2017

Guidances for Single Point Mooring

GC-04-E

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APPLICATION OF
"GUIDANCE FOR SINGLE POINT MOORING"

1. Unless expressly specified otherwise, the requirements in the Guidance apply to single point mooring for which contracts for construction are signed on or after 1 July 2017.
2. The amendments to the Guidance for 2001 edition and their effective date are as follows;

Effective Date : 1 July 2017

Chapter 1 CLASSIFICATION REGISTRY AND SURVEYS

Section 1 Classification Registry

- 103. 1. and 2. have been amended.
- 106. 5. has been newly added.
- 107. 1. (16) has been amended.

Section 2 Testing During Construction

- 201. Table 1.2.1 and Table 1.2.2 have been amended.
- 201. 9. has been amended.

Section 3 Surveys After Construction

- 301. 2. (18) has been amended.
- 302. 2. has been amended.
- 303. 3. has been newly added.
- 304. 2. has been amended.
- 304. 3. and 4. have been newly added.
- 306. has been newly added.

Chapter 2 MATERIALS AND WELDING

Section 1 Materials

- 103. 1. has been amended.
- 104. 3. has been amended.
- 104. 5. has been newly added.
- 105. has been newly added.

Section 3 Weld Design

- 301. 2. has been amended.

Chapter 3 DESIGN OF MOORING SYSTEM

Section 1 Site and Environmental Conditions

- 102. 3. and 5. have been amended.

- 103. 2. has been amended.
- 104. 1., 2., 3., 4. and 6. have been amended.

Section 2 Design Loads

- 203. 2. has been amended.
- 204. and 205. have been amended.

Section 3 Structural Design and Stability

- 302. 1. and 2. have been amended.
- 303. 3. has been amended.
- 304., 305., 306. and 307. have been amended.
- 310. has been newly added.

Section 4 Mooring and Anchoring

- 401., 402., 403., 405. and 406. have been amended.
- 407 has been newly added.

Chapter 4 EQUIPMENT AND SYSTEMS

Section 1 Cargo or Product Transfer Systems

- 104. 1., 2. and 4. have been amended.
- 106. 1., 4. and 5. have been amended.

Section 2 Ancillary Systems and Equipment

- 203. has been amended.
- 204. 5. has been amended.

Section 3 Hazardous Areas and Electrical Installations

- 302. 2. has been amended.

Section 4 Safety Provisions

- 403. and 404. have been amended.

CONTENTS

CHAPTER 1 CLASSIFICATION REGISTRY AND SURVEYS

Section 1 Classification Registry

101. Definitions

1. Single point mooring

A simple point morring(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.

2. Fixed SPM

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

3. Floating SPM

A catenary anchored leg mooring(CALM) is an example of a floating SPM.

4. Anchor leg

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

5. 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.

6. Cargo

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

7. Hawser

Mooring line between SPM structure and moored vessel.

8. 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.

9. Floating hose

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.

10. Underbuoy hose

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

11. 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.

12. 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.

13. Flexible riser

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 is usually comprised of one continuous length, used for relatively greater water depth sand constructed to be used totally submerged.

14. Swing circle

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

102. Classification registry

1. SPM built and surveyed in accordance with the Guidances of this Society (hereafter referred to as "the Guidances") or with alternative arrangements equivalent to the Guidances will be assigned a class in the Registration Master Book.

2. SPM classed with the Society are, for continuation of the classification, to be subjected to the periodical surveys, and are to be maintained in a good condition in accordance with the requirements of the Guidances.

3. When a SPM classed with the Society makes an alteration or modification of such an extent as to influence to the SPM's original performances, the plans have to be submitted for the Society's approval before the work is commenced and the alteration work has to be supervised by the Surveyor.

103. Class notations

1. The class notations assigned to the SPM classed with the Society are to be in accordance with the followings:

(1) For SPM built under the supervision of the Society.
+ KRS - Single Point Mooring (SPM Type *)
(Major equipment items included in SPM **)
*: SPM type such as CALM, SALM, VALM, SPMT etc.
**: State major equipment items such as Buoy Body, Sub-sea Pipe Line, Anchor Leg, PLEM, Floating Hose etc.
ex) (Buoy Body, Sub-sea Pipe Line)
(Buoy Body, Sub-sea Pipe Line, Anchor Leg)
(Buoy Body, Sub-sea Pipe Line, Anchor Leg, PLEM etc.)

(2) For SPM considered to be fit as the result of surveys by the Surveyor after construction.
KRS - Single Point Mooring (SPM Type *)
(Major equipment items included in SPM **)
*: SPM type such as CALM, SALM, VALM, SPMT etc.
**: State major equipment items such as Buoy Body, Sub-sea Pipe Line, Anchor Leg, PLEM, Floating Hose etc.
ex) (Buoy Body, Sub-sea Pipe Line)
(Buoy Body, Sub-sea Pipe Line, Anchor Leg)
(Buoy Body, Sub-sea Pipe Line, Anchor Leg, PLEM etc.)

2. The following data on SPM will be published in the Record where applicable.

(1) Latitude and longitude of the location of the mooring
(2) Length over all and maximum displacement of the ship it is designed to moor
(3) Depth of water at the site
(4) Maximum hawser tension where applicable
(5) General types of cargo and other fluids which the mooring is designed to handle.

104. Classification certificate

1. Where single point moorings have undergone the classification survey during or after construction to the satisfaction of the Surveyor and approved by the Classification Committee, the single point moorings will be classed and entered in the Registration Master with the issue of the Classification Certificates.

2. Where single point moorings have undergone the special survey to the satisfaction of the surveyor, the classification certificate is issued newly.

105. Survey report

On completion of the Classification Survey, Special Survey, Annual Survey and Occasional Survey, the Survey Reports will be issued. Survey results, the date and description of the next surveys, etc. are to be stated in the Survey Reports. The Survey Reports will be used as notice to the Owners.

106. Guidances for classification

1. Application of guidances

These Guidances are applicable to unmanned SPM and are generally intended for temporary moored vessels. These Guidances 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 Guidances regarding other features is to be considered as a guidance to the designer, builder, owner, et al.

2. Related regulations

The Society may require to apply the "Rules for Classification of Steel Ships" for items not specified in this Rules.

3. Owner's responsibilities

(1) Responsibilities of report
When any of the following cases occurs, the Owner is to report to the Society without delay:
 (A) When the SPM is sustained with a sea casualty by which her present class is deemed affected.
 (B) When the Owner is changed.
 (C) When the SPM is withdrawn.
(2) Cooperation of survey
 (A) When a ship is to be surveyed, it is the duty of the Owner to inform the Surveyor of the correct place and items of survey.
 (B) The owner, master or their representatives are to attend the survey according to the items to be examined and are to give necessary assistances.

4. Governmental regulations

The Society may require to apply governmental regulations for items not specified in the Guidances.

5. Unconventional Designs

These Rules apply to conventional SPM designs. A conventional SPM provides temporary offshore mooring to a variety of visiting vessels by means of a hawser or yoke from the buoy or fixed tower. Fluid transfer between the visiting vessel and a sea floor pipeline is performed by an underbuoy hose or riser, and a hose between the buoy or tower and the visiting vessel.

An example of a mooring system design that differs from the above concept is one characterized as a detachable turret-type system. In this case the visiting vessel has a unique mating assembly used to join the buoy and the vessel. The mating assembly may be located inside the hull of the visiting vessel, or the assembly may be mounted externally at an end of the vessel. Fluid flow may occur through jumper hoses or piping between the buoy and vessel. The applicability of these Rules to an unconventional design will be decided by the Society on a case-by-case basis. In such a case, the criteria in these Rules is to be in accordance with the **Guidance for Floating Production Units** or are to be at the discretion of the Society.

107. 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. In general, plans are to include the following where applicable.

