



Exploration & Production

GENERAL SPECIFICATION

STRUCTURAL

GS STR 631

CALM buoy terminals

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1. Scope

This specification defines the general requirements for the design, fabrication and installation of a Catenary Anchor Leg Mooring (CALM) buoy.

This specification covers all types of CALM buoys moored in typical shallow waters (say 100m or less). It does not cover other types of Single Point Moorings, such as SALM, SALS, ALP.

It covers the export of oil or condensate and should not be applied without careful assessment to LPG or LNG.

Deep water CALM buoys requiring a specific export line are mentioned in some aspects of this specification, but not covered in details due to the novel nature of the concept. Therefore, an additional specification will be required for such a system.

The purpose of the buoy is to moor a vessel, usually a tanker, by its bow to transfer one or more fluids between the buoy and the vessel. In certain cases, the vessel may be an F(P)SO permanently connected to the buoy, with an offloading tanker connected to the F(P)SO in tandem or alongside.

As a single point mooring, the CALM buoy allows the moored tanker, or the combination F(P)SO / tanker, to weathervane according to the environment while transferring fluids.

The CALM buoy system, hereinafter designated as the BUOY, shall typically consist of the following components:

- A **buoy body**, comprising a fixed part (connected to the risers) and a rotating part (connected to the floating hoses).
- **Mooring lines** and their **anchor points** to moor the buoy on the seabed.
- **Floating hoses** connecting the buoy body to the tanker ship.
- **Hawser line(s)** to moor the ship to the buoy.
- One or more subsea Pipe Line End Manifolds, or **PLEM**, anchored to the seabed and providing a link between the submarine pipeline(s) and the risers.
- **Risers** (or underwater hoses) connecting the PLEM to the buoy body. For deep and ultra deep water, the PLEM and risers may be replaced by **export lines**.

Therefore, the boundaries of the BUOY scope are :

- The spool piece between the PLEM and sealine (spool piece included in scope) or end of export line.
- The end of the floating hoses on tanker side (tanker rail hose).

2. Reference documents

The complete BUOY shall be designed, manufactured, tested and installed in accordance with (in descending order of priority) :

- The Project Particular Specifications (PPS).
- This General Specification.
- Any other contractual specifications issued by COMPANY.

- The rules of the Classification Society (CS) chosen by COMPANY.
- Any other regulations recognised by the international petroleum industry, solely in the event that matters arise which are not covered in any of the above or are imprecise or arguable in the above regulations or standards.

The BUOY will comply with applicable International and National regulations.

CONTRACTOR shall obtain copies of all referenced documents and shall make them readily available to all personnel involved in the work.

In case of conflict, the most stringent requirement shall be applied unless derogated by written approval of the Company and CS.

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Standards

Reference	Title
BS 1435	Specification for Rubber Hose Assemblies for Oil Suction and Discharge Services
IEC 7910	Part 10: Electrical apparatus for Gas atmosphere: for Classification of hazardous areas
ANSI B16.5	Pipe Flanges and Flanged Fittings
ANSI B13.20	Ring Joint Gaskets and Grooves for Steel Pipe Flanges
ANSI B 31.3	Chemical plants and petroleum refinery piping
ASME Section 8 division 1	Rules for Construction of Pressure Vessels
AWS D1.1	American Welding Society Structural Welding Code

Professional Documents

Reference	Title
API RP 2SK	Recommended practice for Design and Analysis of Station keeping Systems for Floating Structures
API SPEC 2F	Mooring chain
API RP 2SM	Recommended practice for design, manufacture, installation and maintenance of synthetic fiber ropes for offshore mooring
OCIMF	Offshore loading Safety guidelines
OCIMF	SPM Hose System Design Commentary
OCIMF	Guide to purchasing, manufacturing and testing of loading and discharge hoses for offshore moorings
OCIMF	Specification for rubber, reinforced, smooth bore, oil suction and discharge hoses for offshore moorings
OCIMF	SPM Hose Ancillary Equipment Guide



Reference	Title
OCIMF	Guide for the handling, storage, inspection and testing of hoses in field
OCIMF	Prototype Hose Testing
OCIMF	Guidelines for the Purchasing and Testing of SPM Hawasers
OCIMF	Hawser Test Report
OCIMF	Procedures for quality control and inspection during the production of hawsers
OCIMF	Guidelines for the Alleviation of Excessive Surge Pressure on ESD
OCIMF	Recommendations for equipment employed in the mooring of ships at single point moorings
OCIMF	Recommendations for Oil Tankers Manifolds and Associated Equipment
OCIMF	Mooring equipment guidelines
OCIMF	SPM Maintenance and operations guide

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Noble Denton	Deepwater Fibre Moorings. An engineer's design guide

Classification Society Rules

Reference	Title
ABS	Rules for Building and Classing Single Point Moorings 1996
DNV OS-E301	Position Mooring
DNV: TNA 503	Flexible pipes and Hoses for Submarine Systems
BV NI 493	Classification of Mooring Systems for Permanent Offshore Units
BV NR 432	Certification of synthetic fibre ropes for mooring systems
BV NR 494	Rules for the Classification of Offshore Loading and Offloading Buoys

Total General Specifications

Reference	Title
GS COR 100	Design of cathodic protection of offshore structures
GS COR 201	Supply of sacrificial anodes
GS COR 350	External protection of offshore and related structures and equipment by painting
GS COR 351	External protection of structures and equipment by painting. Floating Structures
GS ELE 031	Design of earthing and bonding systems
GS ELE 079	Electric apparatus for explosive gas atmosphere
GS ELE 151	DC uninterruptible power supply systems
GS ELE 161	Electrical cables
GS GEO 101	Offshore geotechnical soil survey
GS GEO 201	Offshore geophysical survey
GS GEO 501	Metocean survey
GS INS 102	Instrumentation identification
GS INS 146	Design of generation and distribution of hydraulic energy
GS PVV 111	Piping design specification
GS PVV 112	Piping Material Classes
GS PVV 142	Valves
GS PVV 143	Metallic pipes
GS PVV 144	Fittings
GS PVV 145	Flanges
GS PVV 146	Bolting for piping
GS PVV 147	Gaskets for piping and vessels

Reference	Title
GS PVV 151	Carbon steel subsea ball valves
GS PVV 171	Steel piping fabrication
GS PVV 173	Pneumatic testing of aboveground piping systems
GS SPS 024	Subsea mechanical quarter turn actuator
GS STR 201	Materials for offshore steel structures
GS STR 301	Fabrication of offshore steel structures
GS STR 401	Load-out, sea-fastening, transportation and installation of offshore structures
GS STR 403	Acceptance criteria of a support vessel for offshore works
GS STR 611	Determination of the location of an offshore terminal
GS STR 661	FPSO: Design requirements for mooring and anchoring systems

3. General

3.1 Definitions

“**Classification Society**” designates any of the agreed Classifications Societies responsible for the classification of the CALM buoy

“**PPS**” designates the applicable Project Particular Specifications.

“**BUOY**” means the complete CALM buoy system, including mooring system, buoy body, fluid transfer system from PLEM to floating hose and all buoy equipment.

“**ENGINEERING**” designates all drawings, calculations and procedures required for the design, fabrication and installation on site of the BUOY.

“**WORKS**” means all and any part of the works and services required to be performed by CONTRACTOR for the fabrication and installation of the BUOY.

“**INSTALLATION**” designates all operations necessary for the safe positioning of the buoy on its operation site, namely all transport, installation works, services and tests.

“**MANUFACTURER**” designates any subcontractor that has been awarded a contract for the supply of the buoy or any of its components.

“**APPROVAL**” means COMPANY written assent. Approval by COMPANY shall in no way relieve CONTRACTOR of any of his obligations, responsibilities or liabilities.

3.2 Classification / MWS

The CALM shall be classed by a classification society selected and/or approved by the COMPANY. The items covered by class include the buoy, the PLEM, the anchoring and anchoring points, the hoses, the hawsers and including all ancillaries and parts (piping, rotating parts, swivel, monitoring equipment, etc.)

The Classification Society shall be responsible for verifying the ENGINEERING and WORKS and will stipulate the design and operating limits of the CALM Buoy in the class certificate.



A Marine Warranty Surveyor (MWS) shall be responsible to verify the INSTALLATION.

The scope of work of the CS and MWS shall be approved by COMPANY and mutually agreed between COMPANY, CONTRACTOR and CS/ MWS prior to CS/ MWS Contracting.

The programme of inspections and test required for the classification certificate renewal shall be approved by COMPANY and mutually agreed between COMPANY, CONTRACTOR and CS prior Contracting.

The CS and MWS are selected by COMPANY on a project specific basis.

3.3 Abbreviations

CALM:	Catenary Anchor Leg Mooring
CS	Classification Society
FPSO:	Floating Production Storage Offloading
FSO:	Floating Storage Offloading
PLEM:	Pipeline End Manifold
PPS	Project Particular Specification
SPM:	Single Point Mooring
MWS:	Marine Warranty Surveyor

4. Basis of design

All units are to be in SI (metric) system. All co-ordinates shall be given in the UTM, WGS-84 system and in the SITE national system.

4.1 BUOY design life

Unless otherwise specified in the PPS, the design life of a CALM buoy shall be 30 years. Possibility to perform drydocking or not during design life shall be clearly addressed in the PPS

4.2 Project specific constraints

Any project specific constraints (such as existing local equipment and logistics, technical support available) will be indicated in the PPS along with all relevant drawings and shall be taken into account by CONTRACTOR in the design of the BUOY.

4.3 Maximum and minimum tanker size

The maximum and minimum tanker size and loading conditions to be accommodated by the CALM Buoy will be defined in the PPS and shall be motivated by an early specific study, based on the terminal needs and output characteristics, survey of local available tankers and desired size of parcels.

4.4 Marine operations

The marine assistance for the operations of mooring of the export tanker, handling the offloading lines, the means available (assistance tugs, service boat) shall be described in the PPS.

4.5 Fluid characteristics & pigging

The fluid characteristics will be provided in the PPS.

According to the fluid characteristics, the requirement or not to pig the sealine (with consequences on PLEM and possibly risers design) will be stated in the PPS and shall be based on an early specific study.

4.6 Flow rate and design pressure

The required flow rate in m³/h and design pressure are specified in the PPS, based on early specific study.

Requirement for flushing the lines shall be addressed in the PPS

4.7 Site general chart, bathymetry, CALM Buoy location

If not already available, a geophysical site survey shall be conducted as specified in **GS GEO 201** to determine the local water depth and bathymetry map on the expected footprint of the buoy terminal, including the sealine.

A complete chart of the proposed mooring area and sealine route shall be included in the PPS. This chart is to show depth soundings (reduced to Chart Datum levels, to be the same as LAT levels), obstructions, all possible existing installations (platforms, sealines, cables, etc.), manoeuvring area, and where applicable the approach channel from deep water or an established navigation channel.

The site selection for the buoy implantation, and in particular the selection of required water depth and safety distances to existing installations (if any), shall be made according to **GS STR 611**.

Final site selection shall be safe with respect to possible existing installations and shall allow safe manoeuvring, mooring and complete weathervaning of the maximum tanker size established.

4.8 Metocean conditions

If not already available, a metocean survey shall be conducted as specified in **GS GEO 501**, to determine the local environmental conditions.

The directional wave, wind, current conditions and tides (MSL, HAT, LAT and storm surges) shall be specified for extreme environments (at least 100yr and 1yr return period), as well as for fatigue environments (scatter diagrams).

The metocean document shall also provide a general description of the zone of interest, identifying known processes, existence of prevailing directions, correlation or not between wind, waves and currents.

If the zone of interest is known to have current and wind reversals, the metocean document shall, if possible, indicate corresponding possible changes in direction, intensities and corresponding durations. Reversals shall be understood as changes in direction and intensities over time.

The applicable metocean conditions are stated in the PPS.

4.9 Site soil conditions

If not already available, an offshore geotechnical soil survey shall be conducted as specified in **GS GEO 101**.

The applicable soil conditions are stated in the PPS.

4.10 Hazardous area considerations

The buoy shall be considered at least as a hazardous area class 2 for all electrical equipment. Particular aspects such as break-away coupling operation, discharge capacities, vents,... have to be specifically addressed and may lead to zone 1 requirement.

4.11 Monitoring

The need for global behaviour, motion, hawser tension, mooring line tension monitoring has to be addressed in the PPS.

For deep-sea application, mooring line tension monitoring and global behaviour recording are mandatory.

5. Design

All deliverables identified hereafter for the design of the BUOY shall be provided by CONTRACTOR to COMPANY and CS for their APPROVAL prior to procurement and commencement of the BUOY fabrication.

5.1 Mooring system

5.1.1 Mooring system components and basic requirements

The mooring system of the buoy is composed of the following parts: *mooring lines*, *anchors*, *chain stoppers*, *connecting elements* and *hawser*.

For all components of the mooring system, the method of *installation*, tensioning, re-tensioning, monitoring, *inspection* and *maintenance*, as well as the possible need for *replacement* of components during service life shall be carefully assessed by CONTRACTOR at an early stage of design, as these operations can have an important impact on the choice of the mooring lines and their design. This is particularly important for **deep water** CALM buoy systems.

Particular attention shall be paid for the initial installation which may require few length adjustment to achieve the target position.

5.1.1.1 Mooring lines

Chains shall be of the offshore grade type.

Particular care shall be taken to limit and to evaluate local effects such as but not limited to in-plane and out-plane bending, shear, torsion, wearing in terms of strength and fatigue resistance in particular at the chain-stopper, hawse, anchors, etc...

