

2.1

Connection details of the welded structural members, including type and size of the welds are to be clearly indicated on the plans submitted for approval. An explanation of all symbols or abbreviations used in detailing the weld connections should be included in the plans.

2.2

Details of proposed welding procedure are to be submitted indicating preheating temperature and any post-welding treatment, if employed. Extent to which automatic welding, including deep penetration welding, is employed should also be indicated.

2.3

The actual sizes of fillet welds are to be indicated on detail drawings or on a separate welding schedule and submitted for approval in each individual case.

SECTION 2 Welding and Welded Connections

1 General

1.1

In general, welding and welded connections are to comply with the requirements of ACS Rules for Classification of Vessels, as appropriate to the structural members being considered.

PART

3

Mooring System Design

Chapter 1 General

SECTION 1 Definitions and Abbreviations

1 Definitions

1.1

For the purpose of ACS SPM Rules, the following definitions and explanations, in alphabetical order, shall apply:

Anchor Leg

Mooring element connecting the single point mooring structure to the seabed at the anchor point, and is essential for station keeping of the system.

Buoyancy Element

A buoyancy member provided to support the weight of mooring equipment or risers, and designed to resist differential pressure from submergence and internal pressure.

Hawser

Mooring line between SPM structure and moored vessel.

Hose

Conduit designed to convey fluids between supply and delivery points with significant relative movement and able to tolerate large deflections. Typically, a hose is comprised of a string or series of short hose segments joined together at flanged ends.

Hose, Floating

Hose or hose string located between the SPM structure and the moored vessel for the purpose of conveying fluid. When not connected to a moored vessel, it remains connected to the SPM structure and floats on the sea water surface.

Hose, Underbuoy

Hose or hose string located between the SPM structure and the pipeline end manifold (PLEM) for the purpose of conveying fluids.

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Chapter	1	General
Section	1	Definitions and Abbreviations

Main Bearing

The bearing which supports the load from the mooring and hawser and provides a mechanism for the moored vessel to rotate or weathervane about the mooring structure

Product

Any fluid transferred between the moored vessel and the pipeline end manifold (PLEM) such as crude oil, petroleum product, petroleum gas, slurry, and bunkers.

Product Swivel

A mechanism which provides for passage of cargo or product while allowing the main structure to weathervane freely with respect to the fixed or anchored structure without significant leakage at the rated design pressure.

Recognized Consultant

A person or organization recognized by ACS as being capable of providing specialized knowledge or assistance.

Riser, Flexible

Conduit designed to convey fluids between supply and delivery points with or without significant relative movement and able to tolerate large deflections. A flexible riser usually comprises one continuous length, used for relatively greater water depths and constructed to be used totally submerged.

Single Point Mooring (SPM)

A Simple Point Mooring (hereafter referred to as "SPM") which permits a vessel to weathervane while the vessel is moored to a fixed or floating structure anchored to the seabed by a rigid or articulated structural system or by catenary spread mooring. Examples of such system are CALM, SALM, tower mooring, etc.

SPM, Fixed

A tower mooring and a single anchor leg mooring (SALM) which are gravity based (fixed or pinned) system are defined here as fixed SPMs.

SPM, Floating

A Catenary Anchored Leg Mooring (CALM) is an example of a floating SPM.

Swing Circle

The swing circle is the area swept by the moored vessel as it revolves about the mooring point.

2 **Abbreviations**

ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
DWT	Dead Weight
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
NACE	National Association of Corrosion Engineers
NDT	Non-Destructive Testing
OCIMF	Oil Companies International Marine Forum
PLEM	Pipe Line End Manifold
ROV	Remotely Operated Vehicle
UWILD	Underwater Inspection In Lieu of Drydocking

SECTION 2 Site and Environmental Conditions

1 General

1.1

The provisions of this Section are intended to establish the method of defining the location of the SPM, the environmental conditions which will affect operations at the SPM and which are to be considered in establishing design criteria, and the bottom soil conditions which affect the anchorage of the SPM.

2 Mooring Location

2.1 Site Chart

A complete chart of the mooring area is to be submitted. This chart is to show depth soundings and obstructions within the swing circle, the maneuvering area, and where applicable, the approach channel from deep water or an established navigation channel. The chart may be based on local charts published by government agencies or on hydrographic surveys conducted by a recognized consultant. In the case of charts based on hydrographic surveys, a survey report is to be submitted describing the surveying method, equipment, and personnel employed to conduct the survey.

The exact location and water depth of the mooring base or pipeline end manifold (PLEM), and each anchor point, is to be indicated on the chart. The route of the submarine pipeline and of all other pipelines and cables is to be indicated on the chart. If the mooring is associated with other SPMs in the area, or with a pumping or control platform, these features are to be indicated on the chart. All other features and water use areas which may present potential navigational hazards are to be identified. All existing and planned navigation aids such as lights, buoys, and shore markers which will be used in conjunction with the mooring are to be indicated and identified on the chart.

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Chapter	1	General
Section	2	Site and Environmental Conditions

2.2 Bottom Topography

All depths on the chart are to be referenced to the datum of the local navigational chart. The chart is to be based on depth soundings taken at 15 m horizontal intervals or less.

The chart is to show bottom contours at a vertical interval of 1.5 m . Where the bottom is irregular, the spacing of soundings is to be reduced. Where side scan sonar or wire drag is employed, the spacing of soundings may be increased.

All obstacles, such as sunken wrecks, rocks, and pinnacles are to be identified and their clear depths indicated. Where such obstacles are encountered, wire drag at a depth beneath the required water depth or a side scan sonar survey is to be conducted throughout.

Where it is shown that water depth is far in excess of the required water depth, the survey may be appropriately modified.

2.3 Maneuvering Area

The maneuvering area is to be indicated and captioned on the site chart. The maneuvering area is defined as the area through which a vessel is to maneuver in making an approach to, or a departure from, the SPM. The shape and size of the maneuvering area are to be established based on pertinent local conditions.

The radius of the maneuvering area about the mooring is to be at least three (3) times the length of the largest vessel for which the SPM is designed, plus the hawser length and maximum buoy offset in the Design Operating Condition defined in 3-1-2/4.1(1) .

Where it can be shown that the prevailing environment (wind, waves, current, and tides) favorably influences the mooring maneuver, and that the vessel can always maneuver to and from the SPM without danger, the maneuvering area may be appropriately modified. Where tugs will always be used to assist in mooring, the maneuvering area may be appropriately modified. Where mooring maneuvers are to be made in extreme environments, the minimum radius is to be increased. Fixed obstacles such as platforms or buoys, other than the mooring, are not to be anywhere within the maneuvering area. The route of the submarine pipelines may be marked by a buoy at the edge of the maneuvering area. It is suggested that no other pipelines exist in the SPM maneuvering area.

2.4 Swing Circle

The swing circle as defined in 3-1-1/1.1 is to be indicated and captioned on the site chart. The radius of the swing circle is the sum of the horizontal excursion of the SPM from its center position under operating hawser load and minimum tide, the horizontal projection of the length of the hawser under operating hawser load, the length overall of the largest vessel for which the SPM is designed, and a safety allowance of 30 m.

2.5 Water Depth

The water depth at any place within the maneuvering area is to be such that no vessel which may use the SPM system will touch the sea bottom or any protrusion there from in any sea condition under which such a vessel is expected to be present as outlined in the design premises within the maneuvering area.

The designer may elect to specify limiting drafts for various vessel sizes when the proposed water depth is not sufficient to allow a vessel of the maximum size to be moored in the maneuvering area under the design operating environmental condition.

The determination of the required water depth is to be based upon calculations, data from ship model tests or full scale trials, designers' experience or other available sources of information.

The designer is to submit evidence to demonstrate to the satisfaction of ACS that in determining the required water depth, the following effects have been considered:

- (i) Vessel's dimensions and other relevant characteristics
- (ii) Wave height, wave period, and compass direction with respect to the vessel
- (iii) The prevailing wind and astronomical tides
- (iv) The expected vessel's heaving, rolling and pitching and vessel under keel clearance of at least 1 meter
- (v) The consistency of the sea bottom material or the character of any protrusion from the sea bottom
- (vi) The level of accuracy of the depth survey data
- (vii) Predicted variation of seabed profile due to sediment transport during the design life

3 Soils Data

3.1 Bottom Soil Condition

The general character of the soil on the sea floor throughout the maneuvering area is to be indicated on the site chart. The presence of a rock bottom or of rock outcroppings is to be clearly indicated. Where soil movements such as soil slides, excessive erosion or deposition of soil, or an active fault are suspected, an analysis by a soils consultant of the nature and degree of this hazard is to be submitted.

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3.2 Sub-Bottom Soil Conditions

Soil data should be taken in the vicinity of the mooring site. An interpretation of such data is to be submitted by a soils consultant.

In the case of a mooring having a piled or gravity base, a boring or probing is to be taken at the location of the base to the depth of any piles or to a depth sufficient to establish the soil characteristics of the site.

Site investigation in general should be in accordance with ACS Rules for Building and Classing Offshore Installations (Offshore Installations Rules).

For mooring systems with anchor piles, gravity boxes, or drag anchors, borings or probings are to be taken at all anchor locations to the depth of any piles or to a depth sufficient to establish the soil characteristics of the site. As an alternative, sub-bottom profile runs may be taken and correlated with at least two (2) borings or probings in the SPM vicinity and an interpretation may be made by a soils consultant to adequately establish the soil profile at all anchor pile locations.

4 Environmental Conditions and Data

4.1 Environmental Conditions

The design of an SPM system is to consider the following two environmental conditions:

1. Design Operating Condition (DOC)

The operating environmental condition for an SPM is defined as the maximum sea state in which a vessel is permitted to remain moored to the SPM without exceeding the allowable loads and stresses required in Parts 3 and 4 of these Rules. Wind, waves, and the associated currents used in the design shall be based on site specific data, as determined by recognized meteorological and oceanographic consultants.

2. Design Environmental Condition (DEC)

The Design Environmental Condition for an SPM design is defined as the environmental condition with maximum wind, waves, and associated currents based on a 100-year recurrence interval. At this condition, no vessel is moored to the SPM system, unless the SPM system is specifically designed for this situation. The wind, waves, and the associated currents are to be established by recognized meteorological and oceanographic consultants.

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4.2 Waves

1. Design Operating Wave

The characteristics of the wave for the Design Operating Condition described in 3-1-2/4.1(1) are to be established. The wave characteristics are to include wave height in terms of significant wave height (the average of the highest one third wave heights), associated wave spectrum and associated mean spectral period.

2. Design Environmental Wave

The wave characteristics representing the Design Environmental Condition as described in 3-1-2/4.1(2) for the design of an SPM and its anchorage are to be established based on not less than a 100-year recurrence interval. The characteristics to describe the storm wave are to include:

- The significant wave height and the maximum wave height
- The maximum wave in terms of maximum crest elevation above mean low water
- An indication if the wave is expected to be a breaking wave
- The wave spectrum
- Associated mean spectral period corresponding to the maximum wave
- The tide surge associated with the maximum wave

When component parts are designed for a wave representing lesser recurrence interval, they are to be noted in the design document.

3. Wave Statistics

A report is to be submitted presenting wave statistics for the mooring area. The statistics are to be based on wave data analyzed and interpreted by a recognized consultant. The statistics are to include a table showing the frequency distribution of wave height, period, and direction, and a table or graph showing the recurrence period of waves.