(1) General arrangement
(2) An arrangement plan of watertight compartmentation, including the location, type and disposition of watertight and weathertight closures
(3) Structural arrangement showing shell plating, framing, bulkheads, flats, main and bracing members, joint details, as applicable
(4) Details of watertight doors and hatches
(5) Welding details and procedures
(6) Corrosion control arrangement
(7) Type, location and amount of permanent ballast, if any
(8) Bilge, sounding and venting arrangements
(9) Hazardous areas
(10) Electrical system one line diagrams
(11) Location of fire safety equipment
(12) Mooring arrangement
(13) Mooring components including anchor leg, associated hardware, hawser, and hawser load-deflection characteristics
(14) Foundations for mooring components, industrial equipment, etc. showing attachments to hull structure
(15) Anchoring system showing the size of anchor, holding capacity of piles, pile sizes, and capacity, etc.
(16) PLEM (Pipe Line End Manifold) where applicable
(17) SPM main bearing
(18) Cargo or Product swivel including swivel driving mechanism, swivel bearing, electrical swivel details
(19) Product or cargo system piping schematic drawing with bill of materials
(20) Design data of equipment, piping, and related components including min. and max. design pressure and temperature
(21) Ancillary piping system schematic drawing with bills of material
(22) Floating and underbuoy hoses/flexible risers
(23) Telemetry/Control system
(24) Navigation aids
(25) Methods and locations for NDT
(26) Plans for conducting underwater inspections in lieu of drydocking
(27) Test and inspection plan for all major load carrying or pressure retaining components including cargo or product swivel, electrical swivel, bearings
(28) Test procedures

2. Site chart

To demonstrate that navigational considerations have been taken into account in establishing the mooring location, a site chart of the mooring are is to be submitted in accordance with **Ch 3** 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

Reports on subjects including the following are to be submitted in accordance with **Ch 3, Sec 1.**

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

4. Calculations

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

(1) Structural design in accordance with **Ch 3, Sec 3**
(2) Stability calculations in accordance with **Ch 3, Sec 3**
(3) Mooring and anchorage in accordance with **Ch 3, Sec 4**
(4) Piping in accordance with Sections **Ch 4, Sec 1** and **Sec 2**
(5) Calculations for all pressure retaining and load bearing components in accordance with **Ch 4**
(6) Swivel stack static and dynamic analysis in accordance with **Ch 4**

5. Additional plans

Where deemed necessary by the Society, submission of additional plans and calculations other than those specified above may be required.

108. Information booklet & maintenance manual

1. For each SPM, a document is to be submitted. This document is to include as follows :

(1) Recommendations regarding operation and maintenance of the SPM facility
(2) The design criteria for the SPM
(3) Information regarding the mooring area
(4) Components of the SPM.

2. Items included in Information Booklet & Maintenance Manual

(1) Site chart
(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 component and details of those component 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 disconnecting a vessel at the SPM.
(8) Recommended procedure for connecting disconnecting floating hose to a tanker's manifold.
(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 rises, 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 & Maintenance Manual is to be submitted for review, by the Society 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. The Society is not responsible for the operation of by the SPM.

The information Booklet & Maintenance Manual required by these Guidances may contain information required by flag Administrations.

Section 2 Testing During Construction

201. Tank, bulkhead and fitting/Tightness Testing

1. General

Following parts are to be tested and proven tight. Refer to **Table 1.2.1** for specific test requirements. Close visual examination combined with NDT may be accepted in certain areas where specially approved, as an alternative to hose testing.

(1) Hatch, watertight passageway
(2) Joint and penetration part of pipe
(3) Tank & watertight bulkhead or flat

2. Tank testing

A tank testing procedure is to be submitted for review and approval.

Table 1.2.1 lists the types of tests which normally apply. Where permitted in **Table 1.2.1,** 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 joint 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. Are test pressure differential should normally be $0.15 \times 10^5 Pa$ ($0.15\ kg/cm^2$). Prior to inspection, it is recommended that the air pressure in the tank is raised to $0.20 \times 10^5 Pa$ ($0.2\ kg/cm^2$) and kept at the level for about 1 hour to reach a stabilized state, with a minium number of personnel in the vicinity of the tank, and then lowered to the test pressure. Means are to be provided to prevent accidental over pressuring 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.

3. Hydorstatic testing

Tank designs and configurations of a non-conventional nature may be required to be hydrostatically tested. Tanks or unit 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 maybe applied before hydrostatic testing provided all welded joint and penetrations are visually examined to the satisfaction of the Surveyor before special coating is applied.

4. Hose testing

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 $2.0 \times 10^5 Pa$ ($2.0\ kg/cm^2$) is to be applied at a maximum distance of $1.5\ m$. The mozzle diameter is not to be less than $12\ mm$.

5. 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.

(1) Anchor legs
Anchor legs consist of mooring chains, connectors such as shackles, connecting links, and other fittings. 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 **Ch 3, Sec 4.**

(2) Mooring between vessel and SPM
Mooring between vessel and SPM which may include either flexible hawsers or rigid mooring structure (rig 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) Tower mooring
Tower mooring designed as a fixed structure, usually made of tubular members, may be used in

place of buoyant structure and mooring lines.

(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 **Pt 4** of "Rules for Classification of Steel Ships".

6. 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 **Table 1.2.1** and **Table 1.2.2** for specific requirements.

Table 1.2.1 Initial tank & Bulkheads tightness test requirements

Item	Test method
Tanks, Watertight bulkheads, Flats & boundaries, Dry spaces, Oil storage, Void space boundaries required to be watertight	Air test or hydro test
Chain lockers	To be filled with water
Hawse pipes, Watertight closing appliances	Hose test
Void space boundaries required to be watertight	Air test or Hose test

7. 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 1.2.2** for specific requirements.

8. Hoses, flexible risers

(1) Hose/Flexible riser testing

Refer to **Ch 4, Sec 1** of these Guidances.

(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.

9. 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.

Table 1.2.2 Survey and Testing Requirements During Construction

Item	A	B	C	D
Buoy structure, Buoyancy element, PLEM Structures and other structure	○	○	○	
Piles, Anchors	○	○	○	
Cargo/Product swivel	○	○	○	
Hydraulic swivel	○	○	○	
Electrical swivel			○	
Swivel driving mechanism			○	
SPM main bearing	○	○	○	
Flexible risers, Underbuoy hoses	○	○	○	
Floating hoses	○	○	○	
Expansion joints of piping				○
Mooring chain, Mooring Wire, Synthetic Mooring Rope and Mooring Components	○	○	○	
Chain Stopper	○	○	○	
Mooring hawser, Chafe Chain			○	
Standard valves, fittings, flanges				○
Electrical controls/telemetry				○
Navigation aids				○
Load Pins			○	
Winch [1)]			○	
Leak Recovery System			○	
Leak Reservoir	○	○	○	
Hydraulic Power Unit, Umbilical				○
Pig Launcher				○

Remarks :

A : The following items to be verified.
- Materials for compliance with drawings/specification and their traceability record
- Welding and NDT specifications and procedures
- Welder and NDT personnel qualification records.

B : To be attended during critical phases of fabrication such as fit-up, alignment, and NDT examination as indicated in Test and Inspection plan.

C : To be attended in order to witness and report on factory acceptance testing.

D : 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 for code.

[1)] : Design Calculations may be required

Section 3 Surveys After Construction

301. Annual surveys

1. Due range

Annual surveys are to be carried out within three(3) months before or after each anniversary date.

2. Survey items

At each Annual Survey, the SPM is to be generally examined so far as can be seen and placed in satisfactory condition as necessary.

(1) Hatch
  (A) Coaming
    (a) Coamings including deck connection
    (b) Hatch cover plating, stiffeners and brackets
  (B) Hatches fitted with mechanically operated steel covers
    (a) Hatch cover(cover plating, stiffener),
    (b) Cross joints
    (c) Gaskets, cleats and dogs
  (C) Exposed steel hatch covers are to be examined to confirm structural integrity and capability of maintaining weathertightness.
  (D) 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.
(2) Manholes, scuttles
(3) Ventilators, air pipes together with flame screens, scuppers and discharges serving spaces in the SPM.
(4) Watertight bulkheads, bulkhead penetrations, and the operation of any doors in the same.
(5) Guard rails, lifelines, and access ladderways.
(6) Verification of loading guidance and stability data as applicable.
(7) Verification that no alterations have been made to the SPM which affect the classification.
(8) Anchoring and mooring equipment including verification of mooring chain tensions.
(9) Confirmation that electrical equipment in hazardous locations has been properly maintained.
(10) Product lines, swivel, seal
(11) Confirmation that there are no potential sources of ignition in or near the cargo area and that access ladders are in good condition.
(12) Cargo equipment and piping apparatus including supports, gland seals, remote control and shut-down devices.
(13) Bilge pumping system.
(14) Ventilation system including ducting. dampers and screens.
(15) Verification that cargo discharge pressure gauges and level indicator systems are operational.
(16) Structural areas of the SPM hull or buoy particularly susceptible to corrosion, including spaces used for salt-water ballast as accessible. Thickness gaugings may be required.
(17) Lights, navigational aids, etc., if applicable.
(18) The maintenance records of the SPM system are to be reviewed to the satisfaction of the attending Surveyor.

302. Special surveys

1. Due range

(1) Special Surveys are to be carried out at a date not exceeding 5 years from the completion date of classification survey or the due date of the previous Special Suruey.
(2) If the Special Surveys are carried out at a date which shall be more than 3 months earlier than the due date of Special Survey, the next Special Survey shall be assigned at th date of 5 years after the completion date of concerned Special Survey.
(3) Special consideration may be given to Special Survey requirements in the case of single point moorings of unusual design in lay-up or in unusual circumstances.
(4) Special Surveys may be commenced at the 4th Annual Survey after Classification Survey or previous Special Survey and be progressed during the succeeding year with a view to com-

pletion by the due date. As part of the preparation for the Special Survey, the thickness measurement as the required for the forthcoming Special Survey are to be taken to the extent accessible and practicable in connection with the 4th Annual Survey.