Particular care shall be taken if synthetic lines are used for **deep water** buoys. In this case, CONTRACTOR shall refer to the CS guidelines, **API RP 2SM** and the Noble Denton "Deepwater Fibre Moorings – An Engineer's Design Guide" as preliminary documents for design guidelines.



5.1.1.2 Anchor points

If not already prescribed in the PPS, CONTRACTOR shall determine, with COMPANY APPROVAL, the most adapted type of anchors for the project, based on soil conditions, ease of installation, equipment availability, type of mooring, or other.

5.1.1.3 Chain stoppers

Unless otherwise specified in the PPS, the chain stoppers of the buoy shall be of the ratchet type, whose design is to be submitted to COMPANY for APPROVAL.

The chain stoppers shall swivel about a horizontal axis perpendicular to the direction of the anchor chain. The link gripped in the chain stopper shall be in a vertical plane to avoid working under a bending load.

Particular care shall be taken to limit and to evaluate local effects such as but not limited to in-plane and out-plane bending, shear, torsion, wearing in terms of strength and fatigue resistance

5.1.1.4 Connectors

In the choice of connectors, CONTRACTOR shall demonstrate that the arrangement chosen will permit easy installation and replacement of those sections particularly exposed to wear and corrosion.

CONTRACTOR shall also demonstrate that the connectors have equal or greater properties than the mooring lines in terms of strength and fatigue resistance.

5.1.1.5 Hawser

If the BUOY is used to directly moor offloading tankers, there shall be only one (1) hawser, irrespective of the tanker size. Note that this departs from OCIMF standards.

If the BUOY is used to moor an F(P)SO (semi)permanently, with offloading tankers connecting to the F(P)SO, there shall be two (2) identical, redundant hawsers between the BUOY and F(P)SO, and one (1) hawser between the tanker in tandem and the F(P)SO.

The hawser, hawser make up and fittings are to be as per OCIMF standards. The chaffing chain for mooring on the tanker side shall be made by the chain Manufacturer. A special link between diameter 76 mm and diameter 54 mm links shall be provided instead of a Kenter link to avoid risk of blockage through the stopper.

The hawser shall be protected by polyurethane sheathing over a length of 10m on both ends to protect the nylon from chafing.

The use of a quick release hook is recommended and should be confirmed in the PPS.

Hawser-storage on a reel between offloading may be assessed.

One spare hawser shall be supplied and properly store according to Manufacturer recommendation

5.1.2 Design criteria

5.1.2.1 Offset limits

The allowable offset limits of the buoy, both in intact and damaged conditions, are based on the type of riser / export line to be accommodated, local water depth and metocean conditions. As

such, the offset limits shall be determined in conjunction with the riser / export line design analysis, as well as by advice from riser / export line MANUFACTURER.

Final offset limits shall be shown by CONTRACTOR to be compatible with riser design tolerances.

5.1.2.2 Mooring line length

If drag anchors are used, no uplift force shall be accepted for intact or damaged conditions, in either extreme or operational environments. A typical one (1) shot of chain length (27.5 meters) shall always remain on the seafloor.

For vertically loaded anchors, such as piles, the line length and corresponding amount of uplift shall be compatible with the anchor design.

5.1.2.3 Hawser length

Hawser length shall be determined to minimise fishtailing, slackness and high loads in the hawser during tanker offloading as well as the risk of collision.

5.1.2.4 Maximum tension limits for mooring lines and anchors

Safety factors for maximum tension in mooring lines vary according to references. However, for dynamic analysis, standard safety factors as defined by [API RP 2SK](#) for steel anchor lines and drag anchors, and [API RP 2A](#) for anchor piles, as modified by the following table, are applicable. Suction anchors safety factors are to be confirmed in the PPS. Summary tables of recommended values are provided below:

Mooring line	Mooring system condition	
	Intact	Damage
(Quasi static)*	2.00	1.43
Dynamic	1.67	1.25

Drag anchor	Mooring system condition	
	Intact	Damage
(Quasi static)*	1.80	1.50
Dynamic	1.50	1.3

Piles anchor	Mooring system condition	
	Intact	Damage
(Quasi static)*	2.00	1.50
Dynamic	1.50	1.30

* For reference only, since quasi static analysis is only valid for preliminary studies.

5.1.2.5 Corrosion and wear allowance

In addition to the above safety factors, a corrosion and wear allowance for the anchor lines and connecting elements shall be taken into account for the determination of final diameters / sizes of the lines make up. The following values apply, in mm per year of service life:

Splash zone and connections	0.3
Intermediary zone or catenary	0.2
Touch down zone, seabed	0.4

5.1.2.6 Maximum tension limits for hawser and related equipment

The Safety Factor for hawsers loads shall be three (3), meaning that the final hawser selected shall have a minimum wet guaranteed breaking load (in used condition) of three times the extreme load found in the design analysis.

Factor to be checked with calculation method (quasi-static/extreme)

The strength of the ancillary equipment (such as quick-release hook and its supports) shall be such that it is not the weak point in the line. Protection by calibrated weak point at a value not lower than the extreme load can be envisaged if required.

5.1.2.7 Fatigue life

Unless fatigue design curves are provided by the MANUFACTURER, **API RP 2SK** curves shall be used for conventional material and cable construction types.

The fatigue life of any component of the mooring system (chains, wire, shackles, Kenter links, chain stoppers, etc.) shall be at least ten (10) times the design life for current line and local effects.

5.1.2.8 Contacts

There shall be no contact between mooring lines and risers/export lines and pipes/PLEM.

5.1.2.9 Synthetic lines case

In the absence of a unified reference, the design criteria for synthetic mooring lines shall be based on CS guidelines, **API RP 2SM** or Noble Denton "Deepwater Fibre Moorings - An Engineer's Design Guide", whichever is more conservative. As a minimum the safety factor defined in 5.1.2.4 shall be increased of 10% for polyester ropes and 20% for other synthetic ropes.

Additional design criteria, as compared to steel mooring, relate to minimum tension, creep rupture, line length due to elongation, tension – bend and axial compression fatigue, no contact with seabed.

The upper part of the synthetic rope shall remain at all times at a minimum water depth of 100m.

5.1.3 Design procedure

5.1.3.1 Methodology

CONTRACTOR is required to provide a detailed description of the methodology and numerical tools used for the determination of mooring lines, anchors and hawser loads, which are to be reported in the design load report. If the numerical tools used are not publicly recognized, evidence for quality controls and calibrations shall be provided. The proposed methodology shall comply with all requirements and paragraphs stated hereafter.

The mooring system study shall consider two main configurations: *stand-alone* (no tanker connected) and *operational* (buoy with tanker and tug(s) connected, or buoy with F(P)SO , tanker and tug(s) connected).

In any case, quasi static analysis is only acceptable for preliminary design. Final detailed design shall be based on a dynamic analysis. Quasi-dynamic analysis (in the sense of Bureau Veritas' safety factors) will be accepted only if line dynamics are proved to be insignificant.

For details not covered in the present specification, **API RP 2SK** for steel mooring design, **API RP 2SM** / Noble Denton "Deepwater Fibre Moorings An Engineer's Design Guide" for synthetic mooring lines and requirements in **GS STR 661** shall be used.

5.1.3.2 Model tests

Model tests shall be performed for CALM buoy in particular when the design has unconventional features, such as a CALM Buoy in deep or ultra deep water, or CALM buoy in very shallow water and harsh environments, or when the CONTRACTOR has not already performed model tests for a similar terminal. The decision not to perform model tests will be made on a project specific basis.

The aim of the model test is to confirm the design results and determine the operational limits.

If tank tests are performed, a specific test program shall be prepared and submitted to COMPANY in a separate document, prior to the model tests and after preliminary numerical simulations, so as to determine specific test objectives. Model tests preliminary considerations to be followed are indicated in **GS STR 661**.

If prior model test data is used to supplement numerical models, CONTRACTOR shall prove the relevance of the model test data to the project and describe clearly how it will be used in the design methodology.

5.1.3.3 Risers / Export lines

For deep water CALM terminals, CONTRACTOR shall include the influence of the export lines in the mooring calculations, as coupling effects between the buoy and export lines may not be negligible.

For deep water CALM terminals, particular attention shall be paid to the possible modification of the system stiffness and buoy RAOs due to the presence of export lines, and additional drag load and damping due to current on export lines. Those effects are to be evaluated through a fully coupled analysis, in which case the design of the mooring lines and export lines, which are part of the fluid transfer system, shall be made together.

5.1.3.4 Hawasers

For the operational cases, the hawser dynamic loads induced by both horizontal and vertical motions at the hawser extremities shall be taken into account.

5.1.3.5 Input data file

The complete input data file used for numerical simulations shall be provided by CONTRACTOR to COMPANY, and shall be included in the design load report.

The input data file shall contain at least the following information:

- Environmental conditions and parameters, bathymetry characteristics
- Buoy, F(P)SO, tanker and tug(s) characteristics
- Mooring lines characteristics creeping and stiffness in used conditions
- Hawser characteristics (stiffness in used conditions)

- Wind and current forces (areas, coefficients and corresponding forces at different headings)
- Hydrodynamic data (added mass, radiation damping, first order wave forces, RAOs, mean drift)
- Damping coefficients and expressions (viscous, mooring lines, slow drift).
- Slow drift forces

Following are some specific requirements on some of these items:

5.1.3.5.1 Hydrodynamic data

Refer to [GS STR 661](#).

Hydrodynamic data shall include effects of changes in tanker draft for the full and ballast conditions, unless it is demonstrated that the effect is insignificant.

Unless more precise data is available, tanker ballast draft can be taken as 40% of the full draft.

5.1.3.5.2 Wind and current forces data

Wind and current forces can be obtained from OCIMF for tankers or from [API RP 2SK](#) guidelines, or from recognized software such as WINDOS for wind forces.

For tankers in shallow water, the effect of under keel clearance shall be taken into account, as this will increase lateral loads due to current.

5.1.3.5.3 Damping data

Refer to [GS STR 661](#).

5.1.3.5.4 Slow drift data

Refer to [GS STR 661](#).

5.1.3.5.5 Hawser data

Characteristics of hawser (Minimum Wet Breaking Load, load-elongation curve, weight, etc.) shall come from specifications of a recognized MANUFACTURER.

5.1.3.6 Design load case matrix

A design load case matrix shall be prepared by CONTRACTOR for the *stand-alone case* and *operational case*, for both *intact* and *damaged* cases. The two matrices shall summarize all cases studied, and shall be included in the design load report.

The stand-alone case shall correspond to the 100yr return period events. The operational case shall correspond, as a first approximation, to the 1yr return period events. The corresponding waves, wind and current conditions shall be defined in the PPS.

The damaged case shall correspond to the failure of one (1) mooring line, which will be either the most loaded line or second most loaded line, whichever is the most critical from the strength and fatigue point of view. In addition, any two line broken damage case shall be analysed with a safety factor of 1.1 unless otherwise specified in the PPS.

The operational case shall consider at least two drafts for the tanker, namely the ballast draft and fully loaded draft. In case of an FSO and tanker connected to the buoy, the two cases FSO fully loaded / tanker on ballast, FSO on ballast / tanker fully loaded shall be covered.

For both stand-alone and operational cases, the water depth giving the maximum design forces shall be selected.

Notes on operational cases:

To determine the load cases direction-wise, CONTRACTOR shall find the combinations in direction of wind/wave/current that lead to the maximum design forces for the mooring, anchors, risers and hawser. For this exercise, CONTRACTOR will usefully consider all information provided in the metocean design basis, in particular prevailing environments directions and existing correlations of environments, if any identified. If not, a systematic approach shall be used to determine worse cases, as part of the methodology to be described.

To determine the load cases intensity-wise, CONTRACTOR shall use the wind/wave/current intensities associated to each direction, up to $\pm 22.5^\circ$. For example, if a current coming from the North is considered, its associated intensity shall be the maximum of the NE, N, NW intensities.

5.1.3.7 Sensitivity analyses

Due to the importance and uncertainties on wave periods and wave spectra on floaters motions, the design load case matrix shall include, for the identified sizing cases, a sensitivity study on the wave period (± 2 seconds) and spectrum parameters.

In practice, the steady one-minute mean average wind can be used for preliminary design. In detailed design, the influence of wind dynamics shall be checked for the extremes due to the possible influence on slow drift motion of the tanker.

Other sensitivity analyses may be required if other uncertainties are identified, which can have an impact on the mooring design.

5.1.3.8 Wind/current reversals

Due to the importance of current and wind reversals on the behavior of the moored tanker, the design load case matrix shall cover at least two cases of such reversals, if any are identified in the metocean report.

5.1.3.9 Extreme response analysis

Frequency domain analysis can be used for initial design, determination of the sizing cases and screening when numerous simulations are needed (typically for operational case).

Time domain simulations, with minimum duration of 3 hours, shall then be performed on the sizing cases.

Statistics of extremes can be determined according to [API RP 2SK](#) guidelines for frequency domain results, provided that the peaks are shown to follow a narrow banded, Rayleigh distributed process. For time domain analysis of critical cases, storm duration of 3 hours shall be simulated at least five (5) times, and statistical fitting techniques (such as Weibull) shall be used to determine Most Probable Maximum values over the 3 hours storm duration.

The extreme response analysis shall provide maximum loads in anchor lines, anchor points, and hawser, as well as buoy maximum excursions, all according to the design load case matrix.

In particular, the chosen rating of main bearing shall be stated and design maximum hawser mooring load shall be shown to be less.

The no contact criteria as defined in 5.1.2.8 shall be checked under survival and operating cases.