It is recommended that data be obtained from a wave recorder operated in the general vicinity of the SPM for a period of time sufficiently long to establish the reliability of the wave statistics. If the site of the wave recorder is in a different water depth or different exposure from the mooring site, an interpretation to transfer the data to the mooring site is to be performed by a recognized consultant. Alternatively, data may be based on wave observation records for a period of time sufficiently long to establish the reliability of the wave statistics from a local shore station or from published references. The bias of such observations against design storms and therefore against extreme wave heights is to be accounted for. Hindcast studies calibrated to measurements for a location nearby the SPM's installation site can also be used to supplement measured data.

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The statistics for the maximum wave are to be based on wave records for a period of time sufficiently long to establish the reliability of the wave statistics performed by a recognized consultant.

4.3 Wind

1. Design Operating Wind

The wind characteristics for the Design Operating Condition described in 3-1-2/4.1(1) are to be established. The wind velocity is to be specified at a height of 10 m above the ocean surface, and averaged over a one minute period. A one-hour wind with appropriate wind spectrum may be used as an alternative approach.

2. Design Environmental Wind

The wind characteristics for the Design Environmental Condition described in 3-1-2/4.1(2) for design of SPM are to be established based on not less than a 100 year recurrence interval. The wind velocity is to be specified at a height of 10 m above the ocean surface and averaged over a one minute period. A one-hour wind with appropriate wind spectrum may be used as an alternative approach.

3. Wind Statistics

A report is to be submitted presenting wind statistics for the mooring area. The statistics are to be based on wind data analyzed and interpreted by a recognized consultant. The statistics are to include a wind rose or table showing the frequency distribution of wind velocity and direction, a table or graph showing the recurrence period of extreme winds, and the percentage of time which the operating wind velocity is expected to be exceeded during a year and during the worst month or season.

Where possible, statistics are preferably to be based on data from an anemometer operated in the general vicinity of the mooring for a period of time sufficiently long to establish the reliability of the wind statistics. If the site of the anemometer is influenced by terrain or is inland or if the mooring site is far offshore, an interpretation to transfer the data to the mooring site, performed by a recognized consultant, is to be submitted.

Alternatively, the statistics may be based on wind velocity determined from synoptic weather chart pressure gradients for a period of time sufficiently long to establish the reliability of the wind statistics performed by a recognized consultant. If synoptic weather charts are not available, the statistics may be based on observations from published references. These records are to be reviewed and interpreted for the site by a recognized consultant. The bias of such observations against extreme storms and therefore against extreme wind speeds is to be accounted for.

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4.4 Current

1. Design Operating Current

The current characteristics for the Design Operating Condition described in 3-1-2/4.1(1) are to be established. The Design Operating Current is defined as the maximum current associated with the maximum wind and waves in which a vessel will remain moored. The current velocities at the sea surface and seabed are to be included. If the current profile is not linear, the velocities at a sufficient number of intermediate depths are also to be included.

2. Design Environmental Current

The current characteristics for the Design Environmental Condition described in 3-1-2/4.1(2) are to be established. The current velocities at the sea surface and seabed are to be included. If the current profile is not linear, the velocities at a sufficient number of intermediate depths are to be included.

4.5 Seiche

The location of the mooring site in relation to seiche nodal points is to be investigated by a recognized consultant if the site is in a basin or other area known for seiche action. Seiche is defined as long period oscillation of the water in a basin as excited by a disturbance such as wind, waves, atmospheric pressure, or earthquake. Mooring sites located at or near seiche nodal points may be influenced by currents not otherwise predicted. If the mooring site is at or near a seiche nodal point, currents induced by seiche are to be reflected in the operating current and maximum current, and the influence of the period of the current on the dynamic response of the moored vessel is to be considered.

4.6 Tidal Data

Tidal data is to be based on astronomical tides and storm surge. The astronomical tidal extremes and tidal means for the mooring site are to be established. Sufficient data is to be submitted to establish the validity of the tide data. Tide levels may preferably be determined from records of a tide gauge in the vicinity of the site or from published tide tables for a location in the vicinity of the site. If the location from which the tide data is obtained is from a remote mooring site, a transformation of the tide data to the mooring site is to be performed by a recognized consultant. The seasonality of extreme tidal variations can be considered when considering the combination of astronomical tide and storm surge.

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The maximum storm surge for the mooring site is to be established if the mooring is in a coastal or estuary location. Sufficient data is to be submitted to establish the validity of this storm surge. Maximum storm surge may preferably be determined from tide records taken near the location. If the location from which the tide data is obtained is remote from the mooring site, a transformation of the tide data to the mooring site is to be performed by a recognized consultant. Storm surge hindcasts for design (extreme) storms performed by a recognized consultant may be submitted.

4.7 Temperatures and Ice

Where drift ice may be a hazard to a mooring or to a vessel navigating to or moored at a mooring or to floating hoses at a mooring, an analysis of the nature and degree of this hazard is to be submitted.

When air temperature and precipitation, spray, or tidal action may combine to cause substantial ice formation on the mooring, an analysis of the degree to which ice may form and how this ice may affect the performance of the mooring is to be submitted.

The structure, equipment, hoses/flexible risers, component parts and their respective material which may be affected by low temperatures are to be examined.

Chapter 2 Design

SECTION 1 Design Loads

1 General

1.1

The design conditions are to be established by varying vessel size and loading conditions to determine the critical loading conditions under the environmental conditions described in 3-1-2/4. The designer is to submit calculations for the design condition. The following loads are to be considered in the design:

- Dead Loads and Buoyancy
- Environmental Loads
- Mooring Loads
- Fatigue Loads

2 Dead Loads and Buoyancy

2.1

Dead loads are the weight of the SPM structure and associated structural appendages, and equipment which are permanently attached to the structure.

The buoyancy of the SPM structure results in upward forces, the distribution of which depends on the distribution of the submergence of the structure.

3 Environmental Loads

3.1

The environmental loads due to the following environmental parameters are to be considered in the design:

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- Waves
- Wind
- Currents
- Tides and storm surges
- Ice and snow
- Marine growth
- Air and sea temperatures

Other phenomena, such as tsunamis, submarine slides, seiche, abnormal composition of air and water, air humidity, salinity, ice drift, icebergs, etc. may require special consideration.

3.2 Wave Loadings

The wave loads on the SPM structure and the moored vessel are to be determined by suitable methods such as strip theory, diffraction theory, Morison's equation, etc. The wave loading on a tower mooring is to be in accordance with the Offshore Installation Rules.

The wave induced responses of a vessel consist of three categories of response (e.g., first order (wave frequency) motions, low frequency or slowly varying motions, and steady drift) are to be taken into account for designing the SPM structure including the mooring line, anchors, piles, etc., as applicable.

3.3 Wind Forces

For a moored vessel, wind forces on the vessel may be calculated using the coefficients presented in the document Prediction of Wind and Current Loads on VLCCs, Oil Companies International Marine Forum (2nd Edition, OCIMF), 1994. For equipment onboard with unusual shape and arrangement, wind forces on such equipment may be calculated as drag forces and are to be added as necessary. Wind tunnel tests may be required in some design to determine the wind loads.

The wind force on the SPM structure and the moored vessel is considered as a constant (steady) force due to the one-minute wind. Alternatively, the designer may use a one-hour wind with appropriate wind spectrum.

The wind force on the SPM structure and wind exposed appendages and unusual items onboard the vessel may be calculated as drag force. The wind pressure P_{wind} on any particular windage may be calculated using the following equations:

$$P_{wind} = 0.6100 \times C_h \times C_s \times V_{wind}^2 \quad (N / m^2)$$

Where:

V_{wind} = the wind velocity (m/sec)

C_s = the shape coefficient (dimensionless), see Table 3-1(a) for reference only.

C_h = the height coefficient (dimensionless), is given by the following equation:

$$C_h = \left(\frac{V_Z}{V_{ref}} \right)^2$$

Where:

V_{ref} = velocity of wind at reference elevation (Z_{ref}) of 10 m

V_Z = velocity of wind at a height Z above waterline, is to be calculated as follows:

$$V_Z = V_{ref} \times \left(\frac{Z}{Z_{ref}} \right)^\beta$$

V_Z is to be taken as equal to V_{ref} at elevations below the reference elevation Z_{ref} .

$\beta = 0.10$ typically for one-minute average wind, other values supported by site specific data will be specially considered.

The height coefficients to represent the wind velocity profile (corresponding to β value of 0.10) are presented in Table 3-1(b) for height intervals of 15.25 meters.

Table 3-1(a) : Values of C_s	
Shape	C_s
Spherical	0.4
Cylindrical	0.5
Large Flat Surface (Hull, Deckhouse, etc.)	1.0
Clustered Deckhouses or Similar Structures	1.10
Truss Structure (each face) (30% of projected block areas for both front and back sides)	1.25
Exposed Under Deck Beams and Girders	1.30
Small Parts	1.40
Isolated Structural Shapes (Cranes, Booms, etc.)	1.50
Note: Shapes or combinations of shapes which do not readily fall into the specified categories will be subject to special consideration by ACS.	

Table 3-1(b): Values of C_h (for $\beta = 0.10$)		
Height above waterline (m)		C_h
Over	Not Exceeding	
0	15.3	1.0
15.3	30.5	1.18
30.5	46.0	1.31
46.0	61.0	1.40
61.0	76.0	1.47
76.0	91.5	1.53
91.5	106.5	1.68

The corresponding wind force F_{wind} on the windage is:

$$F_{wind} = P_{wind} \times A_{wind} \quad (N)$$

Where:

A_{wind} = projected area of windage on a plane normal to the direction of the wind, in m^2

3.4 Current Forces

For a moored vessel, current forces on the vessel alone may be calculated by using coefficients based on model test data as presented in Prediction of Wind and Current Loads on VLCCs, published by OCIMF (2nd Edition, 1994). For underwater bodies of unusual shape and arrangement, model tests may be required to determine the current forces.

The current forces on the submerged buoy and/or mooring structure, hull of the moored vessel, mooring lines, risers or any other submerged objects associated with the system are to be calculated using the appropriate current profile. The basis of the current profile depends on the environmental conditions described in 3-1-2/4.1.

Current force F_c on the submerged part of the mooring structure, mooring lines, risers, etc., is to be calculated as the drag force as shown below:

$$F_c = \frac{1}{2} \rho \times C_D \times A_c \times u_c \times |u_c| \quad (kN)$$

Where:

$\rho = 1.025 \text{ tonnes / m}^3$, Sea Water Density

C_D = Drag Coefficient, in steady flow (dimensionless)

For circular cylindrical members at Reynold's numbers greater than 1×10^6 , C_D may be taken as 0.62 provided that marine fouling is prevented or periodically removed.

u_c = Current Velocity vector normal to the plane of projected area, (m/sec)

A_c = Projected Area exposed to current, (m²)

4 Mooring Loads

4.1

The design loads of mooring legs and mooring elements (flexible hawsers or rigid mooring elements such as arm and yoke) between the vessel and SPM may be calculated based on physical model testing of the system, or by analytical methods verified by physical model testing of a similar system. The calculation to determine the mooring load is to include high frequency, low frequency, and mooring line dynamics. The most probable extreme values are to be obtained by time domain analysis for the design environmental conditions described in 3-1-2/4.1 using a storm duration of three hours, unless specific site data supports other durations.