(5) Where the Special Survey is commenced prior to the 4th Annual Survey, the entire survey is normally to be completed within l5 months if such work is to be credited to the Special Survey. In this case, items are tank test, thickness measurement and docking survey.

2. Requirements of surveys

Special Survey of the SPM hull or buoy is to include compliance with the foregoing Annual Survey and Drydocking Survey requirements and in addition, the following requirements as listed below are to be carried out as applicable.

(1) Floating SPM system
 (A) The following items 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. External thickness gaugings may be required to confirm corrosion control.
  (a) SPM buoy or platform structure including bracing members
  (b) Tanks, cofferdams, void spaces, sponsons, chain lockers, machinery spaces
  (c) Watertight bulkheads and decks
  (d) All other internal spaces
  (e) The following compartments and spaces may be waived provided that upon a general examination, the Surveyor considers their condition to be satisfactory.
   (i) Tanks and other normally closed compartments filled with foam or corrosion inhibitors
   (ii) Tanks used only for lube oil, light fuel oil, diesel oil, or other non-corrosive products
 (B) Mooring components including chain stoppers, hawser padeyes, etc.
 (C) Foundations and supporting headers, brackets and stiffeners from cargo transfer related apparatus, where attached to hull or deck structure.
 (D) 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(remotely operated vehicle), in lieu of a diver, is to be specially considered. The under water examination is to be carried out in accordance with an approved procedure using two (2) way audio visual communication.
 (E) 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.
 (F) Special attention should be paid to the following areas.
  (a) Splash zones on the hull, related structure
  (b) In ballast tanks, and free-flooded spaces
 (G) Where inspection of under water 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.
 (H) 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) Fixed SPM system
 (A) A drydocking survey or equivalent underwater inspection of the SPM shall be carried out. This survey shall include examination of the following areas.
 When underwater inspection in lieu of drydocking survey is requested, the underwater inspection procedures including all NDT and structural detail inspection are to be submitted for review and approval. Surveyor is to use those approved procedures as basis for their surveys.
 Any suspect areas where axcessive corrosion is evident shall be thickness gauged.
  (a) Entire hull structure of the SPM body
  (b) Protective coating, cathodic protection system

(c) Chain stoppers and their locking devices
(d) Floating hose connecting spool pieces, if applicable, and the underwater part of the flexible riser spool pieces.

(B) In any case gaugings shall be taken on the hull of the SPM when it has undergone service for 15 years or more.

(C) An examination shall be made on all anchor chains for excessive corrosion and wastage. In particular the areas to be specially examined are the areas having the most relative movement between the chain links and these areas are normally in way of the seabed touch down sections of the catenary part of the chains. The chains shall also be inspected for loose studs and link elongation and sufficient representative locations shall be gauged for wear and wastage. Areas susceptible to corrosion such as the wind-and water areas are to be specially gauged.

(D) A close examination shall be carried out on all mooring components and accessibles structural members which carry mooring loads. These structures include ;
(a) chain stoppers, structures in way of the chain stoppers
(b) structural bearing housing and turret areas
(c) structures in way of the mooring system components for the off-loading vessels.

(E) A general inspection shall also be carried out on the degree of scour or exposure in way of the anchor or anchor piles to ascertain that these components are not over exposed an extent that may cause a pull up on the anchors/piles.

(F) An examination shall be carried out on the main bearing of the SPM system.
This examination shall include visual inspection of bearing, if accessible, for water egress into the structural housing, corrosion, pitting and excessive wear. If the bearing is inaccessible at least the weardown shall be ascertained and the condition of the bearing seals verified. If disassembled the bearing rollers and the racer housings shall be specially examined.

(G) For other unconventional types of SPMs, special attention shall be paid to inaccessible part of structures. Suspect areas may have to be subjected to some form of NDT. Areas that are inaccessible shall at least be verified in order by gauging the boundary structures.

(H) The chain tensions shall be checked and where found not in compliance with the of specifications shall be readjusted accordingly. Excessive loss of chain tensions shall be investigated. Tensions are normally checked by way of measuring their catenary angles and their relative catenary water depths. Every SPM has its own designed acceptable chain tensions corresponding to a given chain angle with 1-2 degree tolerance.

(I) Fluid and electrical swivels shall be disassembled and examined for wear and tear and the seals shall be examined for deterioration. Upon completion of the reconditioning of the fluid swivels, they shall be hydrostatically tested. Similarly the electrical swivels shall be insulation tested.

(J) During underwater inspection of the SPM system the flexible risers shall be examined including all the support buoyancy tanks. Risers shall be inspected for kinks in high stress areas such as areas in way of the end flanges, areas in way of the arch support clamps and the bottom of all looped areas. Should spreader bars be fitted to separate more than one riser string they shall be inspected for excessive wear and tear. Excessively worn shackles and chain links of the spread bar system shall be renewed. Hydrostatic tests may be required to be carried out on the risers as deemed necessary by the attending Surveyor.

(K) Floating hoses shall be examined for kinks, surface cracks chaffing damages, etc. Hydrostatic and vacuum tests may be required to be carried out on the floating hose string as deemed necessary by the attending Surveyor.

(L) The entire compliment of safety equipment shall be examined in proper order. Safety equipment includes lifebuoys, obstruction lights, portable fire extinguishers, blinker lights for the floating hose strings, etc.

(M) For the structure of a tower mooring, the applicable requirements of the **Rules for Fixed Offshore Structures** are to be used.

(3) Mooring hardware

(A) The complete mooring system including anchor, 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(remotely operated vehicle). 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.

(B) Examination Out of the Water

(a) 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).

(b) When requested in lieu of (a) above, the Society will consider as an alternative the results of a strength analysis and a fatigue assessment performed in accordance with the **Guidance for Floating Production Units**. This alternative entails the dynamic analysis, anchor leg broken conditions, corrosion assumptions, fatigue life predictions, Fatigue Design Factors (FDFs), etc. specified in the 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.

(C) Mooring system component (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

(A) 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(5) years. In the event cargo hoses have been renewed or replaced with new hoses within the five(5) year period the above requirements may be modified and removal and testing deferred until the hose has been in service five(5) years. Vacuum testing of cargo hoses is required in association with Special Survey or after five(5) years of service as indicated above.

(B) Flexible risers

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

(a) Underwater examination of the flexible risers including arch support buoyancy tanks.

(b) 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.

(c) Examination of wear and tear on spreader bars, if fitted which separate one riser string from another.

(d) Hydrostatic testing of flexible risers to be carried out to working pressure.

(e) 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 of the SPM is to be examined and tested as required by the attending Surveyor. Refer to **Ch 4, Sec 4** for requirements applicable to the safety equipment.

(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.

303. Drydocking surveys or equivalent

1. Due range

An examination of the underwater parts of each SPM and associated mooring hardware is to be made at intervals not exceeding five(5) years. This examination is to align with the due date of the Special Survey.

2. Requirements of surveys

(1) Underwater parts of each SPM and associated mooring hardware
(2) External surfaces of the SPM
(3) Prior to examinatiorn, 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.

3. Underwater Survey in Lieu of Drydocking (UWILD)

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

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

304. Lay-up and reactivation

1. The Society is to be notified by the Owner that an SPM has been laid-up or otherwise removed from service. No periodical surveys are to be carried out for classed SPM when they are laid-up. Lay-up procedures and arrangements for maintenance of conditions during lay-up may be submitted to the Society for review and verification by survey.

2. In the case where the SPM has been laid up for an extended period (i.e., six (6) 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.

3. Where the lay-up preparation and procedures have been submitted to the Society 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 up-dating survey at time of reactivation.

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

305. 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 Society before the work of alterations is commenced and such work when approved is carried out to the satisfaction of the Surveyor.

306. Welding and Replacement of Materials

1. Ordinary and Higher Strength Structural Steels

Welding or other fabrication performed on structural steels is to be in accordance with the requirements of **Ch 2, Sec 3** of this Guidance and **Pt 2, Ch 2** of "Rules for Classification of Steel ships".

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 **Ch 2, Sec 3** of this

Guidance and **Pt 2** of "Rules for Classification of Steel ships".

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 the Society. ⚓

CHAPTER 2 MATERIALS AND WELDING

Section 1 Materials

101. General

1. These requirements are intended for single point moorings (hereinafter reffered to as "SPM") to be constructed of materials manufactured and tested in accordance with the requirements of these Chapter and where applicable, **Pt 2** of "Rules for classification of Steel ships."

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

102. Structure

1. Materials used in the construction of the SPM buoy structure are to comply with **Pt 2** of "Rules for classification of Steel ships."

2. Critical load carrying components in the mooring load path, such as hawser connection padeyes, are to be considered as primary application structure.

3. Materials used in the construction of the tower mooring structure are to be in accordance with **Pt 2** of "Rules for classification of Steel ships." The use of other commercial material specifications for SPM applications will be specially considered.