CONTRACTOR shall advise, based on results for operating conditions, the bollard pull requirements for a tug assisting during the offloading operations.

5.1.3.10 Fatigue analysis

A fatigue analysis shall be performed at least on the most loaded and critical mooring line (including chain stoppers) according to a methodology to be described by CONTRACTOR, such as the one described in [API RP 2SK](#).

The fatigue curves and stress concentration factors used shall be clearly identified and justified.

For Deep Water CALM Buoy, the particular project specification shall define the percentage of time when a lifting tanker is moored at the buoy. It is emphasised that the presence of the lifting tanker will significantly modify the hydrodynamics of the buoy and therefore affect the fatigue lives of the mooring line components.

5.1.3.11 Anchor point design

Following the determination of design loads on anchors, CONTRACTOR shall perform the anchor point design according to the type of anchor selected.

5.1.4 Operating thresholds, terminal availability analyses

5.1.4.1 Disconnect criteria

CONTRACTOR shall indicate the different thresholds, in terms of joint allowable Hs, wind speed and if possible current speed, up to which a tanker may remain safely connected to the CALM buoy (or to the F(P)SO), with loading already stopped.

This is referred to as the cast off or disconnect criteria and shall consist of a table summarising the allowable weather operating envelope. The thresholds will be defined by the following limiting criteria: maximum allowable mooring force in hawser and buoy structural components, maximum allowable tension in anchor legs, maximum allowable load in anchor point.

CONTRACTOR shall clearly define the methodology used to determine the disconnect criteria.

5.1.4.2 Connect and stop loading criteria

Any specific requirements in term of weather limits for connecting to the buoy and to stop loading shall be indicated by CONTRACTOR.

5.1.4.3 Availability study

Based on the operating envelope, a simple terminal availability analysis shall be performed, which will confirm the numbers of days per month and per year when the operating thresholds are not exceeded, understanding that this will not take into account the issues of connecting / disconnecting, stop loading and duration of offloading.

5.1.5 Deliverables

The deliverables of the mooring design study shall consist of:

1. The design load report, determining the extreme loads in anchor lines, anchor points, hawser, buoy maximum excursions, fatigue results, mooring lines make up and characteristics, hawser line characteristics and length, CALM buoy design hawser mooring load, as per 5.1.3, 5.1.4, 5.1.5.

2. Input data file used for mooring analysis.
3. The anchor point design report, determining the anchors size.
4. The mooring lines specifications and anchors specifications sent to MANUFACTURER.
5. The offloading operating report, summarising offloading thresholds, terminal availability, tug requirements, as per 5.1.3.9.
6. The general arrangement drawing of the buoy terminal, proposed mooring system and existing installations if any.
7. Detailed drawings of each part of the mooring system make up.
8. Data sheets of equipment proposed.
9. The installation, test, retensioning procedure
10. The inspection, maintenance procedure

5.2 Buoy body

5.2.1 Buoy body components and design types

The buoy body is composed of the following main parts: the *buoy hull* providing buoyancy and stability, a *rotating part* allowing the tanker to weathervane, a *fixed part* to which the mooring lines and risers are connected. Depending on the CALM buoy design, the buoy hull may be the fixed part or the rotating part.

In the case of “turntable buoys”, the fixed part is the buoy hull itself, directly moored to the seabed. The rotating part is called *turntable*, providing a platform where the hawser and floating hoses are connected. The turntable can rotate on the buoy via roller bearing or bogie bearing.

In the case of “turret buoys”, the rotating part is the buoy hull and the fixed part is a turret structure directly moored to the seabed.

5.2.2 Buoy hull design

5.2.2.1 General features

The following features apply to both types of buoy designs (turntable or turret).

The buoy hull shall have a cylindrical or a prismatic shape with reference to the vertical axis.

The hull design shall be such that all surfaces are easily accessible for sand blasting and painting, with no sharp angles.

It shall facilitate inspection and efficient maintenance of the structure and associated equipment.

The overall hull design shall also be made such as to ease installation (towing of the buoy, mooring lines, risers and floating hoses installation, others) and divers interventions (padeyes and welded rungs).

The center of gravity of the hull shall be located on the buoy axis.

The hull shall be fitted below the waterline with a skirt around the hull to protect against tanker impact, and with fenders at the top of the buoy to protect against service boats impact.

It shall have a reinforced structural steel foundation, machined for mounting and installing the main bearing assembly. The bearing foundation shall be designed to accommodate the bearing axial and radial thrust loads and overturning moments, provide means for confirming



dimensional tolerances, provide means for fastening, seating and sealing the bearing assembly, and provide access for inspection of all bearing components offshore.

Decks and other horizontal surfaces shall be designed in order to avoid collection of rain and sea water. Where gratings are not used, relevant horizontal surfaces shall be treated with non slip coating.

The hull shall be divided into several watertight compartments, none of which shall be foam-filled. Each of the compartments shall be accessible by a watertight manhole. The size of the manholes shall be such that the equipment located inside the compartments can pass through. A fixed ladder shall be installed in line with each hatchway.

Each compartment shall be equipped with a sounding pipe. A reinforcing plate shall back the bottom plate in line with each sounding pipe.

The inside of the compartments shall be painted white.

The buoy hull and/or turntable shall be equipped with four or more lifting padeyes, shackles, wire rope slings and spreader bar, if required, for lifting the complete buoy.

The buoy hull shall be fitted with mooring bitts aligned with each of the radial bulkheads and chain stoppers.

The outside wall of the buoy hull shall comprise at least six (6) evenly spaced draft marks. The figures (in Arabic numbers) shall be 0.1 m high and shall be separated by 0.1 m intervals, extending the full buoy hull height, aligned with the radial watertight bulkheads.

The chain numbers shall be marked on the vertical wall of the buoy hull so as to be visible to divers and operators on surface. For an observer looking at the top of the buoy, these numbers shall be in the clockwise direction, with the sea-line placed between the last and the first number.

All the marks shall be welded along their entire perimeter to prevent corrosion, and they shall be painted in a colour contrasting with the hull colour.

5.2.2.2 Hull structural design

The buoy hull shall be a steel welded structure, designed according to COMPANY specifications **GS STR 201**, **GS STR 301**, and CS Rules & Regulations for the parts not covered by COMPANY specifications. It shall be suitably stiffened to maintain the form of the buoy and structural integrity under the worst load combinations from the specified design conditions.

CONTRACTOR shall submit all ENGINEERING documents (drawings and calculations) to COMPANY and CS for APPROVAL prior to start of fabrication.

During detailed design phase, CONTRACTOR shall provide a Finite Element Analysis of the buoy structure, including chain stoppers.

For the **fatigue acceptance criteria**, the following criticality factor table applies for calculating fatigue with the Company requirements as per the notes:

Consequence of failure	Degree of accessibility for inspection, maintenance and repair		
	Not accessible (note 2)	Underwater inspection (note 3)	Dry inspection
Substantial (note 1)	10	4	2
Non substantial	5	2	1

Note 1: Substantial damage as per risk analysis including loss of life, uncontrolled pollution, collision, sinking, other major damage to the installations and major production losses.

Note 2: Includes areas which can be inspected in dry or underwater conditions but require heavy works such as dry-docking for repair.

Note 3: Includes areas which can be inspected in dry conditions but with extensive preparation and heavy impact on operation.

Unless justified by relevant drawing and welding specifications for relevant details, S/N curve not better than F2 shall be used for calculations.

5.2.2.3 Subdivision

CONTRACTOR shall propose the most efficient hull subdivision arrangement with respect to the hull structural integrity and stability, taking into account surge compartment requirements.

5.2.2.4 Intact stability and buoyancy

CONTRACTOR shall justify that the buoy body has enough stability and reserve buoyancy under the following conditions:

- In still water without mooring lines or risers in place
- During towout
- During installation
- In operating conditions, including the weight of chains and risers in water, under maximum water depth and under the loads from the mooring hawser, while connected to the maximum sized import / export tanker
- After breakage of any one of the anchoring lines in 10 year conditions.
- After breakage of any two of the anchoring lines in 1 year conditions
- with a surge tank filled in 10 year conditions.

Under these conditions a freeboard shall be granted to ensure safe access to equipment and tanks for intervention without any risk of progressive flooding.

5.2.2.5 Damaged stability and buoyancy

Unless otherwise specified in the PPS, the damaged stability and subsequent reserve buoyancy of the CALM buoy shall be checked for one (1) annular compartment damaged or two radial compartments. The damaged criteria shall be the one defined by the CS.



CONTRACTOR shall state the conditions in which a tanker can remain moored to the buoy after flooding of a single compartment.

The requirements for the freeboard have to be defined but should be defined for a 1 year condition minimum.

5.2.3 Rotating part design

5.2.3.1 General features

In the case of a “turntable buoy”, the rotating part is the turntable, which shall consist of a one piece steel fabricated ring box structure with the following platforms:

- The mooring platform, fitted with connecting lugs to transmit the mooring hawser loads directly into the turntable structure. The mooring platform shall be designed to incorporate a mooring load monitoring system, as specified in the PPS, and shall provide ample personnel access for inspection and maintenance of the hawser system.
- The piping platform, fitted with connecting points for the floating hoses. The piping platform shall be equipped with permanent cable guides, fairleads and reaction points necessary for alignment and connection of the floating hose string. Sufficient personnel access for inspection and maintenance of piping arm system shall be provided.
- The boat landing platform for the service vessels defined in the PPS, equipped with fenders, two mooring bitts and a ladder. The fendering system shall extend low enough to avoid the hawser entanglement.

In addition, the turntable shall provide support for the buoy hoisting / winch equipment.

The center of gravity of the turntable shall be on the vertical axis of the buoy.

The turntable shall be equipped with sealed ballast boxes of sufficient capacity and located such as to allow the adjustment of the turntable center of gravity.

A tubular frame protective cage shall cover the turntable so that the hawser line cannot catch on projecting parts of the buoy such as valves and piping, winches and handling gear or navigational aids.

Walkways, ladders and handrails shall be fitted to all raised areas of the buoy requiring access by maintenance and operations personnel. Secondary access from sea to the buoy is recommended.

A protective cage shall also be fitted around the hawser line connecting plate on the mooring arm. Cage dimensions and height shall be such as the connecting plate or any other adjacent part will not come in contact with the frame at any time when the design tankers are moored.

Means shall be provided for locking the rotating assembly in any selected position during installation, maintenance or repair operations.

The pipe work of the rotating part shall be arranged such that, when the ship is moored, the floating hoses lead-out is located on the left for hose connections to portside.



In the case of a “turret buoy”, the rotating part is the buoy hull itself. Therefore, it shall have the same features as described in paragraph 5.2.2.1, plus the features described above and a lockable main deckhouse to protect the main bearing and swivel assembly.

5.2.3.2 Structural design

The rotating part (turntable or buoy hull) shall satisfy all requirements stated in Paragraph 5.2.2.2 above.

5.2.3.3 Main bearing

The main bearing is intended to transfer rotationally the tanker-to-buoy mooring forces between the rotating part and the fixed part. The bearing design rating in tons shall be clearly stated, in accordance with the maximum mooring loads and rotating part weight.

CONTRACTOR shall indicate the type of bearing envisaged and shall provide all corresponding specifications for COMPANY 's approval prior to manufacturing. If a roller bearing is used, it shall be a three race roller bearing.

Design, construction and machining of the bearing foundations shall be conducted in close cooperation with the bearing MANUFACTURER to ensure that all relevant design interfaces are within proper tolerances.

CONTRACTOR shall establish detailed installation procedures for the mounting of the bearing.

The bearing shall be fully protected against ingress of seawater and shall provide a means for periodic inspection.

The bearing must come with a central lubricating system so that lubrication can be guaranteed with no clogging at any temperature.

5.2.4 Fixed part design

5.2.4.1 General features

In the case of a “turntable buoy”, the fixed part is the buoy hull and it shall conform to all requirements stated in paragraph 5.2.2.

In the case of a “turret buoy”, the turret shall provide a sound structure for riser and mooring legs attachment via the chain stoppers.

5.2.4.2 Structural design

The fixed part (buoy hull or turret) shall satisfy all requirements stated in Paragraph 5.2.2.2 above.

5.2.5 Lubrication

All moving or rotating parts shall be lubricated preferably with grease. All the grease points shall be equipped with a nipple allowing the grease to be topped up with the help of a lever-type grease gun.

A single type of nipple shall be adopted for all the grease points to be lubricated with a given quality of grease. All the nipples shall be made of monel and shall be fitted with a protective plug.

Any sealing devices which may be provided on the guide rollers of the turntable and on other accessories shall be such as to prevent water ingress while allowing excess grease out.



CONTRACTOR shall supply, for each grease quality, a grease gun having a long enough hose to reach the difficult access points.

5.2.6 Deliverables

The deliverables of the buoy body design study shall consist of :

1. The buoy body structural calculations and FEM design report, including chain stoppers.
2. Weight and CoG report of buoy body.
3. Compartments sounding tables
4. Buoyancy and stability checks.
5. Main bearing design.
6. Lubrication system design.
7. Detailed drawings of buoy body components.
8. Inspection, monitoring, maintenance and repair procedure.

5.3 Fluid transfer system

For CALM in deepwater, specific requirements and equipment are to be defined in the PPS.

5.3.1 Fluid transfer system components

The fluid transfer system is composed of the following main parts, independently of the buoy design type: *PLEM* or other subsurface manifold, *risers / export lines*, *fluid swivel*, *expansion joint*, *product piping*, *valves*, *flanges*, *floating hoses*, *breakaway couplings*, *surge relief system*. Each element shall be designed according to COMPANY specifications.