4.2 Operating Mooring Loads

Operating mooring loads are the loads on the SPM structure and foundation with the vessel moored to it. The loads are to be determined in the operating environment for the established design condition as indicated in Section 3-1-2. Operating mooring loads are to be established and submitted for the hawser, rigid connection between the vessel and the SPM as applicable, and the SPM anchor leg loads.

1. Operating Mooring Load between Vessel and SPM

The operating mooring load between vessel and SPM is to be established for the SPM system, The operating mooring load is defined as the maximum load imposed on the mooring element

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(e.g., hawser or rigid arm and yoke) for the maximum size vessel for the operating environmental condition described in 3-1-2/4.1, unless a smaller moored vessel is apt to impose higher loads under the influence of the operating wind, wave, current, and tides as established in Section 3-1-2. Data and calculations are to be submitted to establish the validity of this operating mooring load.

The operating mooring load may be statistically determined from model testing and/or analysis. The model testing and analysis on which the operating mooring load is based is to reflect the combined effects of wind, waves, current and tides on the loaded and unloaded vessel. If model testing is performed, the model testing is to model the mooring system appropriately in regard to load-displacement characteristics, and pretensioning of mooring legs as applicable.

2. Operating Anchor Leg Loads

The anchor leg loads in the Design Operating Condition are to be established for the anchor leg or legs with the vessel at the mooring. The operating anchor leg load is defined as the maximum load in the most highly loaded anchor leg for the maximum size vessel for which the SPM is designed, or other vessel of a smaller size if the smaller vessel is apt to impose higher loads. For a mooring system with several anchor legs of different size or construction, an operating anchor load is to be established for each anchor leg. Model test data and/or calculations are to be submitted to establish the validity of the operating anchor load.

4.3 Loads from the Design Environmental Condition

Design loads are to be established for the SPM structure, each anchor leg, and the foundation as applicable for the design environmental condition as described in 3-1-2/4.1. Model test data and/or calculations are to be submitted to establish the validity of these loads.

5 Fatigue Loading

For tower mooring system, fatigue analysis of the structure is to be performed in accordance with the Offshore Installation Rules. For SPMs with novel designs or buoys with permanently moored vessels, fatigue analysis of the structure is to be performed in accordance with Offshore Installation Rules or FPI Rules, as appropriate.

SECTION 2 Structural Design

1 General

1.1

An SPM structure is generally characterized as a floating or fixed type.

1. Floating SPM Structure

A floating SPM structure consists of a buoyant hull held in position by anchor leg(s) that transmit mooring forces to the seabed, the equipment and piping used to carry fluid cargo or products, and provides a platform for hawser mooring attachment points.

2. Fixed SPM Structure

Fixed SPM structures, such as a SALM (Single Anchor Leg Mooring) or a tower mooring, are typically supported at the seabed by piles or a gravity based foundation. A SALM is often designed as buoyant structure, while a tower mooring may be designed with tubular members. The structure supports the equipment and piping used to carry fluid cargo or products, and provides a platform for hawser (or rigid) mooring attachment points.

2 General Design Criteria

2.1 Strength of Structure

The structure and framing members are to be of adequate size and strength to withstand the mooring, environmentally induced, and other loads established in Section 3-2-1. Each mooring attachment point between vessel and the SPM is to be designed to withstand an appropriate portion of the total operating mooring load on the connecting structure (hawser or rigid yoke). Each anchor attachment point or pile foundation is to be designed to withstand the loads from the Design Operating Condition and the Design Environmental Condition. Stress levels due to loads as determined from Section 3-2-1 are to be within the requirements given in 3-2-2/3 and 3-2-2/4.

2.2 Pile Foundation

For an SPM structure intended to be anchored by piles, the pile design is to be in accordance with the appropriate sections of API RP 2A-WSD, Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms.

2.3 Corrosion Control

Where deemed necessary to suit the particular type and service of the structure, a reduction in scantlings in association with protective coatings with or without sacrificial anodes may be considered from those determined by the requirements in 3-2-2/5.1, 3-2-2/5.2, and 3-2-2/5.3. The maximum reduction that will be allowed is 10% of the shell plating, but not more than 3 mm, provided that the section modulus reduction is no more than 10%. In such instances, the justification for the reduction is to be submitted for review together with the particulars of the coatings with or without sacrificial anodes including the program for maintenance. The plans are to show the required and proposed scantlings, both suitably identified. Where any of the proposed reductions are approved, a notation will be made in the Record that such reductions have been taken.

Where scantlings and structural design are determined by the requirements of 3-2-2/3 and 3-2-2/4, or by alternative structural design methods other than the requirements in 3-2-2/5, the following apply:

- (i) Where effective methods of corrosion control are provided, additional scantlings may not be needed. The particulars of the coatings with or without sacrificial anodes including the program for maintenance are to be submitted.
- (ii) Where effective methods of corrosion control are not provided, the scantlings and structural thicknesses are to be suitably increased by a margin based on expected rates of corrosion particular to the SPM's location and the type of corrosive environment in contact with the structure. The scantling increases are to be submitted to ACS for review.

3 Stresses

3.1 Structural Analysis

The overall structure of the SPM buoy is to be analyzed using appropriate methods, such as frame analysis or finite element methods to determine the resultant stresses for each member, under the loadings stipulated herein. A complete analysis is to be submitted for each of the structural frames

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for review. Full consideration is to be taken of secondary stresses, carryover moments, etc., and of three dimensional aspects such as direction of applied forces or reactions. Consideration is to be given to the need for analysis for each loading condition, including the following:

- (i) Transmission of the operating hawser (or yoke) load from the hawser (or yoke) attachment point(s) to the anchor leg attachment point(s) or to the foundation
- (ii) Application of the maximum anchor load to the anchor leg attachment point including application of appropriate wave and hydrostatic loads, in the case of a floating structure
- (iii) Application of the maximum wave, maximum wind, and maximum current loads in the case of a fixed structure

3.2 Bending Stresses

1. Provisions Against Local Buckling

When computing bending stresses, the effective flange areas are to be reduced in accordance with accepted “shear lag” and local buckling theories. Local stiffeners are to be of sufficient size to prevent local buckling or the allowable stress is to be reduced proportionately.

2. Consideration of Eccentric Axial Loading

In the consideration of bending stresses, elastic deflections are to be taken into account when determining the effects of eccentricity of axial loading and the resulting bending moments superimposed on the bending moments computed for other types of loadings.

3.3 Buckling Stresses

The possibility of buckling of structural elements is to be specially considered in accordance with 3-2-2/4.3. For a fixed SPM structure, the buckling of tubular members is to be evaluated in accordance with the ACS Offshore Installation Rules.

3.4 Shear Stresses

When computing shear stresses in bulkheads, plate girder webs, or shell plating, only the area of the web is to be considered effective. The total depth of the girder may be considered as the web depth.

4 Allowable Stresses

4.1 General

The structural elements of the SPM structure are to be analyzed using the loading cases stipulated below. The resultant stresses are to be determined for each loading case, and the stresses are not to exceed the allowable stresses in 3-2-2/4.2 .

The load cases to be considered are as follows:

- (i) **Design Operating Load Case.** The combined gravity, environmental, and mooring loads for the operating environmental condition, as described in 3-1-2/4.1(1)
- (ii) **Design Environmental Load Case.** The combined gravity and environmental loads for the storm condition, as described in 3-1-2/4.1(2). If mooring loads are present in the design environmental condition they are to be combined with the gravity and environmental loads.

4.2 Member Stresses

Individual stress components and, as applicable, direct combinations of such stresses, are not to exceed the allowable stress (σ), as obtained from the following equation:

$$\sigma = \frac{\sigma_y}{F.S.}$$

Where:

σ_y = Specified Minimum Yield Strength

$F.S.$ = Factor of Safety

For the loading as defined in 3-2-2/4.1(i):
= 1.67 for axial or bending stress
= 2.50 for shear stress

For the loading as defined in 3-2-2/4.1(ii):
= 1.25 for axial or bending stress
= 1.88 for shear stress

4.3 Buckling Considerations

Where buckling of a structural element due to compressive or shear stresses, or both, is a consideration, the compressive or shear stress is not to exceed the corresponding allowable stress (σ) as obtained from the following equation:

$$\sigma = \frac{\sigma_{cr}}{F.S.}$$

Where:

σ_{cr} = critical compressive or shear buckling stress of the structural element, appropriate to its dimensional configuration, boundary conditions, loading pattern, material, etc.

$F.S.$ = Factor of Safety
= 1.67 for the loading as defined in 3-2-2/4.1(i)
= 2.50 for the loading as defined in 3-2-2/4.1(ii)

4.4 Members Subjected to Combined Axial Load and Bending

1. Axial Compression in Combination with Compression due to Bending

When structural members are subjected to axial compression in combination with compression due to bending, the computed stresses are to comply with the following requirements:

$$\begin{aligned} \text{when } \sigma_a/F_a \leq 0.15 : \quad & \sigma_a/F_a + \sigma_b/F_b \leq 1.0 \\ \text{when } \sigma_a/F_a > 0.15 : \quad & \sigma_a/F_a + \frac{C_m \sigma_b}{(1 - \sigma_a/F_e') F_b} \leq 1.0 \end{aligned}$$

and in addition, at ends of members:

$$\begin{aligned} 1.67(\sigma_a/\sigma_y) + \sigma_b/F_b &\leq 1.0 && \text{for the loading as defined in 3-2-2/4.1(i)} \\ 1.25(\sigma_a/\sigma_y) + \sigma_b/F_b &\leq 1.0 && \text{for the loading as defined in 3-2-2/4.1(ii)} \end{aligned}$$

2. Axial Tension in Combination with Tension due to Bending

When structural members are subjected to axial tension in combination with tension due to bending, the computed stresses are to comply with the following requirements:

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$$\sigma_a + \sigma_b \leq 0.6\sigma_y \quad \text{for the loading as defined in 3-2-2/4.1(i)}$$

$$\sigma_a + \sigma_b \leq 0.8\sigma_y \quad \text{for the loading as defined in 3-2-2/4.1(ii)}$$

However, the computed bending compressive stress, σ_b , taken alone shall not exceed F_b .

where:

σ_a = computed axial compressive or tensile stress

σ_b = computed compressive or tensile stress due to bending

σ_y = specified minimum yield strength of the material

F_a = allowable axial compressive stress, which is to be the least of the following:

- (i) Yield stress divided by factor of safety for axial stress specified in 3-2-2/4.2
- (ii) Overall buckling stress divided by factor of safety specified in 3-2-2/4.5(1);
- (iii) Local buckling stress divided by factor of safety for axial stress specified in 3-2-2/4.5(2).

F_b = allowable axial compressive stress due to bending, determined by dividing the yield stress or local buckling stress, whichever is less, by the factor of safety specified in 3-2-2/4.2

$F'_e \equiv$ Euler buckling stress $= \frac{5.15 E}{(Kl/r)^2}$, may be increased by 1/3 for combined loadings as defined in 3-2-2/4.2.