103. Mooring system

1. Materials used in the construction of anchors, anchor legs, associated hardware, etc. are to comply with one of the following when applicable:

(1) **Pt 2** of "Rules for Classification of Steel ships."

(2) National Standard or the Standard internationally recognized considered as equivalent by the Society (API Specifications 9A and RP 9B, ASME Boiler and Pressure Vessel Code).

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

104 Cargo or product transfer systems

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

2. The material specifications of previous **1**. are to comply with National Standard or the Standard internationally recognized considered as equivalent by the Society and are to specify a suitable range of established values for tensile strength, yield strength and ductility at design temperature.

3. Materials used in cargo or product transfer systems that will be exposed to hydrogen sulfide are to be selected within appropriate limits of chemical composition heat treatment and hardness to resist sulfide stress cracking. Material selection is to comply with the requirements of NACE MR 01 75/ ISO 15156.

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

5. Refer to **Ch 4, 104. 4** for further requirements regarding underbuoy hoses/flexible risers and floating hoses.

105. Bearings

Materials used in the construction of bearings and bearing retainers are to comply with appropriate material specifications as may be approved in connection with a particular design. The material specifications are to comply with recognized standards and are to specify a suitable range of required material properties. Materials need not be tested in the presence of the Surveyor. In general they may be accepted on the basis of a review of mill certificates by the Surveyor.

Section 2 Welding and Fabrication

201. General

1. Welding

(1) Welding in SPM hull or buoy construction of the mooring system is to comply with the requirement of this section.
(2) It is recommended that appropriate permanent markings be applied to the side shell of welded SPM buoys or hulls to indicate the location of bulkheads for reference.
(3) In all instances, welding procedures and filler metals are to produce sound welds having strength and toughness comparable to the base material.
(4) Welding of tubular and/or bracing members which may be used in tower mooring is to comply with **Pt 2** of "Rules for classification of Steel ships."

2. Plans and specification

(1) The plans submitted are to clearly indicate the proposed extent of welding to be used in the principal parts of the structure.
The welding process, filler metal and joint design are to be shown on the detail drawings or in separate specifications submitted for approval.
(2) The builders are to prepare and file with the Surveyor a planned procedure to be followed in the erection and welding of the important structural members.

3. Workmanship and supervision

(1) The Surveyor is to satisfy himself that all welders and welding operators to be employed in the construction of SPMs to be classed are properly qualified and are experienced in the work proposed.
(2) Inspection of welds employing methods outlined in **203. 9.** is to be carried out to the satisfaction of the Surveyor.

4. Welding procedures

(1) General
Welding procedure qualification test is to comply with **Pt 2, Ch 2, Sec 4** of "Rules for Classification of Steel ships."
(2) Weld Metal Toughness-Criteria for steels for hull **Pt 2, Ch 2.** of "Rules for Classification of Steel ships."
(3) Weld Metal Toughness -Criteria for Other Steels
Weld metal is to exhibit Charpy V-notch toughness values at least equivalent to transverse base metal requirements.

202. Preparation for welding

1. Edge preparation and fitting

(1) The edge preparation is to be accurate and uniform and the parts to be welded are to be fitted in accordance with the approved joint detail. All means adopted for correcting improper fitting are to be to the satisfaction of the attending Surveyor.
(2) The Surveyor may accept a welding procedure for build up of each edge that does not exceed one half the thickness of the member or 12.5 mm, whichever is the lesser.
(3) Where plates to be joined differ in thickness and have an offset on either side of more than 3 mm, a suitable transition taper is to be provided. For butts in bottom shell, strength deck plating and other joints which may be subject to comparatively high stresses, the transition taper length is to be not less than three times the offset. The transition may be formed by tapering the thicker member or by specifying a weld joint design which will provide the required transition.

2. Alignment

Means are to be provided for maintaining the parts to be welded in correct position and alignment during the welding operation. In general, strong backs, or other appliances used for this purpose are to be so arranged as to allow for expansion and contraction during production welding. The removal of such items is to be carried out to the satisfaction of the Surveyor.

3. Cleanliness

(1) All surfaces to be welded are to be free from moisture, grease, loose mill scale, excessive rust or shop primer coatings of ordinary thicknesses, thin coatings of linseed oil, or equivalent coatings may be used provided it is demonstrated that their use has no adverse effect in the production of satisfactory welds.
(2) Slag and scale are to be removed not only from the edges to be welded but also from each pass or layer before the deposition of subsequent passes or layers. Weld joins prepared by arc-air gouging may require additional preparation by grinding or chipping and wire brushing prior to welding to minimize the possibility of excessive carbon on the scarfed surfaces. However, these cleanliness requirements is of prime importance in the welding of higher strength steels especially those which are quenched and temperd.

4. Tack welds

(1) Tack welds of consistent good quality, made with the same grade of filler metal as intended for production welding and deposited in such a manner as not to interfere with the completion of the final weld, need not be removed provided they are found upon examination to be thoroughly clean and free from cracks or other defects.
(2) Preheat may be necessary prior to tack welding when the materials to be joined are highly restrained. Special consideration is to be given to use the same preheat as specified in the welding procedure when tack welding higher-strength steels, particularly those materials which are quenched and tempered. These same precautions are to be followed when making any permanent welded markings.

5. Run-on and run-off tabs

When used run-on and run-off tabs are to be fitted to minimize the possibility of high-stress concentrations and base-metal and weld-metal cracking.

6. Stud welding

The use of stud welding for structural attachments is subject to special approval and may require special procedure tests appropriate to each application.

203. Production welding

1. Environment

Proper precautions are to be taken to insure that all welding is done under conditions where the welding site is protected against the deleterious effects of moisture, wind and severe cold.

2. Sequence

Welding is to be planned to progress symmetrically so that shrinkage on both sides of the structure will be equalized. The ends of frames and stiffeners should be left unattached to the plating at the subassembly stage until connecting welds are made in the intersecting systems of plating, framing and stiffeners at the erection stage.

3. Preheat

(1) The use of preheat and interpass temperature control are to be considered when welding higher-strength steels, materials of thick cross-section or materials subject to high restraint. When welding is performed under high humidity conditions or when the surface temperature of steel is below 0 ℃, the control of interpass temperature is to be specially considered
(2) The control of interpass temperature is to be specially considered when welding quenched and tempered higher-strength steels.
(3) When preheat is used the preheat and interpass temperatures are to be in accordance with the accepted welding procedure.

4. Low-hydrogen electrodes or welding processes

(1) Welding of ordinary and higher strength steel
The use of low-hydrogen electrodes or welding processes is recommended for welding all higher-strength steel and may also be considered for ordinary-strength steel weldment subject to high restraint. When using low-hydrogen electrodes or processes, proper precautions are to be taken

to ensure that the electrodes, fluxes and gases used for welding are clean and dry.

(2) Welding of quenched and tempered steels
Unless approved otherwise, matching strength low-hydrogen electrodes or welding processes arc to be used for welding quenched and tempered steels and overmatching should be generally avoided. When welding quenched and tempered steels to other steels, the weld filler metal selection is. to be based on the lower strength. base material being joined and low-hydrogen practice being comparable to that for the higher strength material. In all cases, filler metal strength is to be no less than that of the lowest strength member of the joint unless approved otherwise.

5. Back gouging

(1) Chipping, grinding, arc-air gouging or other suitable methods are to be employed at the root or underside of the weld to obtain sound metal before applying subsequent beads for all full-penetration welds.

(2) When arc-air gouging is employed, a selected technique is to be used so that carbon buildup and burning of the weld or base metals minimized. Quenched and tempered steels are not to be flame gouged.

6. Peening

The use of peening is not recommended for single-pass weld and the root or cover passes on multipass welds. Peening, when used to correct distortion or to reduce residual stresses, is to be effected immediately after depositing and cleaning each weld pass.

7. Fairing

Fairing for correcting distortion in fabrication of main strength members and other plating which may be subject to high stresses is to be carried out only with the express approval of the Surveyor.

8. Visual inspection

The welds are to be regular and uniform with a minimum amount of reinforcement and reasonably free from undercut and overlap. Welds and adjacent base metal are to be free from injurious defects such as arc strikes etc.

9. Non-destructive inspection of welds

(1) Inspection of welded joints in important locations is to be carried out by an approved non-destructive test.

(2) **Annex 2-9** *"Giudance for Radiographic and Ultrasonic inspection of Hull Welds"* of **Pt 2** "Guidances relating to rules for classification of steel ships" or an approved equivalent standard is to be used in evaluating radiographs and ultrasonic indications.

(3) Radiographic or ultrasonic inspection, or both, is to be used when the overall soundness of the weld cross section is to be evaluated. Magnetic-particle or dye-penetrant inspection or other approved methods are to be used when investigating the outer surface of welds or maybe used as a check of intermediate weld passes such as root passes and also to check back-gouged joints prior to depositing subsequent passes.

(4) Surface inspection of important fillet joints, using an approved magnetic particle or dye penetrant method is to be conducted.