Pressure drop calculations

In order to size the different elements of the fluid transfer system, CONTRACTOR shall supply pressure drop calculations in accordance with the characteristics of the product(s) to be conveyed, the piping characteristics, flow rates and all other relevant parameter as defined in the PPS.

The results shall show the various coefficients and lengths taken into account for the tubes, elbows, tapings, reductions, valves and obstacles met all along the terminal transfer circuits.

Calculation results shall be indicated separately for all pieces of equipment along the fluid path, from storage to tanker:

- Piping on storage tank.
- Sealine between storage tank and PLEM
- PLEM
- Risers
- Piping on buoy
- Floating hoses

5.3.2 Surge relief system

In addition to pressure drop calculations, a surge analysis shall be carried out early on in the design phase to determine the maximum incidental surge pressures to be used for transient regime design purposes. This analysis shall identify and consider the most probable surge scenarios.

Based on the surge analysis, CONTRACTOR shall propose to COMPANY for its APPROVAL the most appropriate surge relief system for the specific BUOY studied.

Unless a less severe hypothesis can be justified, the use of a rupture-disc with adequate flowrate and time has to be assumed for the calculation of the surge tank volume, the final aim being to prevent oil release.

Oil removal from the tank has to be also studied.

5.3.3 PLEM / Subsea Manifold

In this section, PLEM only applies to shallow water CALM buoys, which are linked to the shore via a sealine.

5.3.3.1 General requirements

A Pipe Line End Manifold (PLEM) shall be provided to interface between the sealine and the risers. Its main functionalities shall be to provide a safe departure point for the risers to the buoy, a pig station if pigging is required and safe isolation of the sealines and risers by means of valves.

The PLEM shall be located on the seabed in the vicinity of the BUOY, its exact position shall be justified by CONTRACTOR based on the specific riser configuration chosen (see 5.3.2).

The PLEM shall comprise a cylindrical body of the same diameter as the sealine, equipped with a flange for connection to the sealine, a pig launcher / receiver if pigging is required, a tapping for each riser and a main frame supporting all piping and valves to be secured to the seabed. The radius of the curved portions shall be at least 5 times the diameter of the piping.

The tapings shall be fitted with a pig guide if pigging is required.

On each buoy-side tapping a valve shall be installed to isolate the risers for maintenance purpose. The buoy-side tapings shall be angled to suit the configuration of the risers. The sealine side tapping may also be equipped with a valve, depending on design requirements.

Based on the soil conditions and potential expansion of the sealine specified in the PPS, CONTRACTOR shall determine the best means to anchor the PLEM on the seabed, either by anchor piles or gravity ballast, or by allowing sliding along the seabed in the event of substantial pipeline expansion.

If the soil is very loose, the PLEM may be lightened by the addition of buoyancy tanks to provide the buoyancy required to limit the pressure of the PLEM on the soil to the same value as that applied by the sealine.

The PLEM body and tapings up to the valves shall be designed to withstand the same test pressure as the sealine.

Cathodic protection shall be provided in accordance with the PPS, Company specification in reference and specified design life.

The PLEM shall be white paint coated with corrosion allowance as per the PPS.

5.3.3.2 PLEM stability and structural design

CONTRACTOR shall submit to COMPANY for APPROVAL all calculations made to design all components of the PLEM. In particular, CONTRACTOR shall submit :

- Calculation of vertical /horizontal loads exerted on the PLEM outlets by the risers, calculation of horizontal movements, including sealine thermal expansion movement or force,
- PLEM structural design calculations,
- PLEM restraint / anchoring system.

Structural design shall be made according to COMPANY Specifications or CS rules. PLEM anchoring with piles or gravity, shall be defined and calculated according to **API RP 2A**.

5.3.3.3 PLEM valves requirements

By default, the valves on the risers side shall be remotely operated from the buoy body.

However, should the water depth be less than 40m, with mild metocean environment and the BUOY site has a service vessel with divers available on a regular basis, or should the sealine be reasonably short, then COMPANY may elect to have PLEM manual valves.

CONTRACTOR shall refer to the PPS for exact requirements on valves remote control.

When remotely controlled, the PLEM valves shall be equipped with a position indicator with surface reading on the buoy. Capacity shall allow for opening or closing from a control station inside the buoy three consecutive times, and functionally tested at regular periods as specified in the PPS.

5.3.4 Risers

5.3.4.1 General requirements

The risers (or underwater hoses) shall provide a safe flowline between the PLEM and the buoy bottom.

CONTRACTOR shall be responsible for determining and justifying the optimum riser configuration and construction for the BUOY studied, so as to meet all the requirements of this specification and the PPS. Specific attention shall be paid to clashing possibilities.

The risers shall be of the double carcass construction, with effective, demonstrated means to detect a leak between the two carcasses.

Two independent risers shall be provided if there is only one product. In case of several products the risers configuration shall take account of the products compatibility.

If add-on floats are used, the number and attachment of float carriers shall allow to adjust the configuration of the risers by moving the floats. CONTRACTOR shall seek to standardise the hoses equipped with float carriers.

Float fastenings shall be carefully designed to eliminate any risk of loss of floats by corrosion or breakage of the fastenings, and the solution proposed by CONTRACTOR shall be submitted to COMPANY for APPROVAL.

Special attention shall be paid at design stage to the means and systems required, both on the PLEM and under the buoy, to facilitate riser connection and disconnection operations, and to eliminate the risk of twisting of the risers during installation.



The configuration, buoyancy and length of the risers shall be carefully studied to prevent risers chaffing against the sea bottom, against the anchor lines, against other risers and against the buoy hull, whilst allowing full excursion of the buoy without undue stress on the hoses.

Riser ends connected to rigid piping shall have built-in reinforcement.

The risers shall be electrically discontinuous.

On each riser, two (2) indelible white lines shall be made on two (2) lines 180 degrees apart, which shall be positioned identically with respect to the flanges on all the risers. The bolt holes in the flanges on each end of the riser shall be aligned.

§4.4 dealing with pigging recalls the corresponding requirements.

5.3.4.2 Riser Analysis

CONTRACTOR shall perform a detailed riser motion, stress and interference analysis and shall supply full details of calculations performed. The riser analysis shall be coupled with the mooring analysis. However, for small water depths and mild environments, an uncoupled analysis may be accepted.

In the case of steel risers, a fatigue analysis shall also be performed on the risers and riser end connections.

CONTRACTOR is required to provide a detailed description of the methodology and numerical tools used for the riser analysis and motion simulation. A design load case matrix shall be determined by CONTRACTOR similar to the mooring analysis and given to COMPANY for APPROVAL.

The final riser configuration and corresponding calculations shall at least take into account the following:

- Minimum (Near), mean and maximum (far) excursions of the buoy with respect to the PLEM under operating, stand-alone and survival conditions, for both intact and damaged/accidental cases.
- Motion of the components of the system.
- External forces on the riser system.
- Range of specific gravity of the contents envisaged in the riser system.

For each case, CONTRACTOR shall demonstrate that the following criteria are met:

- No interferences at any time between the risers and seabed, PLEM, mooring lines, other riser(s) and buoy hull.
- Maximum tension, compression, minimum bend radius, twisting of risers are within allowable.
- Forces on PLEM and buoy flanges extremities are within allowable.

The allowable characteristics of the risers shall be in accordance with MANUFACTURER 's specifications, latest issue of [BS 1435](#) and [OCIMF](#) "Buoy Mooring Forum Hose Standards".

5.3.5 Export lines

In case of deep water buoys, specific requirements for export lines design and analysis shall be indicated in the PPS. These requirements are similar to the ones for risers in 5.3.4. However, particular attention shall be paid to the offset, the pigging, the fatigue issue of export lines in



case of steel construction, and sensitivity to design parameters such as drag or fatigue environments.

5.3.6 Product swivel

The product swivel consists of two parts, the fixed bottom part, which is supported by the fixed part of the buoy body, and the top part, which rotates with the piping on the rotating part of the buoy. The swivel has a bearing and a set of inner (product) seal and outer (bearing) seals.

5.3.6.1 General requirements

Unless otherwise specified in the PPS, the swivel shall have as many independent passages as there are fluid circuits. In the case where two or more different products are transferred, an empty chamber shall be inserted between the passages, having holes opening onto the outside. Those holes shall not be plugged.

Provision shall be made for eliminating any load transmission to the swivel due to possible minor misalignment between the main bearing of the rotating part and the swivel bearing. The fluid swivel shall be designed to minimise hydraulic reaction forces.

The swivel shall not withstand forces other than those generated by the pressure of the product(s) conveyed. The rotary drive of the mobile portion of the swivel shall be provided by a system that does not introduce any radial force on the swivel.

The seals shall be impervious to both seawater and the transferred products. The type and number of seals shall be determined by CONTRACTOR such as to ensure safe operation of the BUOY without undue interruptions due to of leakage. There shall be at least one inner seal and two outer seals.

Precision machined corrosion resistant materials shall be utilised for the static and dynamic surfaces surrounding all the seals.

Leak detection ports shall be provided for both the inner and outer seals.

The swivel design shall allow product seals to be replaced on-site without removal of the swivel from the buoy and by using the hand tools and equipment provided on the buoy only. No additional outside lifting equipment, such as a crane barge, shall be required to replace the fluid seals.

Air vents shall be provided in the top part of the passages and drainage holes in the bottom for in-situ maintenance purposes. These vents shall be plugged by stainless steel plugs.

The construction of the swivel shall be monitored by the CS and COMPANY representatives at all phases, including assembly and final testing.

5.3.6.2 Swivel design

In the absence of specific requirements by the CS, the swivel shall be designed according to ABS "Rules for Building and Classing Single Point Moorings", paragraph 4.1.7.

The design pressures shall be consistent with the fluid transfer system ratings and surge analysis.

Prior to fabrication, the drawings and calculation notes shall be submitted for APPROVAL to the CS and COMPANY. The notes shall specify the displacement, if any, allowable between the moving part and the fixed part of the swivel compatible with correct operation of the bearing and the expansion joint. The correct operating conditions shall be specified in writing by the Supplier of the equipment concerned.



Electrical swivel joint may have to be provided.

5.3.7 Expansion joint

There shall be an expansion joint on each pipe run after the product swivel.

In the absence of specific requirements by the CS, CONTRACTOR shall design the expansion joint according to ABS "Rules for Building and Classing Single Point Moorings", paragraph 4/1.9.4. The design pressures shall be consistent with the fluid transfer system ratings and surge analysis. Fabrication and testing at MANUFACTURER 's site shall be monitored by CS and COMPANY for final acceptance.

5.3.8 Product piping system

The product piping system is composed of a fixed part below the product swivel and a rotating part above the product swivel, all to be of steel with welded or flanged connections.

5.3.8.1 Piping below the swivel

This piping extends from the bottom of the buoy fixed part to the lower part of the product swivel. It shall consist of at least two pipes of similar size, or more if multiple products apply. The number, size and ratings of the pipes are to be in accordance with the fluid transfer system overall sizing.

A manually operated isolation valve shall be inserted on each pipe before its connection to the swivel. These valves shall be easily accessible in the buoy centre well.

A flanged rigid pipe connecting spool shall be supplied for connection of the piping to the risers / export lines at the required diameter and departure angle.

The lower portion of the piping shall be located, whenever possible, above the bottom of the buoy fixed part, in order to avoid creating projections that may be vulnerable during launching or dry-docking operations, and shall be supplied with blind flanges.

The piping elements before the swivel shall be securely mounted on the buoy fixed part by welding or by bolted clamps, in order to resist internal forces due to fluid flow and pressures and external forces transmitted by the risers motions. Provision shall also be made for expansion.

5.3.8.2 Piping above the swivel

This piping extends from the expansion joint to the floating hose.

CONTRACTOR shall determine the number, size and ratings of the pipes in accordance with the fluid transfer system overall sizing and number of products.

An isolation valve shall be placed on each piping element between the expansion joint and the floating hoses.

A flanged rigid pipe connecting spool, with required end diameter and departure angle, shall be supplied for connection of the floating hoses to the piping. The centre of the connecting flange shall be located at the waterline. The inclination, in relation to the sea surface, of the spool piece shall be carefully designed to achieve a least stressed configuration at the first floating hose and easy installation of the hose. This inclination shall be subject to the written approval of the floating line supplier.

All piping elements shall be supported by welding or clamps to secure them against all loading conditions. In case of clamps, all precautions shall be taken to prevent the transmission of forces detrimental to the expansion joints.

In particular, the last section of pipe connecting to the floating hoses shall be reinforced to resist the loads induced by the floating hoses.

5.3.8.3 Product piping design

The piping design shall be as per COMPANY specifications [GS PVV 112](#), [GS PVV 143](#), [GS PVV 146](#), [GS PVV 147](#), [GS PVV 171](#).

5.3.9 Valves

5.3.9.1 General requirements

All valves on the buoy Fluid Transfer System shall be isolation valves, full flow ball valves, with the exception of the pressure relief valves associated to a specific surge relief system (if any), and the butterfly valves located at the tanker end of the floating hoses.

The isolation valves are located at a minimum on the PLEM at each riser departure, on the buoy product piping below the swivel and on the buoy product piping above the swivel. The pressure relief valves, if any, are located upstream the swivel.

In the case of a manual control valves, the reduction ratio shall be such that not more than 10 kg.m torque is necessary to operate them. The valve stem packing and the reduction gearing shall both be permanently lubricated.

The reduction gears casing, the hand wheels, levers, bolts and nuts shall be made of materials resistant to corrosion from seawater and to impacts.