E = Modulus of Elasticity

l = unsupported length of column

K = effective length factor which accounts for support conditions at ends of length l . For cases where lateral deflection of end supports may exist, K is not to be considered less than 1.0.

r = radius of gyration

C_m = Coefficient as follows:

(1) For compression members in frames subject to joint translation (sideways): $C_m = 0.85$

(2) For restrained compression members in frames braced against joint translation and not subject to transverse loading between their supports, in the plane of bending:
 $C_m = 0.6 - 0.4(M_1/M_2)$, but not less than 0.4, where M_1/M_2 is the ratio of the smaller to

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larger moments at the ends of that portion of the member un-braced in the plane of bending under consideration. The ratio M_1/M_2 is positive when the member is bent in reverse curvature and negative when it is bent in single curvature

(3) For compressive members in frames braced against joint translation in the plane of loading and subject to transverse loading between their supports, the value of C_m may be determined by rational analysis. However, in lieu of such analysis, the following values may be used:

- a) For members whose ends are restrained, $C_m = 0.85$;
- b) For members whose ends are unrestrained, $C_m = 1.0$

4.5 Column Buckling Stresses

1. Overall Buckling

For compression members which are subject to overall column buckling, the critical buckling stress is to be obtained from the following equations:

$$\sigma_{cr} = \sigma_y - (\sigma_y^2 / 4\pi^2 E)(Kl/r)^2 \quad \text{when } Kl/r < \sqrt{2\pi^2 E / \sigma_y}$$

$$\sigma_{cr} = \pi^2 E / (Kl/r)^2 \quad \text{when } Kl/r \geq \sqrt{2\pi^2 E / \sigma_y}$$

where:

σ_{cr} \equiv critical overall buckling stress

σ_y \equiv Specified Minimum Yield Strength

E , K , l , r , and σ_y are defined in 3-2-2/4.4(2)

The factor of safety, $F.S.$, for overall column buckling is to be as follows:

(a) For the loading as defined in 3-2-2/4.1(i)

$$F.S. = 1.67 \left[1 + 0.15 \frac{Kl/r}{\sqrt{2\pi^2 E / \sigma_y}} \right] \quad \text{when } Kl/r < \sqrt{2\pi^2 E / \sigma_y}$$

$$F.S. = 1.92 \quad \text{when } Kl/r \geq \sqrt{2\pi^2 E / \sigma_y}$$

(b) For the loading as defined in 3-2-2/4.1(ii)

$$F.S. = 1.35 \left[1 + 0.15 \frac{Kl/r}{\sqrt{2\pi^2 E / \sigma_y}} \right] \quad \text{when} \quad Kl/r < \sqrt{2\pi^2 E / \sigma_y}$$

$$F.S. = 1.44 \quad \text{when} \quad Kl/r \geq \sqrt{2\pi^2 E / \sigma_y}$$

2. Local Buckling

Members which are subjected to axial compression or compression due to bending are to be investigated for local buckling, as appropriate, in addition to overall buckling as specified in 3-2-2/4.5(1).

In the case of unstiffened or ring-stiffened cylindrical shells, local buckling is to be investigated if the proportions of the shell conform to the following relationship:

$$\frac{D}{t} > \frac{E}{9\sigma_y}$$

where:

D = mean diameter of cylindrical shell

t = thickness of cylindrical shell (expressed in the same units as D)

E and σ_y are defined in 3-2-2/4.5(1).

4.6 Equivalent Stress Criteria for Plated Structures

For plated structures, members may be designed according to the von Mises equivalent stress criterion, where the equivalent stress (σ_{eq}), defined as follows, is not to exceed $\sigma_y / F.S.$

$$\sigma_{eq} = \sqrt{\sigma_{xx}^2 + \sigma_{yy}^2 - \sigma_{xx} \sigma_{yy} + 3\tau_{xy}^2}$$

Where:

σ_{xx} = calculated in-plane stress in the x direction

σ_{yy} = calculated in-plane stress in the y direction

τ_{xy} = calculated in-plane shear stress

σ_y = specified minimum yield strength of the material

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F.S. = Factor of Safety
= 1.43 for the loading as defined in 3-2-2/4.1(i)
= 1.11 for the loading as defined in 3-2-2/4.1(ii)

Note: The Factor of Safety will be specially considered when the stress components account for surface stresses due to lateral pressures.

5 Structural Design

The hull and frame(s) which are part of the floating structure are to be designed in accordance with the requirements of 3-2-2/3 and 3-2-2/4. In addition to those requirements, the scantlings of plating, stiffeners, and beams are to meet the requirements of 3-2-2/5.1, 3-2-2/5.2, and 3-2-2/5.3. Alternatively the hull and frame design is to be based on a systematic analysis based on sound engineering principles and accounting for the external static and dynamic pressures imposed by the marine environment and the internal pressure of the contents of tanks and floodable compartments.

5.1 Plating

1. Hull and Watertight Bulkhead Plating

Hull plating is to be of the thickness derived from the following equation:

$$t = (s \times k \times \sqrt{q \times h} / 254) + 2.5 \quad (mm)$$

but not less than 6.5 mm or $s/150 + 2.5$ mm, whichever is greater.

Where:

t = thickness (mm)

s = stiffener spacing (mm)

$$k = \begin{cases} (3.075 \sqrt{\alpha} - 2.077) / (\alpha + 0.272) & (1 \leq \alpha \leq 2) \\ 1 & (\alpha > 2) \end{cases}$$

α = aspect ratio of the panel (longer edge/shorter edge)

$$q = 235 / Y \quad (N/mm^2)$$

Y = specified minimum yield point or yield strength, in N/mm^2 , or 72% of the specified minimum tensile strength, whichever is the lesser

h = for plating, the greatest distance, in m, from the lower edge of the plate to a point defined as the following:

- (a) Void Compartment Space. Where the internal space is a void compartment, the head is to be taken to the maximum permissible draft of the SPM in service.

(b) Areas Subject to Wave Immersion. The highest wave crest level during the most unfavorable design situation, or 1.0 m, whichever is greater.

2. Tank Plating

Where the internal space is a tank, the design head, h , in association with the equation given in 3-2-2/5.1(1), is to be taken from the lower edge of the plate to a point located at two thirds of the distance from the top of the tank to the top of the overflow or 1.0 m, whichever is greater. Where the specific gravity of the liquid exceeds 1.05, the design head, h , in this section is to be increased by the ratio of the specific gravity to 1.05 .

5.2 Stiffeners and Beams

The section modulus, SM , of each bulkhead stiffener or beam in association with the plating to which it is attached, is not to be less than obtained from the following equation:

$$SM = Q f c h s l^2 \quad (cm^3)$$

Where:

$$f = 7.8$$

$c = 0.9$ for stiffeners having clip attachments to decks or flats at the ends or having such attachments at one end with the other end supported by girders
 $= 1.00$ for stiffeners supported at both ends by girders

$h =$ vertical distance, in m, from the middle of length l to the same heights to which h for plating is measured (see 3-2-2/5.1)

$s =$ spacing of stiffeners, in m

$l =$ length, in m , between supports. Where brackets are fitted at shell, deck, or bulkhead supports, and the brackets are in accordance with Table 3-2 and have a slope of approximately 45 degrees, the length l may be measured to a point on the bracket located at a distance from the toe equal to 25% of the length of the bracket.

$Q =$ material strength factor

$= 1.0$ for mild steel

$= 0.8$ for high tensile steel

5.3 Girders and Webs

1. Strength Requirements

Each girder or web which supports a frame, beam, or stiffener is to have a section modulus, SM, not less than obtained from the following equation:

$$SM = Q f c h s l^2 \quad (cm^3)$$

Where:

$$f = 4.74$$

$$c = 1.5$$

h = vertical distance, in m, from the middle of s in the case of girders or from the middle of l in the case of webs, to the same heights to which h for plating is measured (see 3-2-2/5.1)

s = sum of half lengths, in m (on each side of girder or web) of the stiffeners or beams supported

l = length, in m, between supports. Where brackets are fitted at shell, deck, or bulkhead supports, and the brackets are in accordance with Table 3-2 and have a slope of approximately 45 degrees, the length l may be measured to a point on the bracket located at a distance from the toe equal to 25% of the length of the bracket.

Q = material strength factor

= 1.0 for mild steel

= 0.8 for high tensile steel

Where efficient struts are fitted connecting girders or webs on each side of the tanks and spaced not more than four (4) times the depth of the girder or web, the section modulus, SM, for each girder or web may be one-half that obtained from the above.

2. Proportions

Girders and webs are to have a depth not less than $0.125l$ where no struts or ties are fitted, and $0.0833l$ where struts are fitted. The thickness is not to be less than 1% of depth plus 3 mm, but need not exceed 11 mm. In general, the depth is not to be less than 2.5 times the depth of cutouts.

3. Tripping Brackets

Girders and webs are to be supported by tripping brackets at intervals of about 3 m near the change of the section. Where the width of the unsupported face plate exceeds 200 mm, tripping brackets are to support the face plate.

6 Fixed Mooring Structure

The fixed mooring structure is to be analyzed as a space frame taking into account the gravity, functional, environmental, and mooring loads. The analysis is to take into account operating and maximum conditions. For SALM type of mooring structure, the analysis is to be in accordance with the requirements of 3-2-2/3 and 3-2-2/4. The connections between vessel and fixed mooring platform other than those stated in 3-4-1/5 should be adequately designed. The design of the fixed mooring platform is to withstand the operating and design environmental conditions as described in 3-1-2/4.1. A structure with buoyant structural elements is to meet requirements of 3-2-2/3 and 3-2-2/4, while a tower mooring structure designed as a gravity-based fixed structure with tubular members is to be in accordance with the requirements of the ACS Offshore Installation Rules.

7 Additional Structural Requirements

An appropriate system is to be designed to prevent damage to the cargo transfer system due to impact from attendant vessels.

8 Buoyancy Tanks for Hoses/Flexible Risers

The buoyancy tank provides buoyancy to support the weight of hoses and flexible risers belonging to the single point mooring system.

The average shell membrane stress at the test pressure is to be limited to 90% of the minimum specified yield strength when subject to hydrostatic testing, and to 80% of the yield strength under pneumatic testing. The combination of average shell membrane stress and bending stress at design operating pressure is to be limited to 50% of the ultimate strength, or the minimum specified yield strength, whichever is less. When the external pressure is not compensated by internal pressure the stress values are also to be checked against critical buckling.

9 PipeLine End Manifold (PLEM)

The PLEM is required to sustain the maximum anticipated loads from the underbuoy hose/flexible riser under conditions defined in 3-2-2/4.1. Loads on the PLEM and the buoy from the underbuoy hoses/ flexible riser are to be calculated from an appropriate analysis. The structural design of the PLEM and its foundation are to be in accordance with the ACS Offshore Installation Rules. Refer to Section 4-1-4 of these Rules for the design of the PLEM piping, valves flanges and fittings.

Part 3 Mooring System Design

Chapter 2 Design

Section 2 Structural Design

Table 3-2: Thickness and Flanges of Brackets and Knees (mm)

Depth of Longer Arm	Thickness		Width of Flange
	Plain	Flanged	
150	6.5		
175	7.0		
200	7.0	6.5	30
225	7.5	6.5	30
250	8.0	6.5	30
275	8.0	7.0	35
300	8.5	7.0	35
325	9.0	7.0	40
350	9.0	7.5	40
375	9.5	7.5	45
400	10.0	7.5	45
425	10.0	8.0	45
450	10.5	8.0	50
475	11.0	8.0	50
500	11.0	8.5	55
525	11.5	8.5	55
550	12.0	8.5	55
600	12.5	9.0	60
650	13.0	9.5	65
700	14.0	9.5	70
750	14.5	10.0	75
800		10.5	80
850		10.5	85
900		11.0	90
950		11.5	90
1000		11.5	95
1050		12.0	100
1100		12.5	105
1150		12.5	110
1200		13.0	110

Note: The thickness of brackets is to be suitably increased in cases where the depth at throat is less than two-thirds that of the knee.