(5) Extra high-strength steels, (minimum yield strength, 415-690 N/mm^2) may be susceptible to delayed cracking. When welding these materials, the final NDT is to be delayed sufficiently to permit detection of such defects. Weld run-on or run-off tabs may be used where practical and be sectioned for examination.

10. Repair welding

(1) Defective welds and other injurious defect, as determined by visual inspection; non-destructive test methods, or leakage are to be excavated in way of the defects to sound metal and corrected by rewelding using a suitable repair welding procedure to be consistent with the material being welded.

(2) Removal by grinding of minor surface imperfections such as scars, tack welds and arc strikes may be curried out where permitted by the attending Surveyor.

(3) Special precautions, such as the use of preheat interpass temperature control, and low-hydrogen electrodes, are to be considered when repairing welds in all higher strength steel, ordinary strength steel of thick cross section, or steel subject to high restraint.

(4) In all cases, preheat and interpass temperature control are to be sufficient to maintain dry surfaces.

Section 3 Weld Design

301. Fillet welds

1. General

(1) Plans and specifications
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.

(2) Workmanship
Completed welds are to be to the satisfaction of the attending Surveyor. The gaps between the faying surfaces of members being joined should be kept to a minimum. Where the opening between members being joined exceeds 2 mm and is not greater than 5 mm, the welding size is to be increased by the amount of the opening. Where the opening between members is greater than 5 mm, corrective procedures are to be specially approved by the Surveyor.

(3) Special precautions
Special precaution such as the use of preheat or low-hydrogen electrodes may be required where small fillet are used to attach heavy plates or sections. When heavy sections are attached to relatively light plating, the weld size may be required to be modified.

2. Fillet welds

(1) Size of fillet welds
Fillet welds are generally to be formed by continuous or intermittent fillet welds on each side, as required by **Table 2.l** The leg size, w, of fillet welds is obtained from the following equations.

$$w = t_{pl} C s / l + 2.0\ mm$$

$w_{\min} = 0.3\, t_{pl}$ or $4.5\ mm$ ($4.0\ mm$ Where **5.** is applicable), whichever is greater.

where,

l = the actual length of weld fillet, clear of crater, in mm

s = the distance between successive weld fillets, from center to center, in mm

s/l = 1.0 for continuous fillet welding

t_{pl} = thickness of the thinner of the two members being joined in mm

C = weld factors given in **Table 2.1**

In selecting the leg size and spacing of matched fillet welds, the leg size for the intermittent welds is to be taken as not greater than the designed leg size w or $0.7\,t_{pl} + 2.0\ mm$, whichever is less.
The throat size, t, is to be not less than 0.70 w.
For the weld size for t_{pl} of 6.5 mm or less, see (6)

(2) Length and arrangement of fillet
Where an intermittent weld is permitted by **Table 2.1,** the length of each fillet weld is to be not less than 75 mm for tpl of 7 mm or more, nor less than 65 mm for lesser t_{pl} of 7 mm. The unwelded length is to be not more than 32 t_{pl}.

(3) Intermittent welding at intersection
Where beams, stiffeners, frames, etc., are intermittently welded and pass through slotted girders, shelves or stringers, there is to be a pair of matched intermittent welds on each side of each such intersection, and the beams, stiffeners and frames are to be efficiently attached to the girders, shelves and stringers.

(4) Welding of longitudinal to plating
Welding of longitudinals to plating is to have double continuous welds at the ends and in way of transverses equal in length to depth of the longitudinal.
For deck longitudinals only, a matched pair of welds is required at the transverses.

(5) Stiffeners and webs to hatch covers
Unbracketed stiffeners and webs of hatch covers are to be welded continuously to the plating and to the face plate for a length at ends equal to the end depth of the member.

(6) Thin plating
For plating of 6.5 mm or less, the requirement of (1) may be modified as follows:

$$w = t_{pl} Cs/l + 2.0(1.25 - l/s)\ mm$$

$$w_{\min} = 3.5\ mm$$

The use of above equations for plating. in excess of 6.5 mm may be specially considered depending upon the location and quality control procedure of shipyards.

3. Fillet welds of end connections

Fillet welds of end connections where fillet welds are used are to have continuous welds on each side. In general, the leg sizes of the welds are to be in accordance with **Table 2.1** for unbracketed end attachment, but in special cases where heavy members are attached to relatively light plating, the sizes may be modified.

4. Ends of unbracketed stiffeners

Unbracketed stiffeners of shell, watertight and oiltight bulkheads are to have double continuous welds for one-tenth of their length at each end. Unbracketed stiffeners of nontight structural bulkheads, deckhouse sides and after ends are to have a pair of matched intermittent welds at each end.

5. Reduced weld size

Reduction in fillet weld sizes except for slab longitudinals of thickness greater than 25 mm may be specially approved by the Surveyor in accordance with either (1) or (2) provided the requirements of previous **2.** are satisfied

(1) Controlled gaps
Where quality control facilitates working to a gap between members being attached of 1 mm or less, a reduction in fillet weld leg size w of 0.5 mm may be permitted.

(2) Deep penetration weld
Where automatic double continuous fillet welding is used and quality control facilitates working to a gap between members being attached of 1 mm or less, a reduction in fillet weld leg size w of 1.5 mm may be permitted provided that the penetration at the root is at least 1.5 mm into the members being attached.

6. Lapped joints

Lapped joint are generally to have overlaps of not less width than twice the thinner plate thickness plus 25 mm.

(1) Overlapped end connections
Overlapped end connections of main strength members are to have continuous fillet welds on both edges each equal in size w to the thickness of the thinner of the two plates joined. All other overlapped end connections are to have continuous welds on each edge of sizes w such that the sum of the two is not less than 1.5 times of the thickness of the thinner plate.

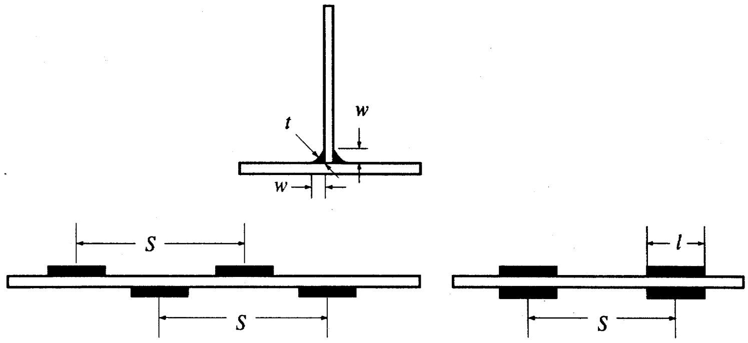
7. Plug weld or slot welds

Plug weld or slot. welds may be specially approved for particular applications. Where used in the body of double and similar locations, such welds may be spaced about 300 mm between centers in both directions.

8. Weld in tubular joints

The weld design of joint of intersecting tubular members which are used in fixed structure in a tower mooring is to be in accordance with the **Pt 2** of "Rules for Fixed Offshore Structures." ⚓

Table 2.1 Weld Factor



Staggered Chained

w = leg size in mm t = throat size in mm

Periphery	Factor C	Welding method
1. Periphery connection		
(1) Tight joints.		
(A) Main bulkhead to deck bottom or inner bottom	0.42	Double continuous
(B) All other tight joints		
(a) watertight bulkhead (t_{pl} < 12.5 mm)		
- one side	0.58	Continuous
- other side	0.12	
(b) all other joints	0.35	Double continuous
(2) Non-tight joints		
(A) Platform decks	0.28	Double continuous
(B) Swash bulkheads in deep tanks	0.20	
(C) Non-tight bulkheads other than item b.	0.15	
2. Bottom floors.		
(1) To shell	0.20	Double continuous
(2) To inner bottom	0.20	Double continuous
(3) To main girders	0.30	Double continuous
(4) To side shell and sulkheads	0.35	Double continuous
(5) Open sloor bracket		
(A) to center girder	0.15	
(B) to margin plate	0.30	Double continuous
3. Bottom girder		
(1) Center girder	0.25	
4. Web frames, stringers, deck girder and deck transverses		
(1) To plating		
(A) in tanks	0.20	
(B) elsewhere	0.15	
(2) To face plates		
(A) face area 〈 64.5 cm^2	0.12	
(B) face area 〉 64.5 cm^2	0.15	
(3) End attachment		
(A) unbracketed (see note 1)	0.55	Double continuous
(B) bracketed	0.40	Double continuous

Table 2.1 Weld factor (continue)

Periphery	Factor C	Welding method
5. Frams, beams and stiffeners		
(1) To shell	0.25	Double continuous
(2) To plating elsewhere	0.12	
(3) End attachment		
(A) unbracketed (see nete 1)	0.45	Double continuous
(B) bracketed	0.35	Double continuous
6. Hatch covers		
(1) Oiltight joints	0.40	Double continuous
(2) Watertight joints		
(A) outside	0.40	continuous
(B) inside	0.15	
(3) Stiffeners and webs to plating and to face plate (see note 2)	0.12	
(4) Stiffeners and web to side plating or other stiffeners		
(A) unbracketed (see note 1)	0.45	Double continuous
(B) bracket	0.35	Double continuous
7. Hatch coamings and ventilators.		
(1) To deck		
(A) at hatch corner	0.45	Double continuous
(B) elsewhere	0.25	Double continuous
(2) Coaming stays		
(A) to deck	0.20	Double continuous
(B) to coaming	0.15	Double continuous
8. Foundations		Double continuous
(1) Major equipment and auxiliaries	0.40	
Notes 1. The weld size is to be determined from the thickness of the member being attached. 2. Unbracketed stiffeners and webs of hatch covers are to be welded continuously to the plating and to the face plate for a length at ends equal to the end depth of the member. 3. With longitudinal framing the weld size is to be increased to give an equivalent weld area to that obtained Without cutouts for longitudinal.		