The sealines or export lines shall be equipped with ESDVs. The valves above the swivel may be manually or remotely operated. CONTRACTOR shall refer to the PPS for the actual manual / actuated valves arrangement.

5.3.9.2 Valves design

All valves shall be designed according to COMPANY Specifications [GS PVV 142](#) and [GS PVV 144](#).

5.3.10 Flanges and fittings

Flanges and fittings shall be designed according to COMPANY Specifications [GS PVV 144](#) and [GS PVV 145](#).

5.3.11 Floating hoses

5.3.11.1 General requirements

Two types of tankers may be available at the BUOY terminal, either tankers of opportunity, with loading manifold at midship or "shuttle" tankers, equipped with a bow loading manifold. The type of tanker that will moor at the buoy shall be stated in the PPS, and the floating hoses designed accordingly.

In any case, the buoy-to-tanker floating hoses shall be made of flexible, double carcass hose sections.

In order to prevent any risk of pollution and damage from water hammering, each floating hose string shall be equipped with a breakaway coupling (see 5.3.12).

The floating hose string shall have the following configuration:

- Full Reinforced Half Float Line (first hose off of the buoy)

- Half Reinforced Full Float Line (second hose off of the buoy)
- Mainline Floating Lines
- Hose Breakaway Couplings
- Tanker Tail Floating Lines (before the rail hose on the tanker)
- Tanker Rail Floating Lines (last hose over the rail on the tanker)
- OCIMF ancillary / hose end equipment

The OCIMF ancillary equipment includes, per hose string, a gear operated butterfly valve, camlock coupling with spool piece, lightweight blind flange, hang off or snubbing chain, auxiliary chain, pick-up chain, combined pick-up / marker buoy.

The floating hoses shall have built-in buoyancy, with a reserve buoyancy of at least 25% (for an immersed, seawater-filled hose).

In particular, the buoyancy required for the rail hose shall take into account the weight of the equipment located at the end of the rail hose described above.

The design working pressure of the floating hoses shall be 1/5 of the bursting pressure.

The floating hoses shall have adequate length to allow safe and easy connection to the manifold of the maximum and minimum tanker sizes indicated in the PPS, in ballast condition.

The weight of the floating hoses to be picked up for connection to the tanker manifold (assuming a light ship and a floating line full of seawater) shall be less than the Safe Working Load (SWL) of the hoisting machine of the minimum tanker size, as mentioned in the PPS. In the event that this requirement is incompatible with the floating hoses used, the line of floating hoses shall be terminated by either a section or two branches of reduced diameter.

Diameter reductions, if any, shall be integrated in the floating lines providing the transition, in their end parts. The transition hose shall not be internally tapered. If split into two branches, the reduction shall be made at the Y-coupling.

The flow-rates in the reduced diameter sections shall be less than the values indicated by the MANUFACTURER, especially if they are greater than the standard flow-rate of 15m/s.

There shall be a difference in length between each line of one standard hose length, the shortest line being the innermost one, or the one connected to the foremost part of the ship.

The hoses end flanges shall be welded onto the steel end pieces built into the line ends.

The hoses shall be electrically continuous except for the tail hose on the tanker end, which shall be electrically discontinuous as per OCIMF.

The outer surface of the flanges shall be either galvanised or coated with an approved anti-corrosion product.

The floating hoses shall be equipped with signal lights, as per 5.4.1.2 below.

5.3.11.2 Floating hoses design

Unless otherwise specified herein or in the PPS, the complete floating hose strings shall be designed and equipped as per OCIMF hose standards,.

CONTRACTOR shall determine and state in his tender all the characteristics of the hoses proposed and in particular the nature, composition, diameter, length, thickness, ancillaries to be

added, head loss, hoisting weight of the tail hose, efforts at both ends of the floating hose strings.

5.3.12 Breakaway couplings (BAC)

Each floating hose shall be equipped with a breakaway coupling of the double closure type.

The BAC shall be located as close to the import / export tanker as possible, at a distance such that they always remain in water when connected to the manifold(s) of all possible tankers, even in ballast condition.

CONTRACTOR shall determine, in agreement with COMPANY, the philosophy of usage of the BAC, i.e. in what case it shall part.

CONTRACTOR, in relation with breakaway couplings MANUFACTURER, shall provide the main settings, i.e. parting load threshold, internal pressure threshold, closing speed, and demonstrate that the values chosen are coherent with the specific fluid transfer system design and the intended purpose of the breakaway coupling.

In any case, the following recommendations shall be followed for BAC setting:

BAC parting load shall be such as it will be less than the weakest link of the complete floating hose string, including rigging equipment on board tankers to support tanker rail hose, and connection on buoy side.

BAC closing speed shall be set slow enough to avoid pressure surges in the fluid transfer system and pumping equipment, while minimising the amount of pollution during closure. The closing speed shall be based on the results of the surge analysis and the knowledge of the maximum pressure in transient mode acceptable in the fluid transfer system.

5.3.13 Deliverables

The deliverables of the Fluid Transfer System (FTS) study shall consist of:

1. Pressure drop calculations of the entire FTS.
2. Surge analysis and surge relief system design.
3. PLEM design as per 5.3.3.2.
4. Riser simulation report as per 5.3.4.2, for extreme and fatigue.
5. Product piping structural calculations.
6. Swivel and expansion joint design.
7. Floating hoses strings design and ancillary equipment, including breakaway couplings settings
8. Corresponding drawings for entire FTS
9. Data sheets of all equipment involved (risers, floating hoses, ancillaries, breakaway couplings...)

5.4 Equipment

The BUOY shall be fitted with the following equipment :



5.4.1 Safety

5.4.1.1 Access and protection

All exposed areas on the buoy to be accessed by personnel for operation, inspection and maintenance purposes shall be equipped with ladders and fixed or removable tubular guard rails, in such a manner not to interfere with the operation of the facility.

5.4.1.2 Lifebuoys

CONTRACTOR shall supply and install two (2) life-buoys equipped with the regulatory light, on a 50-meter rope. The supports for the two life-buoys shall be placed at two opposite points on the deck.

5.4.1.3 Fire extinguisher

A fire fighting system suitable for extinguishing both oil and electrical fires shall be installed on the CALM buoy.

CONTRACTOR shall supply and install two (2) fire extinguishers, with a 10 kg charge, to be located on the turntable and housed in a watertight locker. The PPS may impose a COMPANY specific model.

5.4.2 Navigation aids

Signal light, foghorn, radar reflectors and flashing beacons shall be provided by CONTRACTOR as required by Classification Society, International and National Rules and Regulations and OCIMF guidelines.

5.4.2.1 Buoy signal light

The buoy shall be equipped with a signal light. The light shall have a range of 9260m (five nautical miles) for a transmission factor of 0.7 and a horizontal visibility of 360°. It shall be fully automatic and shall comprise the following components:

- A photocell to switch the lamp on and off automatically at nightfall and daybreak,
- An automatic lamp changer with at least four (4) lamps,
- A programmable flasher allowing to obtain the flashing frequency approved by the Lighthouses and Beacons Authority of the country concerned.

The characteristics of this light (colour and flash) shall likewise meet the requirements of the same above stated authority.

The light shall be positioned high enough and in such manner as not to be hidden by any obstruction.

5.4.2.2 Floating hoses signal light

At least two signal lights shall be provided to mark the floating lines. Each light shall be built as a watertight, self-contained unit consisting of :

- The electric battery supplying the power,
- The light itself with its flasher program to meet the required characteristics,
- A photocell to switch the lamp on and off at daybreak and nightfall.

5.4.2.3 Fog horn

An electric fog horn shall be installed on the buoy. The horn shall have a minimum range of 2778 m (one and a half nautical mile), a sound intensity of 100.4 decibels at 7.62 m (25 feet), over 360° of a horizontal plane. The minimum sound emission frequency shall be 400 Hz.

The sound program shall be determined by agreement with the competent Authorities of the country concerned.

The horn shall be actuated by an automatic, remote and manual switch and it shall be positioned such that it is not obstructed by other equipment.

5.4.2.4 Radar reflector

A radar reflector at least 0.50m across shall be installed on the buoy. The type and position of this reflector shall be specified by the MANUFACTURER.

5.4.3 Hoists and winch

The buoy shall be equipped with an air or hydraulic driven winch and hoist system strong enough to safely accomplish the following installation and maintenance operations: (dis)connection and (re)tensioning of the mooring lines, (dis)connection of the floating hoses and risers, handling of fluid swivel or other equipment during maintenance.

The winch shall consist of a pneumatic or hydraulic drive motor, brake gear, clutch, winch drum, frame and base. It shall be designed for continuous service in an offshore marine environment, including exposure to salt water spray.

A davit or tripod including wire rope sheaves and pulley/guides shall be mounted on the buoy above the centerwell to service the risers and swivel. A fixed A-frame or similar equipment shall be fitted on the buoy to service the mooring lines and other equipment.

The winch system shall be supplied with all the necessary ancillaries, in particular cables with minimum load safety factor of three (3) and adequate length, clamps, hooks, pulley blocks, sheaves, reaction points, fairleads, shackles, rigging to perform all the functions.

The Safe Working Load shall be welded on each lifting equipment.

CONTRACTOR shall provide a detailed description of all the tensioning and handling gear, including winch pull capacity, static holding capacity, drum wire rope spooling capacity, wire rope diameter and length, etc.

5.4.4 Telemetry system

A telemetry system shall be fitted on the buoy for data transmission and remote controls. The specific arrangements and choices of parameters to be monitored and/or controlled remotely depend on the type of buoy and local environment considered. These choices shall be clearly defined and justified in the PPS, through a specific telemetry requirements study.

As a general recommendation, the amount of monitoring and remote controls shall be minimised.

The following equipment may be remotely actuated :

- Valves on piping platform of the buoy
- Fog horn

The parameters to be monitored shall be as a minimum :

- Hawser load tension
- Hook status (if provided)
- Buoy position for berthing aid and monitoring
- Valve status
- Transmission status
- Battery voltage

Other parameters, such as product pressure, waves, wind and current conditions may be monitored on a specific basis, to be justified by the initial telemetry requirements study.

All parameters shall be monitored from the Base Station and from the Portable Unit, which is to be enclosed in a lightweight, watertight carrying case.

In all cases, the Remote Telemetry Unit on the buoy shall be protected by a ventilated cabinet.

The telemetry system specifications shall be described in the PPS and designed in cooperation with specific MANUFACTURER. It shall comply with COMPANY specifications INS and ELE.

5.4.5 Electrical power

The electrical energy necessary for operating the buoy light, fog horn, telemetry system or any other relevant device shall be furnished by rechargeable batteries or dry cells. The capacity of these batteries or cells shall be sufficient to power the devices for at least six (6) months without recharging or before replacement.

The batteries or cells shall be placed in a sealed and secured compartment, readily accessible for checking and replacing the elements. The batteries or cells themselves shall be sealed and shall not release gases, and they shall be unaffected by the buoy's movements (tilt).

In order to maintain full battery charge, the batteries shall be rechargeable by any of the following means, depending on the requirements of the PPS : solar panels, wind generator, any other suitable device.

The electric current produced shall be regulated. All electrical fittings and cabling shall be certified as intrinsically safe. The electrical power design shall be in accordance with COMPANY specifications **GS ELE 031, GS ELE 079, GS ELE 151, GS ELE 161**.

5.4.6 Bilge system

CONTRACTOR shall provide a pumping capability and a piping system for transferring seawater and/or other fluids from tanks and voids compartments within the CALM hull overboard, or to a discharge line for collection and disposal. A pump can be connected to any of the compartments where suitable mounting brackets shall be fitted. In addition, piping shall be designed to be connected to an external mean (pump on a service vessel). Corresponding hose with sufficient length shall be provided and stored on the buoy.

5.4.7 Tools

CONTRACTOR shall supply the necessary tools for maintenance of all equipment and in particular the following tools:

- Set of split key wrenches and set of double-ended offset ring wrenches covering the whole range of bolts and nuts used on the equipment supplied,



- A set of standard maintenance tools, including at least: hammer, various sized chisels, punch, hacksaw, screw drivers of various sizes and tips, pliers and adjustable wrench,
- A set of all the special wrenches and keys necessary for dismantling or operating mechanical components such as roller pins, bogies axles, sounding plugs, glands, etc.
- Two explosion proof, portable work lamps,
- All other tools and tooling required for the items supplied by CONTRACTOR.

All of these tools and tooling shall be stored in one or more toolboxes.

5.4.8 Deliverables

The deliverables of the Equipment design section shall consist of:

1. Winch and hoisting definition and capacities justifications.
2. Telemetry system definition.
3. Data sheets of all equipment.

5.5 Corrosion management

The corrosion management is based on protection by cathodic protection and painting and additional thickness giving corrosion allowance as explained after:

5.5.1 Cathodic protection

Cathodic protection of the BUOY shall be made by sacrificial anodes, according to COMPANY specifications **GS COR 100** and **GS COR 201**.

The number, weight and arrangement of the sacrificial anodes shall be such as to ensure the protection and integrity of the buoy body and chains for a duration to be specified by the PPS.

Cathodic protection of the PLEM and its support shall extend for the design life of the BUOY.

To facilitate future replacement by divers, the anodes shall be bolted on brackets. In case of anodes placed very close to the surfaces to be protected, the anode face closest to the wall to be protected shall be plastified.

CONTRACTOR shall submit all cathodic protection calculations to COMPANY for APPROVAL, specifying the following:

- Value of proposed current in accordance with environmental characteristics,
- Areas involved
- Anode material (exact chemical composition),
- Electrochemical properties,
- Anode dimensions, quantities and positions.