Chapter 3 Stability

SECTION 1 Stability and Watertight/Weathertight Integrity

1 Stability

The hull is to be divided by bulkheads into watertight compartments. Watertight manholes are to be provided for access to all main floodable compartments.

1.1 Intact Stability

1. Conditions

The hull is to be stable under the following conditions:

- (i) In calm water without mooring leg(s) in place
- (ii) During installation
- (iii) In the operating environment with all mooring legs in place and pretensioned under the operating hawser load
- (iv) Under tow, if the buoy is towed

2. Design Verification

The designer is also to verify the following:

- (1) The metacentric height shall be positive in the calm water equilibrium position for all afloat conditions without any mooring leg(s) in place.
- (2) The righting energy (area under the righting moment curve) at or before the angle of the second intercept of the righting and the overturning moment curve or the down flooding angle, which is less, is to reach a value of not less than 40% in excess of the area under the overturning moment curve to the same limiting angle. Overturning moments shall be taken as moments which result from the environmental and operational loads during towout,

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installation and operation where applicable. Static angle of heel due to overturning moment is to be below the first downflooding point.

- (3) The hull shall reserve enough buoyancy so that the buoy will not capsize or sink due to the pull of the anchor legs under pretension and of the underbuoy hoses/flexible risers under the Design Environmental Condition.
- (4) The stability shall be calculated in a disconnected mode corresponding to environmental conditions with a return period of 100 years.

1.2 Damage Stability

The designer is to verify that the buoy has enough reserve buoyancy to stay afloat in a condition with at least one compartment (adjacent to the sea) damaged. It is also required to verify that the final damage waterline is below the first downflooding point in a damage equilibrium condition with one compartment damaged under the design operating condition.

Chapter 4 Equipment

SECTION 1 Anchoring and Mooring Equipment

1 General

The mooring legs and anchors of an SPM are to be designed to protect against the failure of the underbuoy hose or riser with one anchor line broken, for the design environmental conditions described in 3-1-2/4.1.

2 Anchor Points

The anchors are to be designed to have adequate holding capacity. For mooring systems with drag anchors, the holding capacity of each anchor is to be determined by using the soil characteristics of the bottom samples. The type of anchorage for the anchor leg(s) is to be selected according to conditions of the seabed and the maximum design anchor load.

The factor of safety is defined as the minimum holding capacity of an anchor divided by the maximum design anchor load. The required minimum factors of safety, given below, depend on whether the mooring system is considered intact or broken and how the design loads are calculated. The minimum required factors of safety can be based on one of the following two options. The option selected is to match that used in 3-4-1/3.

Option 1

When the mooring system is considered as being intact and the design loads are calculated in accordance with 3-2-1/4.1 and 3-2-1/4.2, required minimum factors of safety are:

For the Design Operating Load Case of 3-2-2/4.1(i): 2.0

For the Design Environmental Load Case of 3-2-2/4.1(ii): 1.5

Where lower factors of safety of anchor leg(s) are desired with additional mooring analysis for any one line broken case as indicated in 3-4-1/3, the factor of safety on the holding capacity of the anchor in a broken line case for the Design Operating Load Case should not be less than 1.60.

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Option 2

The criteria of 3-4-1/4.

In the case of an SPM system using anchor piles, it is recommended that pile foundations be designed to comply with the appropriate sections of API RP 2A. A pile driving record or pile grouting record is to be taken and submitted for each pile. The method of installation of the piles and the equipment employed is to be included in the pile driving record.

Where the anchoring system uses gravity boxes, resistance against sliding, uplifting, and overturning of the gravity boxes are to be analyzed. The forces due to environmental, gravity and mooring are to be taken into account appropriately. Scour effects on the gravity boxes are to be considered in the design.

Where a Vertically Loaded Anchor (VLA) is used, reference is to be made to 3-4-1/4.

After the mooring system is deployed, each mooring line will be required to be pull-tested. During the test, each mooring line is to be pulled to the maximum design load determined by dynamic analysis for the intact design condition and held at that load for 30 minutes in presence of ACS Surveyor. The pull test load is to be the greater of the following two values:

- Maximum design load of mooring line for the Design Operating Load Case
- Maximum design load of mooring line for the Design Environmental Case

For certain high efficiency drag anchors in soft clay, the test load may be reduced to not less than 80 percent of the maximum intact design load. For all types of anchors, the attainment of design-required minimum soil penetration depth is to be verified at the site.

ACS will determine the necessity of a maximum intact design tension pull test depending on the extent of the geotechnical investigation, the magnitude of loading, analytical methods used for the geotechnical design and the experience with the soils in the area of interest. For suction piles, ACS will review the pile installation records to verify the agreement between the calculated suction pressures and the suction pressure used to install the suction piles. For conventional piles, ACS will review the pile installation records to verify agreement between the calculated pile driving blow counts and the actual blow counts required to drive the piles to the design penetrations.

If the maximum intact design tension pull tests are waived, ACS will require preloading each anchor to a load that is necessary to develop the ultimate holding capacity of the anchor, but not less than the mean intact design tension, and to verify the integrity and alignment of the mooring line.

3 Anchor Leg(s)

The minimum factor of safety against the breakage of each anchor leg component can be based on one of the following two options. The option selected is to match that used in 3-4-1/2.

Option I

When the mooring system is considered as being intact and the design loads are calculated in accordance with 3-2-1/4.1 and 3-2-1/4.2, required minimum factors of safety are:

For the Design Operating Load Case of 3-2-2/4.1(i): 3.0

For the Design Environmental Load Case of 3-2-2/4.1(ii): 2.5

A lower factor of safety of 2.5 for anchor leg components will be allowed for the intact Design Operating Load Case if an analysis of the mooring system with any one line broken provides a factor of safety of at least 2.00 with respect to the minimum breaking strength of anchor leg component(s).

Option II

The criteria of 3-4-1/4.

The mooring structure of a fixed SPM system is to be designed in accordance with 3-2-2/6.

4 Anchors and Chains

Anchors and Chains are to comply with the requirements of Part 2 of ACS Rules for Classification of Vessels. Equipment designed to other standards will be specially considered.

5 Mooring between Vessel and SPM

When hawsers are used as the connecting links, they are to be designed using the following factors of safety on the breaking strength of the weakest part:

- With one fairlead: F.S. = 1.67
- With multiple fairleads: F.S. = 2.50

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The strength of ropes or hawsers is to be determined in accordance with and certified to the latest version of *OCIMF Prototype Rope Testing*.

The breaking strength of spliced rope is to be established by appropriate testing. The breaking strength of the hawser to be used is to be the lower value of the hawser in wet or dry condition.

Where the vessel is moored to the SPM using hawsers running through more than two fairleads on the vessel, the hawser loads are to be calculated as if there are only two fairleads.

Hawser manufacture is to comply with the *OCIMF Quality Control and Inspection during the Production of Hawsers*.

When a rigid mooring structure is used as the mooring structure between the vessel and the SPM, the connecting structures are to comply with ACS MODU Rules.

6 Structural Components

If not indicated elsewhere in these Rules, the structural and mechanical components (mooring hardware (e.g., connecting links, shackles, chain stoppers, fairleads, etc.)) which transmit the mooring loads are to be designed to the Minimum Breaking Load (MBL) of the mooring line. Items such as chain stoppers and fairleads can be designed to other criteria if it is intended that they are to maintain structural integrity after failure of the mooring line.

PART

4

Equipment and System

Chapter 1 Cargo or Product Transfer Systems

SECTION 1 General

1 Application

The provisions of this Chapter are applicable to the cargo or product transfer system and associated components of single point moorings (SPM). The cargo or product transfer system includes all system components from the seafloor connection to a pipeline to the first flange on the loading tanker or other type of unit. Pipe Line End Manifolds (PLEMs), if provided, are to comply with the provisions of this Chapter.

1.1 Conditions Applicable to Pipeline Connection

The following conditions apply to the PLEM or connection between the undersea pipeline and the underbuoy hoses/flexible risers:

- (i) It is to be anchored to the sea bottom to resist forces due to waves, current, and forces imposed by the SPM and the undersea pipeline.
- (ii) A means of closure is to be provided to permit isolation of the SPM from the undersea pipeline.

2 Material

Refer to 2-1-2/4 for material requirements for cargo or product transfer systems.

SECTION 2 Hoses/Flexible Risers

1 General

The length of the hose/flexible riser system, provision for buoyancy, spreaders between hoses/flexible risers, external restraints (if required), and angle of connection to the pipeline end and the SPM are to be established taking into account at least the following:

- (1) Maximum excursion of the SPM structure both under the operating conditions with a moored vessel and the design conditions without a moored vessel;
- (2) Motion of the components of the system;
- (3) External forces on the hose/flexible riser system;
- (4) Range of specific gravity of the contents of the hose/flexible riser system including the various cargoes anticipated and sea water;
- (5) Installation tolerances

2 Underbuoy Hoses/Flexible Risers

The system is to be designed to avoid chafing of underwater hoses/flexible risers due to contact with the SPM hull or buoy, anchor legs or applicable mooring system, seabed, and other hoses/flexible risers (if any). Systems designed with wear protection against incidental seabed contact in design environmental condition will be specially considered. Checking of designs for interference is required. Adequately reinforced hoses/flexible risers in areas of maximum hose/flexible riser flexing are to be provided. The procedures for installation, removal (if applicable), and maintenance are to be submitted for review.

3 Floating Hoses

Lifting arrangements are to be provided at the end of the floating hose. Special hose is to be provided at the vessel end to accommodate the bending of the hose over the vessel rail (Tanker Rail Hose). The vessel end of the hose is to be provided with a blind flange to avoid

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contamination of the sea water. Consideration is to be given to providing swivels, specially reinforced hose, or both, at the connection of the floating hose with components of the SPM system. Consideration is to be given to providing a breakaway coupling with shutoff valves in each floating hose string to provide surge and axial overload protection to the hose string, and to minimize pollution in the event of an excessive pressure surge or tanker breakout.

4 Construction

All hose is to comply with the *OCIMF Guide to Manufacturing and Purchasing Hoses for Offshore Moorings* and is to be manufactured to ACS Survey and Inspection. Prototype hose approval in accordance with Section 3 of this standard is required.

Variations from the *OCIMF Guide* as required to satisfy the system's operating conditions will be considered on a case-by-case basis. Adequate justification for such variations will be required.

The bolting and gasket materials and design are to comply with an applicable recognized design standard and be suitable for their intended service.

Flexible risers, if utilized, are to meet the requirements found in the *API RP 17B: Recommended Practice for Flexible Pipe*.

5 System Design Pressure

Design pressure is defined as the larger of:

- (i) The shut-off head at the vessel's manifold at zero flow, plus the gravity head of the contents to the part of the SPM pipe or hose in question.
- (ii) The head calculated due to surge pressure, resulting from design valve closing times.

6 Testing

Each length of hose is to be subjected to hydrostatic and vacuum tests in accordance with requirements of the *OCIMF Guide to Manufacturing and Purchasing Hoses for Offshore Moorings*. These tests are to be witnessed by a Surveyor. In all cases where the design pressure of the system exceeds 15.5 bar, the hydrostatic test is to be carried out at not less than the design pressure. Where flexible risers are used, they are to be tested using recognized standards.