CHAPTER 3 DESIGN OF MOORING SYSTEM

Section 1 Site and Environmental Conditions

101. General

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.

102. Mooring location

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 marine consultant. In 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 pipe line 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.

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.

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 abut 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 **104. 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 environment, 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.

4. Swing circle

The swing circle 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.

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 therefrom in any sea condition under which such a vessel is expected to be present as outlined in the design premiss 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 the Society that in determining the required water depth, the following effects have been considered:

(1) Vessel's dimensions and other relevant characteristics
(2) Wave height, wave period, and compass direction with respect to the vessel.
(3) The prevailing wind and astronomical tides.
(4) The expected vessel's heaving, rolling and pitching and adequate vessel under keel clearance.
(5) The consistency of the sea bottom material or the character of any protrusion from the sea bottom.
(6) The level of accuracy of the depth survey data.
(7) Predicted variation of seabed profile due to sediment transport during the design life

103. Soils data

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 movement 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.

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 **Ch 4, Sec. 7** of the **Rules for Fixed Offshore Structures**. 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.

104. Design environmental conditions and data

1. Design environmental conditions

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

(1) Design operating condition
The operating environmental condition for an SPM is defined as the maximum seastate in which a vessel is permitted to remain moored to the SPM without exceeding the allowable loads and stresses required in **Ch 3** and **4** of this Guidances. Wind, waves and the associated current used in the design shall be based on site specific data, as determined by marine and meteorological consultants.

(2) Design environmental condition
The storm 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 marine and meteorological consultants.

2. Waves

(1) Design operating wave
The characteristics of the wave for the Design operating condition described in **Par 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 **Par 1** 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, and 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 marine 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 design storm 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. lf 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 marine 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. 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 marine consultant.

3. Wind

(1) Design operating wind
The wind characteristics for the Design operating condition described in **Par 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 **Par 1** 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) 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 marine consultant The statistics are

to include following;

(a) a wind rose or table showing the frequency distribution of wind velocity and direction,

(b) a table or graph showing the recurrence period of extreme winds,

(c) the percentage of time which the operating wind velocity is expected to be exceeded during a year and during the worst month or season.

(B) 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 marine 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 marine 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 marine consultant. The bias of such observations against extreme storms and therefore against extreme wind speeds is to be accounted for.

4. Current

(1) Design operating current

The current characteristics for the Design operating condition described in **Par 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 storm current characteristics for the Design environmental condition described in **Par 1** 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.

5. Seiche

The location of the mooring site in relation to seiche nodal points is to be investigated by a marine 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.

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 marine consultant. The seasonality of extreme tidal variations can be considered when considering the combination of astronomical tide and storm surge.

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 marine consultant. Storm surge hindcasts for design (extreme) storms performed by a marine consultant may be submitted.

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.

Section 2 Design Loads

201. Design loads

The design conditions are to be established by varying vessel size and loading conditions to determine the critical loading conditions under the enviornmental conditions described in **104.** The designer is to submit calculations for the design condition. The following loads are to be considered in the design:

(1) Dead loads and buoyancy
(2) Environmental loads
(3) Mooring loads
(4) Fatigue loads

202. Dead loads and buoyancy

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 result in upward forces, the distribution of which depends on the distribution of the submergence of the structure.

203. Environmental loads

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

(1) Waves
(2) Wind
(3) Currents
(4) Tides and storm surges
(5) Ice and snow
(6) Marine growth
(7) Air and sea temperatures
(8) 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.

1. 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 **Pt 3** of "Rules for Fixed Offshore Structures."

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.

2. 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 :

$$P_{wind} = 0.61\ C_s \times C_h \times V^2{}_{wind} \quad (N/m^2)$$

V_{wind} : Wind velocity in m/s

C_s : Shape coefficient (dimensionless) in Table 2.1

C_h : Height coefficient (dimensionless) as follows

$$C_h = (V_z / V_{ref})^2$$

where, the velocity of wind V_z at a height z above water line is to be calculated as follows:

$$V_z = V_{ref} \times (z/Z_{ref})^{\beta}$$

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

V_{ref} : Velocity of wind at an reference elevation Z_{ref} of 10 m

β : 0.10 typically for one-minute average wind, other values supported by site specific data will be specially considered.

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

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

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

The total wind force is then obtained by summing up the wind forces on each windage. The shape coefficients for typical structural shapes are presented (for reference only) in **Table 2.I.** The height coefficients to represent the wind velocity profile(corresponding to β value of 0.10) are presented in **Table 2.2.** for height intervals of 15.25 meters.

Table 2.1 Shape coefficient C_s for windages

Type	C_s
Cylindrical Shapes	0.5 ~ 1.0
Hull above waterline	1.0
Deck house	1.0
Isolated structural shapes(Cranes, channels, beams, angles, etc.)	1.5
Under deck area(smooth)	1.0
Under deck area(exposed beams and girders)	1.3
Truss structure (each face) (*)	1.25
Note: (*) 30 % of projected areas for both front and back sides.	

Table 2.2 Height coefficient C_h

Height above Waterline (m)	C_h
$h \leq 15.3$	1.0
$15.3 < h \leq 30.5$	1.18
$30.5 < h \leq 46.0$	1.31
$46.0 < h \leq 61.0$	1.40
$61.0 < h \leq 76.0$	1.47
$76.0 < h \leq 91.5$	1.53
$91.5 < h \leq 106.5$	1.58

3. 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, rises 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 **104. 1.**

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

$$F_c = 0.50\,\rho\,C_D A_c u_c |u_c| \qquad (kN)$$

ρ : mass density of water, 1.025

C_D : drag coefficient, in steady flow (dimensionless).

u_c : current velocity vector normal to the plane of projected area in m/s

A_c : projected area exposed to current in m^2

204. Mooring loads

The design loads of mooring legs, and mooring elements(flexible hawsers or rigid mooring element 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 condition described in **104. 2** using a storm duration of three hours, unless specific site data supports other durations.

1. 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 **Sec 1.** 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 (e.g., hawser or rigid ann and yoke)for the maximum size vessel for the operating environmental condition described in **104. 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 **Sec 1.** 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 effect 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.

2. Loads from the design environmental condition

Design storm 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 **104. 1.** Model test data and/or calculations are to be submitted to establish the validity of these loads.

205. Fatigue loading

For tower mooring system, fatigue analysis of the structure is to be performed in accordance with **Part 3** of Rules for Fixed Offshore Structures. For SPMs with novel designs or buoys with permanently moored vessels, fatigue analysis of the structure is to be performed in accordance with **Rules for Fixed Offshore Structures** or **Guidance for Floating Production Units**, as appropriate.

Section 3 Structural Design and Stability

301. General

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 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.

302. General design criteria

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 **Sec 2.** 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 **Sec 2** are to be within the requirement given in **303.** and **304.**

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."

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 **305. 1** to **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 sacrifical 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 **303.** and **304.** or by alternative structural design methods other than the requirements in **305.** the following apply :

(1) 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.

(2) 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 the Society for review.

303. Stresses

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

(1) 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,

(2) 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,

(3) Application of the maximum wave, maximum wind and maximum current loads in the case of a fixed structure.

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 moment computed for other types of loadings.

3. Buckling stresses

The possibility of buckling of structural elements is to be specially considered in accordance with **304. 3** For a fixed SPM structure, the buckling of tubular members is to be as deemed appropriate by the Society.

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.

304. Allowable stresses

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 **2.**

The load cases to be considered are as follows:

(1) Design Operating Load Case. The combined gravity, environmental, and mooring loads for the operating environmental condition, as described in **Sec 1 104. 1.** (1).

(2) Design Environmental Load Case. The combined gravity and environmental loads for the storm condition, as described in **Sec 1 104. 1.** (2). If mooring loads are present in the design environmental condition they are to be combined with the gravity and environmental loads.