For calculation of surface areas, the latest revisions of drawings shall be used, and all areas below the Mean Sea Level shall be included. Reference to drawings and revision numbers shall be given.

Special precautions shall be observed in calculations for cathodic protection in the event that the buoy serves as a permanent mooring for a floating storage facility. In this case, COMPANY reserves the right to change the recommended cathodic protection.

5.5.2 Painting

The buoy painting shall be as per COMPANY specification **GS COR 350** and **GS COR 351**.

Recommended colour for external painting shall be orange .

Special care shall be taken at BUOY design stage so that all surfaces are easily accessible for sand blasting and paint, with no sharp angles allowed.

5.5.3 Corrosion allowance

In addition, for a new unit, a thickness addition (corrosion allowance) is required. The following table gives total (in mm) to follow as a minimum: Reasons for deviations shall be fully documented.

Location of elements sides		Top (within 1.m below top)	Elsewhere	Remarks
Ballast tank	Ballast tank	6	4	Applies to members and boundary plates
Ballast tank	Exterior dry (voids, deck)	4	2.	
Ballast tank	Exterior dry/wet (shell)	n.a.	2.	
Ballast tank	Exterior wet (bottom)	n.a.	2.5	
Dry compartment	Exterior dry/wet (shell)	2	2	
Dry compartment	Exterior wet (bottom)	n.a.	2	

6. Fabrication

6.1 Materials and equipment specifications

Requirements on materials specifications and inspections are stated hereafter.

6.1.1 Structural steel plates and profiles

All structural steels used in the construction of the buoy and its components shall comply with **GS STR 201**.

6.1.2 Mooring lines components

All steel castings such as chains and chain-stoppers shall comply with the following references:

- CS Rules and Regulations
- **API RP 2F** Specification for mooring chain,
- **API RP 2SK**
- DNV Certification Notes No. 2.6 Certification of Offshore Mooring Chain (August 1995)
- International Association of Classification Societies (IACS) W22: Quality Assurance for Mooring Chains



- ASTM A 148
- ASTM E 709

If synthetic lines are used, specific requirements shall be made in the PPS.

6.1.3 Anchors

The anchors are fabricated from plate steel to form a welded construction. This steel material shall conform to the CS requirements, unless otherwise specified in the PPS.

6.1.4 Bolting

For assembly of components other than piping and bearings, the bolts, nuts and washers shall conform to the following requirements:

- Bolts : ISO 898/1, (5.8 for all general assembly bolting)
- Nuts : ISO 898/2, (5 for all general assembly bolting)

Bolting shall be painted with the same paint system as for the entire assembly.

The stud bolts and nuts shall be coated with PTFE of a make to be subject to the approval of the COMPANY.

All nuts and bolts other than those for flanges assemblies shall be of a stainless material or carbon steel coated with PTFE. The grade of the nuts and bolts shall be subject to approval of the COMPANY.

6.1.5 Bearing Bolting

Bolts, nuts and washers for bearing pretension bolts are to have the mechanical material requirements of the following:

- Bolts : ISO 898/1
- Nuts : ISO 898/2

Bolts and nuts shall be sherardized with a 50 microns thick coating which acts as a corrosion protection.

6.1.6 Sections

All sections imparting strength to the structures shall undergo acceptance in accordance with the regulations of the selected Classification Society.

6.1.7 Piping, valves and fittings

6.1.7.1 Piping

All pipes used for the fabrication of fluid transfer piping shall conform to COMPANY specifications [GS PVV 112](#) and [GS PVV 143](#).

6.1.7.2 Flanges

All flanges used for the fabrication of fluid transfer piping shall conform to [GS PVV 145](#).

All welding neck flanges shall be of raised face type unless otherwise specified.

All flanges shall be marked with the following : Class, grade and type, pipe thickness, nominal diameter.

6.1.7.3 Welded Pipe Fittings

All welded fittings used for the fabrication of fluid transfer piping such as elbows, reducers, tees, caps, etc. shall conform to **GS PVV 144**.

6.1.7.4 Pipe Bolting

All bolting for product pipe flanges shall be of alloy steel stud bolts with two hexagonal nuts and shall conform to COMPANY specification **GS PVV 146**.

6.1.7.5 Gaskets

All gaskets for connection between rigid pipes and floating lines shall be of "Metaflex" type and shall conform to COMPANY specification **GS PVV 147**.

6.1.7.6 Expansion Joints

All expansion joints used for medium product pressure shall conform to the following requirements:

- - Working temperature : from –30°C to +80°C
- - Material : Resistant to corrosion for crude oil with 25% maximum of aromatic contents and seawater resistant.

6.1.7.7 Valves

All valves used shall conform to the requirements of COMPANY specification **GS PVV 142**.

6.1.8 Risers and Floating hoses

Risers and floating lines shall conform to the requirements of the latest editions of:

OCIMF (Oil Companies Marine Forum)

"Guide for Purchasing, Manufacturing and Testing of Loading and Discharge Hoses for Offshore Mooring", 1991

"Guide for Handling, Storage, Inspection and Testing of Hoses in the Field".

"SPM Hose Ancillary Equipment Guide".

BS (British Standard)

BS 1435 (1975) "Specification for Rubber Hose Assemblies for Oil Suction and Discharge Service)

DNV (Det Norske Veritas)

Technical note TNA 503 "Flexible pipes and Hoses for Submarine Systems"

"Guidelines for Flexible Pipes"

ANSI (America National Standards Institute)

ANSI B16.5 (1982) "Pipe Flanges and Flanged Fittings"

ANSI B13.20 (1973) "Ring Joint Gaskets and Grooves for Steel Pipe Flanges".

6.1.9 Hawsers

Hawsers shall be of nylon and their manufacturing shall fulfil the requirements of the latest editions of the following OCIMF standards:



“Procedures for quality control and inspection during the production of hawsers”

“Prototype rope testing”

“Guide to Purchasing Hawsers”

6.1.10 Navigation aids

The signal light shall conform to the National and International regulations.

The fog horn shall conform to I.A.L.A. range rating criteria.

The radar reflector material shall be as per AISI 316L.

6.2 Provisional acceptance of materials and equipment

All materials used in the fabrication of the BUOY and its components shall undergo a provisional acceptance at the workshop, in accordance with COMPANY and CS requirements, to ensure fitness for purpose of each individual equipment. This acceptance shall lead to the delivery of a provisional acceptance certificate, to be issued by the CS, approved by COMPANY, and allowing the factory release of the materials and equipment.

To complete the provisional acceptance, CONTRACTOR shall submit to COMPANY and CS an Inspection and Test Plan to be agreed upon.

Responsibility for all inspections, checks and tests of all the work done and materials supplied by the CONTRACTOR or his Subcontractors shall lie with the CONTRACTOR and shall be carried out at his expense.

COMPANY may designate as it deems necessary Inspectors in the CONTRACTOR and his Subcontractors construction sites, and at the installation site. However, the inspections, checks and tests performed by such duly designated COMPANY Inspectors shall not relieve the CONTRACTOR of responsibility for all such controls.

In order to permit COMPANY designated Inspectors to make their tests under the best possible conditions, CONTRACTOR shall give them ready access to their worksites and workshops and shall provide all the resources and facilities they need, including premises, office equipment and telephone, to fulfil their inspection tasks.

All certificates, in particular certificates of chemical analysis and mechanical properties of materials, including impact tests, shall be stored carefully for subsequent compilation.

The following is a quick, non exhaustive review of some of the BUOY components to be inspected and tested.

6.2.1 Chains and their accessories

Provisional acceptance of the chains and their accessories shall be in accordance with the regulations of the selected CS.

These tests shall include checking of the mechanical and chemical properties of the material used in the chains and accessories; tensile tests, under a specified load, of all components of the chains and accessories; breaking tests of a number of elements fabricated from the same materials and in the same conditions as the chains and accessories to be supplied.

After passing the tests, the chains and accessories shall be coated with a thick coating of the top quality coal-tar, preceded by shot-blasting, unless otherwise indicated in the PPS.

Acceptance certificates of chains and accessories delivered by the selected CS shall mention as a minimum:

- Chemical characteristics of metal,
- Mechanical characteristics of metal,
- Resilience of metal,
- Test loads of chains and accessories,
- Measures lengths for each chain,
- Identification marks stamped on chains and accessories.

6.2.2 Hawsers

Hawsers and their accessories shall undergo provisional acceptance in accordance with the OCIMF standards. A simulation for the mounting of the hawser line shall be made in the Constructor's workshop.

6.2.3 Risers and floating hoses

All risers and floating hoses shall undergo acceptance tests at the workshop according to trials stipulated in the OCIMF reference documents, latest edition. Each floating line shall be marked in accordance with the instructions of the OCIMF documents.

6.2.4 Swivel

The swivel MANUFACTURER shall submit a complete test plan to CONTRACTOR and COMPANY for their APPROVAL, to be completed at the workshop. This test plan shall contain as a minimum the following tests.

6.2.4.1 Hydrostatic test

The hydrostatic test shall be performed at a pressure equal to one and a half times the maximum service pressure for which the CALM has been designed, and not lower than 435psi.

This test shall be conducted for four (4) consecutive hours without any fall in pressure.

In case of a multi-chamber swivel, the hydrostatic test shall be performed chamber by chamber, and then with all chambers simultaneously.

During the test, the lubrication fittings of the seals shall be removed for the detection of any leaks.

6.2.4.2 Rotation tests

After the swivel passes the hydrostatic test above, it shall be subjected to rotation tests with and without pressure.

1. Free rotation:

In order to check the free rotation of the swivel, it shall be rotated completely once in each direction. No hard point is to be encountered.

2. Rotation with pressure :

After the pressure is raised to:

- The service pressure,

- 50% the service pressure
- pressure of 1 bar (15 psi),

the swivel shall make complete rotations (one in each direction) in 30° increments, with measurement of the break out and sustaining torques.

In case of a multi-chamber swivel, this test shall be performed chamber by chamber, and then for all chambers simultaneously under pressure.

3. Rotation without pressure :

Following the rotation tests with pressure, the swivel, filled with water but without pressure, shall be subjected to a rotation test of its rotating part, which shall make complete rotations (one in each direction), with measurement of torques as above.

After it passes the tests, the swivel shall be thoroughly drained and dried.

Blind flanges shall be supplied with the swivel, fitted with all their bolts.

For shipment, the swivel shall be carefully wedged and blocked, especially to prevent any differential movements between the stationary part and the rotating part.

The Representative of the Classification Society selected shall attend the trials and tests discussed in this paragraph, and shall note the condition of the swivel at the time of shipment.

6.2.5 Acceptance of equipment

The following list, again not exhaustive, defines some of the checks to be performed.

6.2.5.1 Chain stoppers

The chain stoppers shall be tested with a chain identical to the anchor chains, and of sufficient length. Satisfactory opening and closing of the stoppers shall be thoroughly examined. In particular for the ratchet stoppers, CONTRACTOR shall make sure that the locking system can accommodate possible misalignments of the chain during offshore installation.

CONTRACTOR shall take all measures to procure the necessary chain from the supplier, even in the event that the chain is supplied by the COMPANY.

6.2.5.2 Lubrication system

A check shall be performed to ensure that all lubrication piping is correctly filled and that all openings are properly supplied at each stroke of the pump.

All measures shall be taken to protect the lubrication piping against collisions or impact.

6.2.5.3 Navigational light on buoy

The navigation light on the buoy shall be tested after connection to its power source, to make sure of the following:

- Satisfactory operation of the photoelectric cell,
- Satisfactory operation of the automatic lamp changer,
- Conformity of its characteristics with those listed in the technical specification.

6.2.5.4 Navigation lights on floating lines

The navigation lights on floating lines shall be checked to make sure of the following:

- Satisfactory operation of the photoelectric cell,
- Conformity of their characteristics to those listed in the technical specification.

6.2.5.5 Foghorn

After connection to its power source, the foghorn shall be tested to make sure of the following:

- Satisfactory operation of any automatic control devices,
- Conformity of its characteristics with those listed in the technical specification.

6.2.5.6 Battery box

The water tightness of the battery box shall be checked by spraying with water nozzle at a pressure of 6 bars.

6.2.5.7 Winch and tensioning equipment

The winch and tensioning equipment and/or lifting or handling equipment shall be subjected to an operating test with a load to be determined by COMPANY or CS representative. This load shall never be lower than 110% of the normal working load for which the units have been designed.

6.2.5.8 Bilge pump

The bilge pump shall also be checked to guarantee that it is in good working order.

6.3 Fabrication

6.3.1 General requirements

The BUOY fabrication and corresponding inspections shall comply with **GS STR 301** and CS requirements. In case of divergence between COMPANY and CS specifications, the most severe requirements shall apply.

The fabrication shall be done under the supervision of COMPANY representative and / or CS representative.

6.3.2 Manufacturing tolerances

The manufacturing tolerances shall be as follow:

- All outside dimensions of metallic structures, unless otherwise indicated and subject to justification: $\pm 3/1000$.
- Planeity of the deck, bottom, bulkhead:
 - ± 2 mm over a distance of 0.00 to 0.50m,
 - ± 3 mm over a distance of 0.50 to 1.00m,
 - ± 4 mm over a distance of 1.00 to 4.00m,
 - ± 5 mm over a distance exceeding 4.00m.
- Roundness of raceway for guidance of the rotating assembly, in case of bogies and rollers:
 - difference between maximum radius and minimum radius = 6mm,

- real diameter = ± 6 mm over nominal diameter.
- Planeity of raceway in case of bogies and rollers:
 - ± 1 mm over 1m of developed length,
 - ± 3 mm over 5m of developed length.