SECTION 3 Cargo or Product Swivels and Related Systems and Equipment

1 Cargo or Product Swivels

1.1 Design

Cargo or product swivels are to be of steel construction with flanged or welded connections. Details of the swivel connecting stationary SPM piping with rotating piping are to be submitted for approval. Such details are to include fixed and rotating parts details, plate thicknesses, nozzle locations and arrangement, seal and bearing design, and welding.

The swivel design is to consider the most adverse combination of applicable loads. At least the following loads are to be considered:

- (i) Breakaway torque required for each swivel at maximum design pressure
- (ii) Weight of swivel and its structural components
- (iii) Dynamic loads due to vessel motion
- (iv) Piping loads
- (v) Mooring forces
- (vi) Pressure loads
- (vii) Thermal loads

Pressure retaining components of the swivel are to be designed in accordance with a recognized standard such as the *ASME Boiler and Pressure Vessel Code*. Structural components of the swivel and driving mechanism are to comply with Section 3-2-2 of these Rules, the ASME code, or other recognized structural design standard.

1.2 Testing

Testing is to be conducted at the manufacturer's plant in accordance with an approved test procedure in the presence of a Surveyor. The procedure is to address acceptable leakage criteria and is to specify the following tests as a minimum:

- (1) Hydrostatic pressure test to at least 1.5 times the design pressure for at least two hours.
- (2) Hydrostatic pressure test to design pressure through two complete revolutions in each direction at a rate of approximately ten minutes per revolution.

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(3) Hydrostatic pressure test to design pressure through four complete revolutions. The first revolution is to be clockwise, and the final counterclockwise. Each rotation is to be in stages of 30 degrees at a rate of approximately 30 seconds per 30 degrees with a 30 second pause between each 30 degree rotation. For each 30 degree rotation, the breakaway torque and the rotating torque are to be recorded. Where fluid assembly swivel rotates in unison with mooring swivel, this test is to be conducted on the combined system.

2 Leak Monitoring, Recovery and Pressurization System

All piping for leak recovery and pressurization systems is to be of steel construction or equivalent and designed in accordance with *ASME B31.3*.

A pressure balanced, or over-pressured, isolation seal shall be used between the primary seal and the product in gas or gas containing production fluid swivels.

3 Bearings

3.1 Mooring Bearings

Bearings which carry the operating hawser load, rotating structure load and mooring load are to be designed with a safety factor of not less than 2 without destructive yielding of the bearing surfaces.

Bearing mounting bolts are to be designed in accordance with recognized standards. For high tension bolts stress corrosion cracking is to be considered.

3.1 Swivel Bearings

Swivel bearings that do not carry the hawser load are to be designed in accordance with AFBMA Codes (Anti Friction Bearing Manufacturers Association) or other recognized industry standards.

4 Corrosion Protection

The swivels are to be coated on the outside with a suitable corrosion resistant coating. This coating will not be required for parts made of corrosion resistant material. The possibility of corrosion due to the presence of CO₂, O₂, or H₂S in the cargo or product fluid is to be considered in the swivel design.

SECTION 4 Cargo or Product Piping Systems

1 Piping

All piping for the cargo or product transfer system mounted on the SPM is to be of steel with welded or flanged connections. Piping is to be securely mounted on the SPM and anchored to resist the forces resulting from internal pressure and flow in the system and loads induced by the hose/flexible riser system connected to it. Provision is to be made for expansion. Piping is to be shop tested after fabrication to a minimum pressure of 1.5 times the design pressure in the presence of a Surveyor.

Cargo or product piping installed on SPMs is to comply with *ASME B31.3* and other applicable recognized standards, except that piping less than Standard weight should not be used. Standard weight pipe is defined as the American National Standards Institute Schedule 40 up to a maximum wall thickness of 9.5 mm.

2 Valves

A shutoff valve is to be provided on the SPM for each cargo transfer line. Valves are to be of steel construction and capable of manual operation. Valves are to be constructed and tested in accordance with recognized standards such as those of the American National Standards Institute (ANSI). Non-standard valves are those valves that are not certified by the manufacturer as complying with a recognized standard. The use of nonstandard valves is subject to special consideration and drawings of such valves showing details of construction and materials are to be submitted for review, as well as the basis for valve pressure rating, such as design calculations or appropriate burst test data.

3 Flanges and Fittings

Flanges and fittings are to be constructed and tested in accordance with recognized standards such as those of the American National Standards Institute (ANSI). Nonstandard flanges and fittings are those components that are not certified by the manufacturer as complying with a recognized standard. The use of non-standard flanges and fittings is subject to special consideration and drawings of such components showing details of construction, materials and design calculations or test results are to be submitted for review.

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4 Expansion Joints

Expansion joints are to have a maximum allowable working pressure of no greater than one third of the hydrostatic bursting pressure of the joint. For nonmetallic expansion joints, cross sectional drawings of the joint showing construction of the joint including end fitting attachment and a bill of materials are to be submitted for review. Results of the burst test are to be submitted for review.

For metallic bellows expansion joints, cross sectional drawings of the joint along with a bill of materials are to be submitted for review. Calculations and/or burst test results verifying the pressure and temperature rating and fatigue life are to be submitted for review.

5 PLEM Piping

The requirements of 4-1-3/1, 4-1-3/2 and 4-1-3/3 are also applicable to the piping, valves, flanges and fittings forming the Pipe Line End Manifold (PLEM).

Alternatively, the PLEM may also be constructed and tested in accordance with *ASME B31.4 Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids*.

6 Corrosion Protection

The cargo or product piping, valves and fittings are to be coated on the outside with a suitable corrosion resistant coating. This coating will not be required for parts made of corrosion resistant material. The possibility of corrosion due to the presence of CO₂, O₂, or H₂S in the cargo or product fluid is to be considered in the piping design.

Chapter 2 Ancillary Systems and Equipment

SECTION 1 Requirements for Ancillary Systems and Equipment

1 General

Ancillary systems such as hydraulic, pneumatic, fuel, ballast, telemetry, controls; etc., which may be provided on a single point mooring are to comply with the applicable requirements of the ACS MODU Rules, except as specified in this Section.

2 Bilge Pumping

Single point moorings are to be provided with a means for pumping from and draining all tanks and void compartments. Pumping by means of a portable hand operated pump would be acceptable in lieu of a fixed bilge system.

3 Tank Sounding

A manual means of sounding is to be provided for all tanks and void compartments. A sounding pipe is to have a screw cap with chain, a gate valve, or equivalent.

4 Tank Venting

All tanks that are filled or emptied through fixed pumping arrangements and all voids through which pressure piping passes are to be fitted with vent pipes.

The structural arrangement of tanks or voids requiring a vent is to be such as to permit the free passage of air and gasses from all parts of the spaces to the vent pipes. Each tank or void requiring a vent is to be fitted with at least one vent pipe, which is located at the highest part of the tank. Vent pipes are to be arranged to provide adequate self-drainage under normal

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conditions. Vent outlets on the open deck are to terminate by way of return bends. Satisfactory means, permanently attached, are to be provided for closing the vent pipes.

The internal diameter of each vent pipe is not to be less than 51 mm unless specially approved otherwise. Where tanks are to be filled by pump pressure, the aggregate area of the vents on the tank is to be at least 125% of the effective area of the filling line. Notwithstanding the above, the pump capacity and pressure head are to be considered in the sizing of the vents.

Vent pipes are to terminate in the weather and their height is to be at least 760 mm above the deck except where this height may interfere with the working of the SPM, a lower height may be approved provided that the closing arrangements and other circumstances justify a lower height.

5 Ancillary Components

Ancillary mechanical components such as hoists, winches, quick connect and disconnect devices, are to be designed in accordance with applicable industry standards, codes and published recommended practices.

Chapter 3 Hazardous Areas and Electrical Systems

SECTION 1 Hazardous Areas

1 Definitions

Hazardous Areas: Hazardous areas are all those areas where a flammable atmosphere may be expected to exist continuously or intermittently. Hazardous areas are subdivided into Zones 0, 1 and 2 defined as follows:

Zone 0: A zone in which an explosive gas-air mixture is continuously present or present for long periods.

Zone 1: A zone in which an explosive gas-air mixture is likely to occur in normal operating conditions.

Zone 2: A zone in which an explosive gas-air mixture is not likely to occur, and if it occurs, it will exist only for a short time.

Enclosed Space: An enclosed space is considered to be a space bounded by decks and bulkheads which may or may not have doors, windows, or other similar openings.

2 Classification of Areas

The area within 3 meters of a cargo or product swivel is considered a Zone 2 area when in a non-enclosed area.

When a cargo or product swivel is installed within an enclosed space, the space is considered a Zone 1 area.

The inside of tanks, swivels, or pipes containing hydrocarbons are considered Zone 0 areas.

In addition to the hazardous areas defined above, the principles of *API RP 500 Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2*; or *API RP 505 Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2* are to be considered in delineating hazardous areas associated with components of the single point mooring.

SECTION 2 Electrical Installations

1 General

Electrical installations onboard single point moorings are to comply with the requirements of the ACS MODU Rules and the additional or modified requirements contained in this Section. Alternatively, consideration will be given to installations that comply with the requirements contained in this Section and applicable recognized standards, provided that they are not less effective.

2 Cables and Types of Electrical Equipment Permitted in Hazardous Areas

2.1 Electrical Equipment

The following equipment and cables are acceptable for installation in hazardous locations:

1. Zone 0 Areas

Only certified intrinsically-safe circuits or equipment and associated wiring are permitted in Zone 0 areas.

2. Zone 1 Areas

Equipment and cables permitted in Zone 1 areas are to be:

- (i) Certified intrinsically-safe circuits or equipment and associated wiring
- (ii) Certified flameproof (explosion proof) equipment
- (iii) Certified increased safety equipment; for increased safety motors due consideration is to be given to the protection against overcurrent
- (iv) Pressurized enclosure type equipment (pressurization systems are to comply with applicable industry standards)
- (v) Permanently installed cables with metallic armor, a metallic sheath, or installed in metallic conduit with explosion proof gastight fittings. Exception: flexible cables, where necessary, may be installed provided they are of heavy duty type.

3. Zone 2 Areas

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Equipment and cables permitted in Zone 2 areas are all equipment approved for Zone 1 areas and the following equipment provided the operating temperature does not exceed 315°C and provided any brushes, switching mechanisms, or similar arc-producing devices are approved for Zone 1 areas:

- (1) Enclosed squirrel-cage induction motors
- (2) Fixed lighting fixtures protected from mechanical damage
- (3) Transformers, solenoids, or impedance coils in general purpose enclosures
- (4) Cables with moisture-resistant jacket (impervious sheathed) and protected from mechanical damage

2.2 Cable Installation

Electrical conductors are to be run with a view to avoiding as far as practical, spaces where gas may normally be expected to accumulate. No cable splices are allowed in hazardous areas except in intrinsically-safe circuits. Where it is necessary to join cables in a hazardous area (e.g., flexible cable connections to non-flexible cables), the joints are to be made in approved junction boxes.

3 Electrical Swivels

If installed in a hazardous area, the electrical swivel is to be certified by an independent testing laboratory as suitable for installation within such an area as per Section 4-3-1 of these Rules.

The amperage ratings of electrical swivels (slip rings) are to be adequate to carry the full load current of the equipment supplied.