2. Member stresses

Individual stress components and as applicable, direct combinations of such stresses, are not to exceed the allowable stress F, as obtained from the following equation.

$$F = \frac{F_y}{FS}$$

F_y : specified minimum yield point or yield strength as defined in **Pt 2, Sec 1.**

FS : factor of safety

for the loadings as defined in **1.** (1)

for axial or bending stress : 1.67

for shear stress : 2.5

for the loadings as defined in **1.** (2)

for axial or bending stress : 1.25

for shear stress : 1.88

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 F as obtained from the following equation.

$$F = \frac{F_{cr}}{FS}$$

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

FS : factor of safety

1.67 for the loadings as defined in **1.** (1)

1.25 for the loadings as defined in **1.** (2)

4. Members subjected to combined axial load and bending

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

In case of $\frac{f_a}{F_a} \leq 0.15$ $\left(\frac{f_a}{F_a}\right) + \left(\frac{f_b}{F_b}\right) \leq 1.0$, $\frac{f_a}{F_a} > 0.15$ $\left(\frac{f_a}{F_a}\right) + \frac{C_m f_b}{\left(1 - \frac{f_a}{F_e}\right) F_b} \leq 1.0$

and in addition, at ends of members :

for the loadings as defined in **1.** (1)

$$1.67\left(\frac{f_a}{F_y}\right) + \left(\frac{f_b}{F_b}\right) \leq 1.0$$

for the loadings as defined in **1.** (2)

$$1.25\left(\frac{f_a}{F_y}\right)+\left(\frac{f_b}{F_b}\right)\leq 1.0$$

(2) 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 :
However, the computed bending compressive stress, f_b taken alone shall not exceed F_b

for the loadings as defined in **1.** (1)

$$f_a+f_b\leq\frac{F_y}{1.67}$$

for the loadings as defined in **1.** (2)

$$f_a+f_b\leq\frac{F_y}{1.25}$$

where,

f_a : computed axial compressive or tensile stress

f_b : computed compressive or tensile stress due to bending

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

(A) Yield stress divided by factor of safety for axial stress specified in **304. 2.**

(B) Overall buckling stress divided by factor of safety specified in **304. 5.** (1)

(C) Local buckling stress divided by factor of safety for axial stress specified in **304. 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 **304. 2**.

$$F_e=\frac{5.15E}{(Kl/r)^2}$$

F_e : Euler buckling stress, may be increased 1/3 for combined loadings as defined in **304. 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 defections of end supports may exist K is not be considered less than 1.0.

r : radius of gyration

C_m : is a coefficient as follows

(A) For compression members in frames subject to joint translation (sideways),

$$C_m=0.85$$

(B) 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 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 is single curvature.

(C) 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, $C_m = 1.0$

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.

$$\frac{Kl}{r} < \sqrt{\frac{2\pi^2 E}{F_y}} \ , \qquad F_{cr} = F_y - \frac{F_y^2}{4\pi^2 E} \cdot \left(\frac{Kl}{r}\right)^2$$

$$\frac{Kl}{r} \geq \sqrt{\frac{2\pi^2 E}{F_y}} \ , \qquad F_{cr} = \frac{\pi^2 E}{\left(\frac{Kl}{r}\right)^2}$$

F_{cr} : critical oveall bucking stress

F_y : as defined in **2.**

E, K, l, r are defined in **4.** (2)

(2) The factor of safety for overall column buckling is to be as follows

(A) For the loadings as defined in **1.** (1)

$$\frac{Kl}{r} < \sqrt{\frac{2\pi^2 E}{F_y}} \ , \qquad FS = 1.67\left(1 + 0.15\frac{\frac{Kl}{r}}{\sqrt{\frac{2\pi^2 E}{F_y}}}\right)$$

$$\frac{Kl}{r} \geq \sqrt{\frac{2\pi^2 E}{F_y}} \ , \qquad FS = 1.92$$

(B) For the loadings as defined in **1.** (2)

$$\frac{Kl}{r} < \sqrt{\frac{2\pi^2 E}{F_y}} \ , \qquad FS = 1.25\left(1 + 0.15\frac{\frac{Kl}{r}}{\sqrt{\frac{2\pi^2 E}{F_y}}}\right)$$

$$\frac{Kl}{r} \geq \sqrt{\frac{2\pi^2 E}{F_y}} \ , \qquad FS = 1.44$$

(3) Local buckling
Local bucking 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 (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.

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

D : mean diameter of cylindrical shell

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

E and F_y are as defined in (1)

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 F_y/FS.

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

σ_x, σ_y : calculated in-plane stress in the x and y direction

τ_{xy} : calculated in-plane shear stress

F_y : as defined in **2.**

FS : 1.43 for the loading as defined in **1.** (1)

1.11 for the loading as defined in **1.** (2)

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

The buckling strength of plated structures is to be as deemed appropriate by the Society.

305. Structural design

The hull and frame(s) which are part of the floating structure are to be designed in accordance with the requirements of **303.** and **304.** In addition to those requirements, the scantlings of plating, stiffeners, and beams are to meet the requirements of **1** to **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 compartment.

1. Plating

(1) Hull and watertight bulkhead plating
Hull plating is to be of the thickness derived from the following equation. but not less then 6.5 mm or $\frac{s}{150}$+2.5 mm whichever is greater

$$t = \frac{sk\sqrt{(qh)}}{254} + 2.5 \ (mm)$$

t : thickness in mm

s : stiffener spacing in mm

k : (3.075 $\sqrt{a}$ - 2.077) / (a + 0.272) (1 $\leq$ a $\leq$ 2) = 1(a > 2)

a : aspect ratio of the panel (longer edge/shorter edge)

q : 235/Y (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:

1) 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.
2) 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 (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.

2. Stiffeners and beams

The section modulus 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.

$$Z = Kfchsl^2 \quad (cm^3)$$

f : 7.8

c : 0.9 for stiffeners having clip attachment to decks or flats at the ends or having such attachments at one end with the other end supported by girders
1.0 for stiffeners supported at both ends by girders

h : vertical distance, in m, from the middle of length l to the same height to which h for plating is measured **1.** (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 arc in accordance with **Table 3.I** 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.

K : as defined in **Pt 3, Ch 1, 403. of the Rules**.

3. Girders and webs

(1) Strength requirements each girder or web which supports a frame, beam, or stiffener is to have a section modulus not less than obtained from the following equation.

$$Z = Kfchsl^2 \quad (cm^3)$$

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 **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 3.1** 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
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 for each girder or web may be one-half that obtained from the above.

K : as defined in **2.**

(2) Proportions Girders and webs to have a depth not less than 0.125 l where no struts or ties are fitted and 0.0833 l 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 mm 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.

Table 3.1 Thickness and Flange of brackets and kness

Depth of longer arm	Thickness (mm)		Width of flange (mm)
	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	8.2	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	91
950		11.5	91
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 case where the depth at throat is less than two thirds that of the knee.

306. Stability

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

1. Intact stability

(1) The hull is to be stable under the following conditions.
- (A) In calm water without mooring leg(s) in place
- (B) During installation
- (C) In the operating environment with all mooring legs in place and pretensioned under the operating hawser load
- (D) Under tow, if the buoy is towed

(2) The designer is also to verify the following:
- (A) The metacentric height shall be positive in the calm water equilibrium position for all afloat conditions without any mooring leg(s) in place.
- (B) 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, installation and operation where applicable. Static angle of heel due to overturning moment is to be below the first downflooding point.
- (C) 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.
- (D) The stability shall be calculated in a disconnected mode corresponding to environmental conditions with a return period of 100 years.

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 waterline is below the first downflooding point in a damage equilibrium condition with one compartment damaged under the design operating condition.

307. 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 be in accordance with the requirements of **303.** and **304.** The connections between vessel and fixed mooring platform other than those stated in **405.** should be adequately designed. The design of the fixed mooring platform is to withstand the operating and design environmental conditions as described in **304. 1** structure with buoyant structural elements is to meet requirements of **303.** and **304.,** while a tower mooring structure designed as a gravity based fixed structure with tubular members is to be in accordance with **Pt 3** of "Rules for Fixed offshore structures."

308. Additional structural requirements

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

309. 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.

310. Pipeline End Manifold (PLEM)

The PLEM is required to sustain the maximum anticipated loads from the underbuoy hose/ flexible riser under conditions defined in **304. 1**. Loads on the PLEM and the buoy from the underbuoy hoses/ flexible riser are to be calculated from an appropriate analysis. Refer to **Ch 4, 106.** for the design of the PLEM piping, valves flanges and fittings.

Section 4 Mooring and Anchoring

401. 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 **104. 1.** In lieu of the foregoing a means of closure that isolates the SPM from the undersea pipeline may be accepted, but this alternative applies to a hose that is qualified to OCIMF standards (see **Ch 4, 104. 4**).

402. 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 **403.**.

Option i) When the mooring system is considered as being intact and the design loads are calculated in accordance with 3-2-1/7.1 and 3-2-1/7.3, required minimum factors of safety are:

For the Design Operating Load Case of **304. 1.** (1): 2.0

For the Design Environmental Load Case of **304. 1.** (2): 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 **403.**, 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.

Option ii) The criteria of **407.**

In 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 **407.**

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 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.