With respect to bearings and seals, the tolerances given by the suppliers of these items shall prevail in the event that they are more stringent.

If the CALM buoy features separate bearings for rotation of the swivel and for the rotating assembly absorbing the mooring forces, tolerances on concentricity between the swivel and the rotating assembly shall be determined by mutual agreement between the COMPANY and the CONTRACTOR, in accordance with the characteristics of the expansion joint. In no circumstances shall this tolerance cause the expansion joint to work at more than one-quarter of its possibilities in the movements corresponding to this concentricity defect.

All these tolerances shall also be considered for the CALM structure mounting, installation, and in the maintenance and installation procedures.

6.4 Surface preparation and painting

Surface preparation and painting of the BUOY shall be as per relevant COMPANY specifications.

6.5 Final completion and tests

The list of inspections and tests indicated below for the buoy completion does not claim to be exhaustive. Other tests may be performed, on the initiative of the CONTRACTOR, COMPANY's or CS's Inspectors.

A complete list for Completion and Tests, with levels of approvals by COMPANY and CS, and acceptance criteria, shall be proposed by CONTRACTOR and agreed between CONTRACTOR, COMPANY and CS before the fabrication of the buoy.

Similarly to provisional acceptance tests, all tests and inspections performed for the BUOY final completion are at the responsibility and cost of CONTRACTOR.

6.5.1 Buoy water tightness test

Water tightness of the buoy compartments shall be verified by performing an air test at 0.137 bar (2 psig). During the test all welds, hatch, door and manhole gaskets shall be verified by applying a soap water solution and ensuring that no leakage takes place.

Half of the compartments shall first be tested, by alternating compartment tested and not (for example, for a 6 compartments buoy, compartments 1, 3 and 5). Then the other half shall be tested (compartments 2, 4 and 6).

In case of leakage, the compartment shall be depressurised to carry out the necessary repairs, and the tests shall be repeated until complete tightness is obtained.

6.5.2 Checking of swivel with torque measurements

After assembly of the swivel and balancing of the buoy afloat, the rotating part of the buoy shall be placed in rotation to check the following:

- Correct seating of all support rollers in their raceway. Any defective seating shall be corrected,

- The torques required for starting rotation and sustaining rotation of the rotating part, with the piping non-pressurised and under the service pressure alternately,
- Deformations of the expansion joints.

These rotation tests shall be conducted as follows:

- Piping without pressure

Two complete rotations in each direction, with measurement of break out and sustaining torques.

One complete clockwise rotation, with stops at 30° intervals and measurement of break out and sustaining torques, as well as movements of the expansion joint.

One complete anticlockwise rotation, with stops at 30° increments and measurement of break out and sustaining torque.

- Piping under service pressure

Two complete rotations in each direction, with measurement of break out and sustaining torques.

One complete clockwise rotation, with stops at 30° intervals and measurement of break out and sustaining torques, as well as movements of the expansion joint.

One complete anticlockwise rotation, with stops at 30° increments and measurement of break out and sustaining torque.

Sufficiently early before performance of these tests, CONTRACTOR shall describe the system that he intends to use to conduct these tests correctly.

The maximum allowable torque, for the tests with and without pressure, shall not exceed the contractual values.

6.5.3 Pipe tightness

After assembly of all piping components, the piping shall be subjected to a hydrostatic test at a pressure amounting to one and a half times the maximum service pressure for which the CALM has been designed.

This test pressure shall be maintained for twelve (12) consecutive hours without any fall in pressure.

If the characteristics of the expansion joint prevent the application of the test pressure defined above, two hydrostatic tests shall be performed:

- The first, at the pressure given above, and including all the piping except for the expansion joint,
- The second at the maximum allowable pressure for the expansion joint, but not lower than the maximum service pressure for which the CALM is designed, and covering all the piping, including the expansion joint.

Each of these two tests shall be conducted at a continuous load duration of twelve (12) hours without any fall in pressure.

6.5.4 Operation of valves

During the test described in paragraph "Pipe tightness" above, all valves placed in the test circuits shall be open.

After the test pressure has been reached, the satisfactory operation of the valves shall be checked by closing and opening them once.

6.5.5 Pipeline End Manifold checking

The PLEM piping shall be tested at the sealine test pressure, for an uninterrupted period of twenty four (24) hours.

6.5.6 Lifting and tensioning equipment test

All fabricated steel lifting and tensioning equipment shall be proof tested with a test load which shall not exceed the Safe Working Load (SWL) as follows:

- Up to 20 tonnes SWL – Test load to be 25% in excess
- 20 – 50 tonnes SWL – Test load to be 5 tonnes in excess
- Over 50 tonnes SWL – Test load to be 10% in excess failure shall be cause for rejection

6.5.7 Commissioning and testing of all CALM components

After mounting all components on the turntable or in the buoy all components such as, navigation aids, bilge pumps, winch, air motors chain-stopper assembly or hydraulic valves remote control system shall be tested in accordance with their specific manufacturer's specifications in order to confirm their fitness for purpose.

6.5.8 Trimming of the buoy

With the buoy afloat fully equipped, and pipes filled with water, the buoy shall be trimmed by addition of ballast in the boxes provided for this purpose on the rotating assembly.

The trimming shall be checked by reading the draught marks placed on the periphery of the hull. The acceptable difference between two opposing draught marks shall correspond to a maximum angle of 0° 15'.

Any equipment housed in the non-rotating sections shall be positioned so as to balance each other mutually, or to have only a negligible effect on the general balance.

6.5.9 Weighing of the buoy

After balancing, the buoy shall be weighed by a method to be submitted by the yard for COMPANY 's approval. The weight shall be confirmed by measuring the draught marks.

6.5.10 Certificate of final acceptance

Once all inspections and tests have been passed by the BUOY in a satisfactory manner according to the Completion and Test Plan, and prior to shipping, a certificate of conformity equivalent to final acceptance of the BUOY shall be prepared stating, among other things, that the BUOY and its equipment operate correctly and giving the BUOY 's condition before shipping.

The final acceptance certificate shall be prepared and signed jointly by the COMPANY representative, the CS representative, the CONTRACTOR representative, and, as appropriate, by certain equipment and/or materials suppliers.

6.6 Guarantee

The supply shall be guaranteed for a period of twelve (12) months from the date of provisional acceptance on the site, or eighteen (18) months from the date of delivery of the certificate of completion of works; the guarantee shall cover the shorter of these two periods.

The guarantee period shall be extended to five (5) years for cathodic protection of the buoy and twenty (30) years for cathodic protection of the PLEM.

6.7 List of document to be provided

6.7.1 Documents to be supplied after award of contract

CONTRACTOR shall provide the following documents:

- All documents as defined in the above section, in case no modification has been requested by COMPANY, or same documents as final after modification; technical documentation shall be arranged in the form of the technical specification,
- All fabrication and shop drawings, enabling Inspectors appointed by COMPANY to conduct inspection during fabrication,
- Detailed schedule of all fabrication works and supplies,
- Complete bill of quantities,
- Fabrication and erection procedures,
- All drawings and calculation notes approved by the selected Classification Society,
- List of planned supplies of tools and spares,
- Detailed description of welding procedure, size and grade of filler metal and flux, speed of welding, electrical characteristics, number of passes, length, depth of penetration of each weld pass, edge preparation etc,
- Detailed description of destructive and non-destructive inspection and tests,
- All procedures of tests
- Qualification of welders assigned to the job,
- Heat treatment conditions and location,
- Schedule, procedure, type and method of all tests and inspections,
- List of works assigned to Subcontractors, their addresses and yard or workshop locations,
- Fully detailed procurement and fabrication schedule.

All these drawings and documents shall be subject to the approval of the COMPANY, and one copy shall be returned approved to the CONTRACTOR with COMPANY remarks (if any).

All the documents listed in this section above shall be supplied in five (5) copies plus one reproducible copy.

6.7.2 Documents to be supplied during fabrication

CONTRACTOR shall furnish the following documents:

- List of orders to Subcontractors for manufactured materials and for works not performed by CONTRACTOR,



- Planned schedule of main tests,
- Results of tests and certificates,
- Explanatory drawings prepared along work progress.
- Weekly progress reports

6.7.3 Documents to be supplied at end of manufacturing

A complete fabrication dossier shall be compiled and submitted by CONTRACTOR to COMPANY.

6.7.3.1 As-built drawings

All design and fabrication drawings shall be updated in relation to modifications that may have been brought in during the fabrication phase.

A reference mark shall be given to each component and this shall be shown on all drawings and materials lists.

Listings shall clearly indicate the following after the reference mark: component description, quantity, material and sampling.

The above indications are required to facilitate further enquiries of personnel in charge of maintenance and repair.

The above drawings and lists shall be furnished in one (1) reproducible (or sepia) copy plus five (5) copies.

General arrangement drawings combined with a drawing list shall be provided in the same number of copies.

This list shall indicate the latest revision index with the title and number of each drawing.

6.7.3.2 Records of test results

All test performed to terminal and appurtenances shall be recorded including test description, working conditions and subsequent results.

Whenever the first results are not satisfactory, indication thereof shall also be recorded, as well as repairs or modifications carried out to obtain satisfactory results.

All tests shall be signed by the Representatives of both CONTRACTOR and COMPANY.

6.7.3.3 Acceptance certificates

All acceptance certificates (provisional and for final completion) shall be included in the dossier.

6.8 Spare parts

6.8.1 Normal spares

Unless otherwise specified in the PPS, CONTRACTOR shall supply, according to the same terms and conditions as the buoy, the following spare parts:

- 1 spare complete mooring line with ancillary equipment (shackle,...)
- 1 set of seals (static and dynamic) for the swivel unit,
- 4 sets of seals for the break-away coupling

- 1 set of seals for the manholes and access doors,
- 1 bilge pump,
- 1 set of batteries (or dry cells) for each item of electrically powered equipment (main light, fog horn, lights on floating hoses, explosion-proof work lamps),
- 1 set of spare parts as recommended by the supplier of the main light,
- 1 set of spare parts as recommended by the supplier of the fog horn,
- 1 expansion joint of each dimension (if such parts are used in the system supplied),
- 10% of all threaded fasteners fitted, with a minimum of 2 fasteners of each dimension or type,
- 10% of all the seals installed (other than the swivel joint seals), with a minimum of 2 seals of each dimension or type,
- 1 set of anodes,
- 20 liters of paint of each type and/or colour,
- 30% of the grease nipples installed, with a minimum of 10 nipples of each type,
- 25% of each type and/or dimension of floats installed, with a minimum of 2 of each,
- 1 chain stopper (plus 1 chain centering device, if used),
- 4 joining shackles of each dimension used.

6.8.2 Spares for two-year operation

CONTRACTOR shall state the spares he recommends for two (2) years of terminal operation.

These spares shall include at least the following:

- 2 sets of tanker rail hoses,
- 25% of the standard floating hoses,
- 1 complete set of special floating hoses, e.g. buoy-side hose, semi-buoyant hose, Y coupling
- 1 complete line of risers,
- 50% of each type and/or dimension of floats installed, together with the stainless steel float hooping strips,
- 1 set of floating hose termination butterfly valves,
- 1 set of quick-connect couplings for the floating hose ends, together with their operating keys,
- 2 sets of hawsers, complete with shackles, chains or anti-chafing devices and all accessories,
- 1 complete set of floating hose lights,
- 20% of all boltings installed,
- 1 complete set of all seals installed (other than those in the transfer swivel).



7. Installation

7.1 General requirements

The installation CONTRACTOR, hereafter referred as the CONTRACTOR, shall develop the detailed, step by step procedures for the safe INSTALLATION of the BUOY, including transportation to site.

The procedures shall be consistent with relevant marine operation guidelines and OCIMF recommendations.

The installation procedures, as well as marine spread characteristics, shall be submitted to COMPANY, CS and Marine Warranty Surveyor (see below 7.2) for their review and approval prior to the commencement of INSTALLATION WORKS.

CONTRACTOR shall demonstrate in the procedures that the installation methodology and equipment he intends to use will be safe and adequate to perform the INSTALLATION WORKS. The criteria used, such as environmental / weather, as well as emergency contingencies in case of deteriorating weather conditions during critical phases of the installation, shall be clearly stated.

CONTRACTOR shall be liable for any damage occurring to the equipment during unloading, handling, transport, storage and installation of all pieces of equipment.

7.2 Marine Warranty Surveyor

A Marine Warranty Surveyor (MWS) will be selected by COMPANY to witness the installation and provide third party certification of the INSTALLATION.

Witnessing and/or approval by the MWS will not relieve CONTRACTOR from any of his contractual obligations and responsibilities.

7.3 Main equipment and personnel

The following main equipment and corresponding personnel shall be mobilised:

- Transportation or towing vessel to bring buoy from fabrication to installation site
- Derrick / work barge or suitable installation vessel with adequate lifting capacity,
- Diving service, suitable for working at local water depth, equipped with all underwater tools necessary for handling and assembling the equipment described, as well as any contingency operations.
- Position monitoring system.
- Tension monitoring system.
- Weather service.

The installation vessels chosen shall meet the acceptance criteria as set forth in COMPANY specification **GS STR 403**.

Diving operations shall be performed in compliance with IMCA guidelines latest edition.

7.4 Handling and storage

CONTRACTOR shall be liable for any damage occurring to the equipment during unloading, handling, transport or storage, and repairs or replacement shall be made at his expense.