Chapter 4 Safety Provisions

SECTION 1 General

1 Navigation Aids

1.1 Obstruction Lights

Obstruction lights are to be provided as prescribed by the National Authority having jurisdiction. If the SPM is located outside the territorial waters of any National Authority or if no lights are prescribed by the authority having jurisdiction, the following is to be provided as a minimum:

- One 360 degree white light visible for five miles under an atmospheric transmissivity of 0.85, flashing six times per minute, and arranged for operation at least from sunset to sunrise local time.
- It is recommended that the floating hoses be marked with winker lights.

1.2 Fog Signal

Audible fog signals are to be provided if prescribed by the National Authority having jurisdiction.

1.3 Radar Reflector

A radar reflector is to be provided if prescribed by the National Authority having jurisdiction.

2 Fire Fighting Equipment

SPMs are to be equipped with at least one B-II type portable fire extinguisher. Where the risk of an electrical fire also exists, one C-II type portable extinguisher is also to be provided. In lieu of providing two extinguishers, consideration will be given to a single extinguisher of a type suitable for both oil and electrical fires. A B-II rated portable extinguisher could be 9 liter foam, 5 kg carbon dioxide or 5 kg dry chemical. A C-II rated portable extinguisher could be 5 kg carbon dioxide or 5 kg dry chemical.

3 Identification Marks

A name or number is to be assigned to each single point mooring and is to conform to requirements of the National Authority having jurisdiction. This name or number is to be permanently displayed on the structure and will be entered in the ACS Record. Draft marks are to be permanently marked in at least two places on the outside of the buoy hull indicating maximum permissible draft.

PART

5

Testing and Surveys

Chapter 1 Testing During Construction

SECTION 1 Requirements for Testing During Construction

1 Tank, Bulkhead and Fittings/Tightness Testing

1.1 General

After all hatches and watertight accesses are installed, penetrations including pipe connections are fitted, all tanks and watertight bulkheads or flats are to be tested and proven tight. Refer to Table 5-1 for specific test requirements. Close visual examination combined with NDT may be accepted in certain areas where specialty approved, as an alternative to hose testing.

1.2 Tank Testing

A tank testing procedure is to be submitted for review and approval. Table 5-1 lists the types of tests which normally apply.

Where permitted in Table 5-1, air testing or combined air hydrostatic testing by an approved procedure may be accepted unless the specified test is deemed necessary by the Surveyor. Where air testing is adopted, all boundary welds, erection joints and penetrations including pipe connections are to be examined under the approved test procedure with a suitable leak indicator solution prior to the application of special coatings. Air test pressure differential should normally be 0.137 bar. Means are to be provided to prevent accidental overpressuring of tanks during testing. Air pressure drop testing (i.e., checking for leaks by monitoring drop in pressures) is not an acceptable substitute for required hydrostatic or air/soap testing.

Tank testing is to be carried out to the satisfaction of the attending Surveyor, and additional or alternative testing may be required at the Surveyor's discretion.

1.3 Hydrostatic Testing

Tank designs and configurations of a non-conventional nature may be required to be hydrostatically tested. Tanks or units which will be submitted in service and designed to withstand external hydrostatic loading will require hydrostatic testing unless otherwise approved. When hydrostatic testing applies, tests may be carried out before or after the buoy is launched. Special coatings may be applied before hydrostatic testing provided all welded joint and penetrations are visually examined to the satisfaction of the Surveyor before special coating is applied.

1.4 Hose Testing for Tanks

Hose testing is to be carried out under simultaneous inspection of both sides of the joint. The pressure in the hose is not to be less than 2.06 bar.

2 Tank Test for Structural Adequacy

In order to demonstrate the structural adequacy, representative hydrostatic testing of tanks or buoyant structures may be required in connection with the approval of the design. In general this would include at least one tank of each type of new or unusual buoy design. Tank test for structural adequacy is to be carried out to the satisfaction of the attending Surveyor.

3 Mooring System Tests

Each anchor leg is to be examined together with attachments and securing devices provided for connection to the buoy. Proper fitting of components, connectors and securing devices is to be demonstrated.

3.1 Anchor Legs

Anchor legs consist of mooring chains, connectors such as shackles, connecting links, and other fittings. These are to be in accordance with Part 2 of ACS Rules for Classification of Vessels and tested in the presence of the attending Surveyor.

Each mooring leg is to be pull tested upon installation in accordance with an approved procedure in the presence of a Surveyor. The pull test is to be in accordance with 3-4-1/2.

3.2 Mooring between Vessel and SPM

Mooring between vessel and SPM, which may include either flexible hawsers or rigid mooring structure (rigid arms and yokes) are to be examined. The hawsers are to be examined and verified for size, materials, specifications, and type of the approved design. Proper fitting and securing of all components is to be verified. NDT of the rigid mooring structure to the SPM buoy is to be carried out to the satisfaction of the attending Surveyor.

3.3 Tower Mooring

A tower mooring designed as a fixed structure, usually made of tubular members, may be used in place of buoyant structure and mooring lines. The testing of such mooring structure is to be in accordance with the ACS Offshore Installation Rules.

3.4 Pile and Anchor

Where piles or gravity boxes are used as anchoring system of an SPM system, NDT is to be performed.

Surveys regarding the manufacturing and testing of anchors are to be in accordance with Part 2 of ACS Rules for Classification of Vessels.

4 Cargo Transfer System

The entire cargo transfer system including hoses/flexible risers, swivels, and valves is to be hydrostatically tested after installation to the design pressure. Refer to 5-1-1/6 and Table5-2 for specific requirements.

5 Control and Safety System

All control and safety equipment is to be examined and proven to be adequate for the intended service. Refer to Table 5-2 for specific requirements.

6 Hoses/Flexible Risers

6.1 Hose/Flexible Riser Testing

Refer to 4-1-2/6 of these Rules.

6.2 Buoyancy Tank Pressure Test

Any buoyancy tank intended to be pressurized to equalize the external pressure will be tested to a pressure 1.5 times the maximum allowable working pressure.

Table 5-1: Initial Tank and Bulkheads Tightness Test Requirements	
Item	Test Method
Tanks	Air Test or Hydro Test
Watertight Bulkheads, Flats and Boundaries	Air Test or Hydro Test
Dry Spaces	Air Test or Hydro Test
Chain Lockers	To be Filled with Water
Hawse Pipes	Hose Test
Watertight Closing Appliances	Hose Test
Oil Storage	Air Test or Hydro Test
Void Space Boundaries Required to be Watertight	Air Test or Hose Test
Note: “Hose Test” in this Table and 5-1-1/1.4 is intended to mean testing of boundaries with a stream of water from a hose provided for this purpose.	

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Table 5-2: Survey and Testing Requirements During Construction

Item	A	B	C	D
Buoy Structure, Buoyancy Element, PLEM Structures, and other Structures	x	x	x	
Piles/Anchors	x	x	x	
Cargo/Product Swivel	x	x	x	
Hydraulic Swivel	x	x	x	
Electrical Swivel			x	
Swivel Driving Mechanism			x	
SPM Main Bearing	x	x	x	
Flexible Risers, Underbuoy Hoses	x	x	x	
Floating Hoses	x	x	x	
Expansion Joints of Piping				x
Mooring Chain, Mooring Wire, Synthetic Mooring Rope and Mooring Components	x	x	x	
Chain Stopper	x	x	x	
Mooring Hawser, Chafe Chain			x	
Standard Valves, Fittings, Flanges				x
Electrical Controls/Telemetry				x
Navigation Aids				x
Load Pins			x	
Winch*			x	
Leak Recovery System			x	
Leak Reservoir	x	x	x	
Hydraulic Power Unit, Umbilical				x
Pig Launcher				x
Remarks:				
* Design Calculations may be required.				
A. ACS Attendance at Vendor's shop to verify materials for compliance with drawings/specification and their traceability record and to review welding and NDT specifications and procedures, and welder and NDT personnel qualification records.				
B. ACS attendance at Vendor's shop during critical phases of fabrication such as fit-up, alignment, and NDT examination as indicated in Test and Inspection plan.				
C. ACS attendance at Vendor's shop in order to witness and report on factory acceptance testing.				
D. Exempt from ACS Shop Inspection and Testing Attendance. Those items may be accepted based on Vendor or manufacturer providing acceptable documentation that component is designed, manufactured, and tested in accordance with an applicable standard or code.				
Refer to all parts of these Rules for further testing requirements.				

Chapter 2 Surveys After Construction

SECTION 1 Conditions for Surveys After Construction

1 Damage

See 1-1-7/1 of the ACS Generic Rules for Conditions of Classification – Offshore Units and Structures (Part 1).

2 Notification and Availability for Survey

See 1-1-7/3 of the ACS Generic Rules for Conditions of Classification – Offshore Units and Structures (Part 1).

3 Annual Classification Surveys

Annual Classification Surveys are to be made within three months either way of each annual anniversary date of the crediting of the previous Special Periodical Survey or original construction date.

4 Special Periodical Surveys

A Special Periodical Survey is to be completed within five years after the date of build or after the crediting date of the previous Special Periodical Survey. The interval between Special Periodical Surveys may be reduced by the Committee. If a Special Periodical Survey is not completed at one time, it will be credited as of the completion date of the survey but no later than five years from the date of build or from the date recorded for the previous Special Periodical Survey. If the Special Periodical Survey is completed prematurely but within three months prior to the due date, the Special Periodical Survey will be credited to agree with the effective due date. Special consideration may be given to Special Periodical Survey requirements in the case of single point moorings of unusual design, in lay-up or in unusual circumstances. The Committee

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reserves the right to authorize extensions of Rule-required Special Periodical Surveys under extreme circumstances.

Special Periodical Surveys may be commenced at the fourth Annual Survey and be continued with a view to completion by the due date. In connection with the preparation for the Special Periodical Survey, thickness gaugings required for the Special Periodical Surveys are to be taken to the extent accessible and practical in connection with the fourth Annual Survey.

Where the Special Periodical Survey is commenced prior to the fourth annual survey, the entire survey is normally to be completed within 12 months if such work is to be credited to the Special Periodical Survey.

5 Continuous Surveys

5.1

At the request of the Owner, and upon the approval of the proposed arrangements, a system of continuous Surveys may be undertaken whereby the Special Periodical Survey requirements are carried out in regular rotation to complete all the requirements of the particular Special Periodical Survey within a five year period.

If the Continuous Survey is completed beyond the five year period, the completion date will be recorded to agree with the original due date of the cycle. If the Continuous Survey is completed prematurely but within three months prior to the due date, the Special Periodical Survey will be credited to agree with the effective due date.

The Committee reserves the right to authorize extensions of Rule required Special Periodical Surveys under extreme circumstances. Each part (item) surveyed becomes due again for survey approximately five years from the date of survey. For continuous Surveys, a suitable notation will be entered in the Record and the date of completion of the cycle published. If any defects are found during the survey, they are to be dealt with to the satisfaction of the Surveyor.

5.2

At a survey approximately four years after each Special Continuous Survey of an SPM hull or buoy has been credited, thickness gaugings that are required for forthcoming Special Periodical Survey that are accessible are to be taken.

6 Lay-up and Reactivation

6.1

ACS is to be notified by the Owner that the SPM has been laid-up or otherwise removed from service. This status will be noted in the Record and any surveys falling due during lay-up may then be held in abeyance until the SPM is placed back in service. Lay-up procedures and

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arrangements for maintenance of conditions during lay-up may be submitted to ACS for review and verification by survey.