The Society 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, the Society 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, the Society 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, the Society 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.

403. 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 **403.**

Option i) When the mooring system is considered as being intact and the design loads are calculated in accordance with **304. 1.** and **2.**, required minimum factors of safety are:

For the Design Operating Load Case of **304. 1.** (1): 3.0
For the Design Environmental Load Case of **304. 1.** (2): 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 **407.**

The mooring structure of a fixed SPM system is to be designed in accordance with **313.**

404. Anchor and chains

Anchors and chains are to comply with the requirements of **Pt 4, Ch 8.** of "Rules for Mobile Offshore Units". Equipment designed to other standards will be specially considered.

405. 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. 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.

with one fairlead, F.S. = 1.67

with multiple fairleads, F.S. = 2.50

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 be as deemed appropriate by the Society.

406. 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.

407. Alternative Criteria

When requested, the Society will accept the criteria contained in **Ch 6** of **Guidance for Floating Production Units** as an alternative to those given in **402.** and **403.**, above. The application of the alternative criteria includes the specified dynamic analyses, anchor leg broken conditions, corrosion assumptions, fatigue life predictions, etc. that are entailed in the referenced sections of **Guidance for Floating Production Units**. Both the Design Operating Load Case of **304. 1.** (1) and the Design Environmental Load Case of **304. 1.** (2) are to be analyzed, and the load case producing the higher design loads is to be used in the application of the alternative criteria. ⚓

CHAPTER 4 EQUIPMENT AND SYSTEMS

Section 1 Cargo or Product Transfer Systems

101. General

The requirements of this Section are applicable to the cargo or product transfer system and associated components of single point moorings. 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 (hereinafter referred to as "PLEM"), if provided, are to comply with the requirements of this Section.

102. Conditions applicable to pipeline connection

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

1. It is to be anchored to the sea bottom to resist forces due to waves, current, and forces im posed by the SPM and the undersea pipeline.

2. A means of closure is to be provided to permit isolation of the SPM from the undersea pipeline.

103. Materials

Materials for cargo or product transfer systems are to comply with the requirements of **Ch 2, 104.** of the Guidances.

104. 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.

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). System 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 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 shut off 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 hoses are to comply with the OCIMF "Guide to Manufacturing and Purchasing Hoses for Offshore Moorings" (hereinafter referred to as "OCIMF Guide") and is to be manufactured to the Society survey and inspection. Prototype hose approval in accordance with Section 3 of this standard is required.

Variances 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 variances will be required. The bolting and gasket materials and design are to comply with an applicable design standard deemed by the Society and be suitable for their intended service.

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

5. System design pressure

Design pressure is defined as the larger of:

(1) 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.
(2) 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 1.11.6 and 1.11.8 respectively of the OCIMF Guide. 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 standards deemed by the Society.

105. Cargo or product swivels and related systems and equipment

1. Cargo or product swivels

(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:
(A) Breakaway torque required for each swivel at maximum design pressure
(B) Weight of swivel and its structural components
(C) Dynamic loads due to vessel motion
(D) Piping loads
(E) Mooring forces
(F) Pressure loads
(G) Thermal loads
Pressure retaining components of the swivel are to be designed in with a standard deemed appropriated by the Society such as the ASME Boiler and Pressure Vessel Code. Structural components of the swivel and driving mechanism are to comply with **Ch 3, Sec 3** of the Guidances, the ASME code or other structural design standard deemed appropriated by the Society.

(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:
(A) Hydrostatic pressure test to at least 1.5 times the design pressure for at least 2 hours.
(B) Hydrostatic pressure test to design pressure through 2 complete revolutions in each direction at a rate of approximately ten 10 minutes per revolution.
(C) Hydrostatic pressure test to design pressure through 4 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 is to be used between the primary seal and the product in gas or gas containing production fluid swivels.

3. Bearings

(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 standards deemed by the Society. For high tension bolts stress corrosion cracking is to be considered.

(2) Swivel bearings
Swivel bearings that do not carry the hawser load are to be designed in accordance with AFBMA (anti friction bearing manufacturers association) Codes or other industry standards deemed appropriated by the Society.

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 CO_2, O_2, or H_2S in the cargo or product fluid is to be considered in the swivel design.

106. Cargo or Product Piping Systems

1. Piping

All pipings for the cargo or product transfer system mounted on the SPM are 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 the Surveyor.

Cargo or product piping installed on the SPM 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 shut-off 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 standards deemed appropriated by the Society such as those of the American National Standards Institute. Non-standard valves are those valves that are not certified as complying with a standard deemed by the Society. The use of non-standard 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 standards deemed appropriated by the Society such as those of the American National Standards Institute. Non-standard flanges and fittings are those components that are not certified by the manufacturer as complying with a standard deemed appropriated by the Society. 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.

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 non-metallic 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 bust test results verifying the pressure and temperature rating and fatigue life are to be submitted for review.

5. PLEM piping

The requirements of **Par 1** to **3** above are also applicable to the piping, valves, flanges and fittings forming the 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 CO_2, O_2 or H_2S in the cargo or product fluid is to be considered in the piping design.

Section 2 Ancillary Systems and Equipment

201. 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 Rules for Mobile Offshore Unit except as specified in this Section.

202. Bilge pumping

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

203. 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.

204. Air pipes

1. All tanks that are filled or emptied through fixed pumping arrangements and all voids through which pressure piping passes are to be fitted with air pipes.
2. The structural arrangement of tanks or voids requiring an air pipes is to be such as to permit the free passage of air and gasses from all parts of the spaces to the air pipes.
3. Each tank or void space requiring an air pipes is to be fitted with at least one air pipe, which is located at the highest part of them.
4. Air pipes are to be arranged to provide adequate self-drainage under normal conditions. Outlets of air pipes on the open deck are to be terminated by way of return bends. Satisfactory means, permanently attached, are to be provided for closing the vent pipes.

5. The internal diameter of each air 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 air pipes 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 air pipes.

6. Air pipes are to be terminated 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.

205. 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 deemed appropriated by the Society.

Section 3 Hazardous Areas and Electrical Installations

301. General

Electrical installations onboard single point moorings are to comply with the requirements of **Ch 10** of "Rules for Mobile Offshore Units" and the additional or modified requirements contained in this Section. Alternatively, consideration will be given to installations that complying with the requirements contained in this Section and applicable standards deemed by the Society, provided that they are not less effective.

302. Hazardous areas

1. Definitions

(1) Hazardous areas are all those areas where a flammable atmosphere may be expected to exist continuously or intermittently.

(2) 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.

(3) 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

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

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

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

(4) In addition to the hazardous areas defined in (1) to (3) 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 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.

303. Cables and types of electrical equipment permitted in hazardous areas

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

(2) Zone 1 areas

(A) Certified intrinsically-safe circuits or equipment and associated wiring

(B) Certified flameproof (explosion proof) equipment

(C) Certified increased safety equipment; for increased safety motors due consideration is to be given to the protection against overcurrent

(D) Pressurized enclosure type equipment(pressurization systems are to comply with applicable industry standards)

(E) Permanently installed cables with metallic armor, a metallic sheath, or installed in metallic conduit with explosion proof gastight fittings. However, flexible cables, where necessary, may be installed provided they are of heavy duty type.

(3) 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℃ and provided any brushes, switching mechanisms, or similar arc-producing devices are approved for Zone 1 areas:

(A) Enclosed squirrel-cage induction motors

(B) Fixed Lighting fixtures protected from mechanical damage

(C) Transformers, solenoids, or impedance coils in general purpose enclosures

(D) Cables with moisture-resistant jacket (impervious sheathed) and protected from mechanical damage.

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.

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

Section 4 Safety Provisions

401. Navigation aids

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:

(1) One 360 degree white light visible for 5 miles under an atmospheric transmissivity of 0.85, flashing 6 times per minute, and arranged for operation at least from sunset to sunrise local time.

(2) It is recommended that the floating hoses be marked with winker lights.

2. Fog signal

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

402. Radar reflector

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

403. Fire fighting equipment

SPMs are to be equipped with at least one portable fire extinguisher suitable for use on fires involving flammable and combustible liquids. Where the risk of an electrical fire also exists, one portable extinguisher suitable for use on fires involving energized electrical equipment is also to be provided. In lieu of providing 2 extinguishers, consideration will be given to a single extinguisher of a type suitable for both oil and electrical fires. A rated portable extinguisher suitable for use on fires involving flammable and combustible liquids could be 9 l foam, 5 kg carbon dioxide or 5 kg dry chemical. A rated portable extinguisher suitable for use on fires involving energized electrical equipment could be 5 kg carbon dioxide or 5 kg dry chemical.

404. Identification marks

A name or number is to be assigned to each single point mooring and is to confirm 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 Register of Ships of the Society. Draft marks are to be permanently marked in at least 2 places on the outside of the buoy hull indicating maximum permissible draft. ⚓

GUIDANCES FOR SINGLE POINT MOORING

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