CONTRACTOR shall declare the existence of any damage occurring to the equipment and units under his responsibility, as well as the type of measure taken for repair or replacement of the equipment, especially the characteristics of the equipment ordered and the time required for transport to the operations site.

7.4.1.1 Buoy

During storage, handling operations and movements, both on land and at sea, CONTRACTOR shall observe all necessary precautions to prevent damage to the buoy hull. Examples of damage can be chafing of slings on painted surfaces or collisions, which shall be avoided by sheathing and fendering respectively.

For buoy transfers from land to sea, either by lifting or launching, CONTRACTOR shall provide to COMPANY and CS all supporting drawings and calculations to ascertain the strength adequacy of slings, padeyes, under hull supports, adequacy of water depth, etc. as applicable.

7.4.1.2 Floating lines and risers

Floating lines and risers are pieces of equipment for which handling and storage conditions are of major importance. In that respect, vendors and OCIMF recommendations shall be strictly followed.

The following general requirements are valid for all types of lines.

a) Lifting and handling:

Any lifting shall be carried out by means of a spreader bar, that only supports the weight of a single floating line or a riser. The hose shall be suspended from the spreader bar by at least three 150mm wide nylon straps passing around the line body. The slings suspending the spreader bar shall not make an angle less than 90 degrees between them.

The use of small-circumference wire shall be avoided, and, in particular, a floating line or a riser shall never be lifted at a single point in the middle, or at the two ends alone. Similarly, any use of a fork lift truck is prohibited.

A hose shall never be moved by translation motion that causes friction on a hard ground. In general, to avoid any damage, the floating lines or the risers shall be kept in their packing during handling operations, unless damage to the packing itself is liable to affect the line. Should the packing be damaged, it shall be repaired or dismantled (and replaced if necessary).

b) Storage:

In general, floating lines or risers shall be stored in accordance with the rules specified in the OCIMF guides ("Guide for the Handling, Storage, Inspection and Testing of Hoses"), latest editions and in particular according to the following indications.

The floating lines and risers shall not be stored on a quay harbour for a long time without protection against alternate effects of rain and sun, especially in Africa.

- **Storage in original packing:**

As in the case of handling operations, whenever possible the floating lines or the risers shall be stored in their original packing or on pallets provided by the supplier, if these units have not undergone damage liable to affect the hose itself or a neighbouring line.

A hole 100 mm in diameter shall be drilled in the plates protecting the end flanges to guarantee proper ventilation inside the lines.

The floating lines and risers even in their original packing shall be protected against sun, rain and humidity.

- **Other types of storage:**

The following general requirements shall be complied with.

The floating lines or the risers shall be stretched perfectly straight, without direct contact with the ground, and shall rest on four uniformly and sufficiently spaced supports of sufficient width (750mm) to avoid any punching of the outer envelope. Wide chocks shall be used for lateral stability.

While the stacking of hoses is not the best form of the storage, the lack of space may justify such a solution.

No more than two layers shall be stacked, except for floating lines or the risers less than 20 inches (500mm) in diameter, in which a maximum of three layers may be stacked, by placing the largest hoses on the bottom, and preferably those of which the packing is intact.

If floating lines or risers are stacked in two or three layers, each layer shall be separated from its neighbour by timbers with a minimum cross-section of 150 x 75 mm, with a maximum centreline spacing of the planks of 3m, in case of storage with the packing, and 1.8m in case of storage without packing.

The floating lines or the risers shall be stored in a dry, cool, ventilated and dark place.

Prolonged exposure to sunlight shall be avoided by covering the floating lines or the risers with a light-coloured tarpaulin, while maintaining ventilation, especially at the ends.

Storage shall allow regular inspection to check maintenance of the satisfactory storage conditions discussed above.

7.4.1.3 Other equipment

All fragile units, such as navigation equipment (light, foghorn, radar reflection, miscellaneous electrical equipment, remote control if any, etc.) shall be dismantled, crated and conveyed separately to the operation site.

All precautions shall be observed to ensure easy re-assembly of these units, especially the careful marking of electrical cables used for signal power supply or transmission, for subsequent reconnection.

Whenever possible, the chains shall be stored flat to facilitate their identification and subsequent pickup, and chain supplier recommendations shall be complied with.

7.5 Installation specific requirements

Before starting the installation work, CONTRACTOR shall acquaint himself with detailed data related to the work site. The data shall include the exact geographic situation of the terminal, climatic and oceanographic conditions, soil characteristics, water depth, operating conditions (tanker size, type of product(s), characteristics of sea line to be connected to the PLEM, site operating conditions and regulations, i.e. movements on site, radio communications, safety regulations etc).

Any information concerning temporary or permanent systems already located in the site (existing anchoring lines, risers, sea lines) and operations made in the field shall also be included, to avoid hindrance or damage to existing installations.

7.6 BUOY transportation / towing

In addition to securing approval of COMPANY and CS, the transportation equipment and procedure shall meet the approval of port authorities. Documents justifying this approval shall be supplied to COMPANY before towing is performed.

Care will be taken to properly:

- Immobilise the moving parts, particularly the turntable / turret.
- provide beacon
- provide navigation lights
- Close manholes guaranteeing tightness of the compartments.
- Apply a counterweight ballast to ensure adequate trim of the buoy in the towing situation.

When the towing operation is completed, the buoy shall be inspected to check that it has not undergone any damage, both with respect to underwater and above-water surfaces and equipment, and to detect any infiltration of water into the compartments.

7.7 PLEM installation

CONTRACTOR shall evaluate early on the possibility of connecting the sealine to the PLEM at the surface during sealine lay down, in order to avoid intensive diver support. In this case, an interface with the pipeline contractor shall be quickly developed by CONTRACTOR to enable this operation.

Proper care shall be taken by CONTRACTOR to ensure that the anchoring of the PLEM to seabed will not generate any harmful stress in the PLEM or sealine.

7.8 Anchors installation

The anchor installation procedures shall ensure the final, accurate positioning of the anchors and, ultimately, of the buoy relative to the PLEM.

The procedures shall clearly indicate the tolerances or windows accepted for final anchors positioning.

The procedures shall also clearly indicate the expected behaviour of the anchors during installation, such as expected drag distances, penetrations, rates of penetration, etc.

CONTRACTOR shall provide to COMPANY and MWS all relevant records obtained during the installation of each anchor, so as to ascertain the anchors as-installed condition (achieved penetrations, drag distance vs. resistance, etc.)

7.9 Mooring lines installation

7.9.1 Catenary configuration

Each chain element shall be carefully laid on the barge deck or on a jetty, avoiding twisting. The chains shall be connected to the anchors by shackles.

During chain laying operations, sufficient tension shall be applied to avoid waviness of the chains on the seabed, and to ensure correct alignment. Chain twisting shall be avoided.

Each chain placed temporarily on the seabed shall be fitted with a device allowing its identification and recovery.



7.9.2 Taut configuration

Taut mooring using polyester ropes will require special installation procedures, to be developed in accordance with relevant guidelines such as **API RP 2SM**, Noble Denton "Deepwater Fibre Moorings Engineers Design Guide" and Manufacturer's recommendations.

In particular, the installation of polyester lines shall take into account the following additional constraints: the fiber rope is relatively fragile and must be handled with special care, a minimum allowable bending radius is required, the fiber ropes must remain under tension at all time during installation and shall avoid contact with the seabed.

Tension cycles shall also be performed according to manufacturer's requirements.

7.9.3 Testing

Each anchor line shall be tested before connection to the buoy to its maximum design load. If this proves difficult, CONTRACTOR shall seek COMPANY approval for a reduced value.

7.10 Buoy connection

The buoy is to be positioned alongside and leeward of the work barge and protected from damage due to sea induced movement between barge and buoy. If fendering is used it must consider the buoy skirt extension.

It is recommended to connect first the line which will tend to pull the buoy away from the barge or, depending how the barge is positioned, the line that faces prevailing weather.

The buoy will list severely with only one (1) chain connected and is very vulnerable to deteriorating weather conditions while in this position. The entire line hook-up program requires well planned and expedient operations to insure buoy stability.

The number of chain links to be adjusted shall be computed to obtain the chain tension angles as required and to move the buoy within one (1) meter offset of the buoy theoretical centerline.

After adjustment to final pretensions, all chain pretensions / angles shall be re-checked. The chain angular measurement shall be carried out with a suitable protractor, and the tide level at the time of angle measurements shall be recorded. The difference between all angles measured shall not exceed 1° for catenary lines. Angle value shall lay within the tolerances given during design phase. Alternate criteria have to be defined for taut line systems: loadcell, gauge.. to provide reliable and accurate measurement and monitoring.

The relative horizontal distance between the PLEM and the center of the buoy shall be measured and shall lay within tolerances.

The touch-down points of the chains shall be recorded.

After pre-tensioning is completed and confirmed, the chain stopper handling gear is to be cleaned and stowed. Excess chain is to be passed through provided buoy skirt hole adjacent to chain stopper. Excess chain (chain above chain stopper) more than six (6) meters in length is to be cut off and discarded.

7.11 Risers installation

The risers installation procedures shall comply with the OCIMF guidelines in reference.

Also, vendor specific requirements shall be obtained prior to handling and assembly of risers in the field and complied with.



The procedures shall include hydro testing of the riser before connection to the buoy and the installation of hydraulic remote control hoses for PLEM valves (if applicable).

On assembly, special care shall be paid to the correct positioning of the reinforced lengths of the risers end, as well as the marks serving to avoid twisting during subsequent connections to the PLEM and to the buoy.

Upon completion of riser installation the riser configuration will be measured and compared with the design configuration, taking into account the fact that the riser is not filled with oil yet. If necessary the position of the floats and/or the ballasting of the flotation tank will be modified in order to adjust the shape within the required tolerances.

7.12 Floating lines installation

The floating lines installation procedures shall comply with OCIMF guidelines stated in 7.11 and with vendor specific requirements. Procedures shall include pre assembly checks of the equipment supplied and hydro testing of the floating line after it is assembled and before connection to the buoy.

If assembled onshore, the assembled hose string will be towed to the installation site. Vendor recommendation with regard to onshore assembly and tow shall be strictly followed.

The floating lines installation is weather depending. It shall be only initiated if a convenient weather window is forecast.

To connect the floating hoses to the buoy, it might be more convenient for the divers to connect firstly the first off buoy hose alone, then to connect the rest of the string in "open water".

Navigation lights shall be positioned once the line is connected.

7.13 Hawser installation

The hawser make up assembly and installation procedures shall comply with relevant OCIMF guidelines and vendor recommendations.

All components making up the hawser shall be checked prior to assembly and assembled in accordance with the designed arrangement, without adding, deleting or replacing any element whatsoever.

CONTRACTOR shall make sure of the absence of any friction detrimental to the service life of the hawser, and shall ensure that the buoyancy elements are sufficient and correctly positioned.

Special precautions shall be observed in the assembly, clamping and locking of the nuts on the shackles or of the threaded pins, in order to prevent loosening.

It is recommended that the hawser be attached to the buoy following hydrostatic and rotational tests outlined below. All navigation aids and signalling equipment will be mounted: flashing light, foghorn, radar reflector, flood lights, telemetry system and antenna.

7.14 Other equipment installation

CONTRACTOR shall carry out the installation of all equipment that has not been mounted before shipment, or fragile equipment which has been dismantled for transport, such as: flashing light, foghorn, radar reflector, batteries, telemetry system and antenna.

7.15 Tests, inspection

The main tests to be carried out are listed below.



7.15.1 Tests of satisfactory operation

7.15.1.1 Rotation test of turntable or turret

Before connecting the floating lines to the buoy, the turntable or turret shall be rotated to ensure there are no hard spots or irregularities. A complete rotation shall be carried out in each direction. Measurement of the rotation torque shall be performed..

7.15.1.2 Lubrication system

The lubrication system shall be checked for proper operation, by verifying in particular the correct filling of the pipes and all grease points, and usage of lubricants as specified by the MANUFACTURER.

7.15.1.3 Miscellaneous

The telemetry system and navigation aids shall be tested for proper operation: foghorn, fog detector, beacon light, control circuits, batteries, telemetry system, PLEM valve control system, fire extinguishers, life buoys

7.15.2 Inspection of BUOY final configuration

The final configuration of anchoring lines, risers, and the relative position of buoy and PLEM are to be checked by divers as per paragraphs 7.8 and 7.9, and shown to be within acceptable tolerances.

7.15.3 Hydrostatic tests

After installation of the CALM system and connections of all lines (risers and floating lines), the entire CALM system (excluding PLEM) shall be hydrostatically tested to the Maximum Allowable Operating Pressure of the Buoy.

CONTRACTOR shall provide suitable end closures, valves and other equipment needed to perform the hydrostatic test, and shall fill the system with clean sea water. The sea water shall be chemically treated with a dosage of 200 PPM of oxygen scavenger, 200 PPM of inhibitor and 20 PPM (minimum) of fluorescent dye.

The test procedure shall be as follows:

- Raise pressure to the specified test pressure and hold for two (2) hours.
- Lower pressure to approximately fifty percent (50%) of test pressure and hold for two (2) hours.
- Increase pressure to 100% of specified test pressure and hold without additional pumping for eight (8) hours.
- During the last hour of hydrostatic testing, the turntable shall be rotated 360 degrees clockwise and counter clockwise while under pressure. Rotation can be accomplished by towing tanker end of floating line slowly in a wide circle.

7.16 Documents to be supplied

CONTRACTOR shall provide COMPANY with the following documents:

- Detailed BUOY INSTALLATION procedures and reports
- General schedule of INSTALLATION WORKS
- Equipment list with specifications.
- All tests / inspection procedures and results.