6.2

In the case where the SPM has been laid up for an extended period (i.e., six months or more) the requirements for the surveys for reactivation are to be specially considered in this case, due regard being given to the status of the surveys at the time of the commencement of the lay-up period and the length and the conditions under which the SPM had been maintained during that period.

6.3

Where the lay-up preparation and procedures have been submitted to ACS for review and survey, and re-verified annually by survey, consideration may be given to deducting part of all of the time in lay-up from the progression of survey intervals, or to modifying the requirements of the updating survey at time of reactivation.

6.4

For an SPM returning to active service regardless of whether ACS has been informed previously that the SPM has been in lay-up, a Reactivation Survey is required.

7 Incomplete Surveys

When a survey is not completed, the Surveyor is to report immediately upon the work done in order that Owners and the Committee may be advised of the parts still to be surveyed.

8 Alterations

No alterations which affect or may affect classification are to be made to the hull or machinery of a classed SPM unless plans of the proposed alterations are submitted and approved by the ACS before the work of alterations is commenced and such work, when approved, is carried out to the satisfaction of the Surveyor. Nothing contained in this section or in the rule or regulation of any government or other administration, or the issuance of any report or certificate pursuant to this section or such a rule or regulation, is to be deemed to enlarge upon the representations expressed in 1-1-1/1 through 1-1-1/6 of the ACS Generic Rules for Conditions of Classification – Offshore Units and Structures (Part 1) thereof and the issuance and use of any such reports or certificates are to in all respects be governed by 1-1-1/1 through 1-1-1/6 thereof.

9 Welding and Replacement of Materials

9.1 Ordinary and Higher Strength Structural Steels

Welding or other fabrication performed on structural steels is to be in accordance with the requirements of Part 2 of ACS Rules for Classification of Vessels.

9.2 Special Materials

Welding or other fabrication performed on other steel or adjacent to such steel is to be accomplished with procedures approved for the special materials involved. Refer to Part 2 of ACS Rules for Classification of Vessels.

9.3 Substitutions and Alterations

Substitutions of steel differing from that originally installed, alteration of original structural configuration, or change from mechanical fasteners to welded joints is not to be made without approval by ACS.

SECTION 2 Drydocking Surveys or Equivalent

1 General

An examination of the underwater parts of each SPM and associated mooring hardware is to be made at intervals not exceeding five years, This examination is to align with the due date of the Special Survey.

Parts to be examined include external surfaces of the SPM. Prior to examination, all mooring and anchoring attachments are to be cleaned including all openings to the sea, if any. Anchor legs including connecting hardware are to be examined over the full length from the lowest exposed point at the seabed to the connection point at the SPM.

2 Underwater Survey in Lieu of Drydocking (UWILD)

Underwater Survey in lieu of Drydocking (UWILD) can be accepted provided the following are satisfied:

- The underwater inspection procedures are to be submitted for review prior to execution of the UWILD.
- Divers carrying out the underwater inspection are to be suitably qualified.
- The condition of the SPM found during the UWILD is to be acceptable.

SECTION 3 Annual Surveys

1 General

At each Annual Survey, the SPM is to be generally examined so far as can be seen and placed in satisfactory condition as necessary. For a fixed mooring system (e.g., tower mooring system), the surveys are to be carried out in accordance with ACS Offshore Installation Rules. For floating SPM systems, the following items are to be examined, placed in satisfactory condition and reported upon:

1.1 Protection of Hatches and other Openings

- (i) Hatchways, manholes, and scuttles
- (ii) Coamings including deck connection, stiffeners, and brackets
- (iii) Hatches fitted with mechanically operated steel covers including cover plating, stiffener, cross joints, gaskets, cleats and dogs. Exposed steel hatch covers are to be examined to confirm structural integrity and capability of maintaining weathertightness. Where significant wastage of hatch covers is noted, thickness gaugings are to be carried out and renewals made as necessary. Proper operation and functioning of hatch covers and securing arrangements is to be confirmed.
- (iv) Ventilators, air pipes together with flame screens, scuppers and discharges serving spaces in the SPM
- (v) Watertight bulkheads, bulkhead penetrations, and the operation of any doors in the same

1.2 Other Areas

- (i) Protection of personnel: guard rails, lifelines, and access ladderways.
- (ii) Verification of loading guidance and stability data as applicable.
- (iii) Verification that no alterations have been made to the SPM which affect the classification, including verification of mooring chain tensions.

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- (iv) Anchoring and mooring equipment.
- (v) Confirmation that electrical equipment in hazardous locations has been properly maintained.
- (vi) Product lines, swivels, and seals.
- (vii) Confirmation that there are no potential sources of ignition in or near the cargo area and that access ladders are in good condition.
- (viii) Cargo equipment and piping apparatus including supports, gland seals, remote control and shutdown devices.
- (ix) Bilge pumping system.
- (x) Ventilation system including ducting, dampers and screens.
- (xi) Verification that cargo discharge pressure gauges and level indicator systems are operational.
- (xii) Structural areas of the SPM hull or buoy particularly susceptible to corrosion, including spaces used for saltwater ballast, as accessible. Thickness gaugings may be required.
- (xiii) Lights, navigational aids, etc., if applicable.
- (xiv) The maintenance records of the SPM system are to be reviewed and verified to the satisfaction of the attending Surveyor.

SECTION 4 Special Periodical Surveys

1 General

Special Survey No. 1 of the SPM hull or buoy is to include compliance with the foregoing Anneal Survey and Drydocking Survey requirements and in addition, the following requirements as listed below are to be carried out as applicable, the parts examined, placed in satisfactory condition, and reported upon.

2 Structure

2.1 SPM Buoy or Platform Structure

The SPM buoy or platform structure including bracing members, tanks, watertight bulkheads and decks, cofferdams, void spaces, sponsons, chain lockers, machinery spaces, and all other internal spaces are to be examined externally and internally for damage, fractures, or excessive wastage. Thickness gauging of plating and framing may be required where wastage is evident or suspected.

Suspect areas may be required to be tested for tightness, non-destructive tested or thickness gauged. Tanks and other normally closed compartments filled with foam or corrosion inhibitors, and tanks used only for lube oil, light fuel oil, diesel oil, or other noncorrosive products may be waived provided that upon a general examination, the Surveyor considers their condition to be satisfactory. External thickness gaugings may be required to confirm corrosion control.

2.2 Mooring Components

Mooring components including, chain stoppers, hawser padeyes, etc., are to be examined.

2.3 Foundations and Supporting Structure

Foundations and supporting headers, brackets and stiffeners from cargo transfer related apparatus, where attached to hull or deck structure are to be examined.

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2.4 Underwater Parts

Survey of parts of the SPM which are underwater and inaccessible to the Surveyor may be accepted on the basis of an examination by a qualified diver carried out in the presence of the Surveyor. Survey by ROV, in lieu of a diver, is to be specially considered. The underwater examination is to be carried out in accordance with an approved procedure using two way audio visual communications.

2.5 Thickness Gaugings

At each Special Survey, thickness gaugings are to be carried out where wastage is evident or suspect. At Special Survey No. 2 and subsequent Special Surveys, representative gaugings will be required. Special attention should be paid to splash zones on the hull, related structure, in ballast tanks, and free-flooded spaces.

2.6 Inspection of Underwater Joints

Where inspection of underwater joints is required, sufficient cleaning is to be carried out in way of, and water clarity is to be adequate to permit meaningful visual, video, camera or NDT examination as required. Every effort should be made to avoid cleaning damage to special coatings.

2.7 Openings to the Sea

All openings to the sea, together with the cocks and valves connected therewith are to be examined internally and externally while the SPM 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.

2.8 Tower Mooring

For the structure of a tower mooring, the applicable requirements of ACS Offshore Installation Rules are to be used.

3 Mooring Hardware

3.1 Complete Mooring System

The complete mooring system including anchors, chains, chain stoppers, mooring line connectors, securing devices, and pilings as applicable are to be examined. Arrangements are to be made for examination of all underwater areas. Areas not accessible by divers may be examined by ROV. All chain and accessories are to be checked for damage or wastage, especially in way of areas of high loading and high relative movement between chain links. These include seabed touch-down areas, chain stoppers and chain connecting shackles. Particular attention should be given to mooring components or complete leg assemblies for further examination.

3.2 Examination Out of the Water

- (i) Removal of one section of the mooring system for examination out of the water will be required at Special Survey No. 4 (20 years of service).
- (ii) When requested in lieu of (i) above, ACS will consider as an alternative the results of a strength analysis and a fatigue assessment performed in accordance with ACS FPI Rules. This alternative entails the dynamic analysis, anchor leg broken conditions, corrosion assumptions, fatigue life predictions, Fatigue Design Factors (FDFs), etc. specified in ACS FPI Rules. The analyses are to consider the loadings to which the SPM has been subjected to in the past, replacements and repairs carried out on the mooring system, the expected condition of the mooring system components as inferred from the inspection of accessible parts and the expected future service of the SPM until the next Special Survey. The submitted analyses are to suitably reflect the completeness and accuracy of the service and condition records of the SPM.

3.3 Components (Flexible or Rigid) for Mooring of the Attached Vessel

Mooring system components (flexible or rigid) for mooring of the attached vessel are to be examined throughout provided this equipment is associated with the classed SPM. NDT of high stressed joints in rigid mooring connection may be required at the Surveyors discretion. Flexible hawsers are to be examined for wear and filament breakage, Items found worn may require replacement.

4 Cargo Hoses or Flexible Risers

4.1 Cargo Hoses

Cargo hoses forming part of the SPM classification are to be removed, disassembled, pressure tested to rated working pressure, and examined at each Special Survey. This requirement applies to all hoses that have been in service for five years. In the event cargo hoses have been renewed or replaced with new hoses within the five year period, the above requirements may be modified and removal and testing deferred until the hose has been in service five years.

Vacuum testing of cargo hoses is required in association with Special Survey or after five years of service as indicated above.

4.2 Flexible Risers

An inspection manual for risers included as part of the SPM classification is to be submitted to ACS for approval. The manual is to include procedures for the following:

- (i) Underwater examination of the flexible risers including arch support buoyancy tanks.
- (ii) Examination of high stress areas such as areas in way of the end flanges, in way of the arch support clamps and the bottom of all looped areas.
- (iii) Examination of wear and tear on spreader bars, if fitted, which separate one riser string from another.
- (iv) Hydrostatic testing of flexible risers to be carried out to working pressure with special attention paid to upper end terminations.
- (v) Examination of wear and tear on connecting links padeyes between buoyancy tanks and their clump weights, if fitted. Non-destructive testing to be carried out if found necessary.

5 Safety Equipment

Safety equipment associated with the classification of the SPM is to be examined and tested as required by the attending Surveyor. Refer to Section 4-4-1 for requirements applicable to the safety equipment.

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6 Swivel and Cargo Transfer Equipment

Swivel assemblies; foundations, seals and associated piping assemblies are to be examined externally. Pressure retaining sections which convey corrosive or erosive materials are to be opened and examined internally. Thickness gaugings may be required to be taken on cargo transfer pipe lines and associated exposed equipment.

Upon completion of the examination, the swivel assembly is to be hydrostatically tested to design pressure and the sealing capability of the swivel is to be verified through one complete revolution.

7 Electrical Installations

Satisfactory operation of equipment is to be verified 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. These values are to be compared with those previously measured. Any large and abrupt decrease in insulation resistance is to be further investigated and either restored to normal or reviewed as indicated by the conditions found.